DOCTOR OF PHILOSOPHY

Environmental influences on physical activity and weight status in children from deprived multi-ethnic backgrounds in Coventry

Eyre, Emma

Award date:
2014

Awarding institution:
Coventry University

Department of Applied Science and Health

Doctor of Philosophy Thesis

Environmental influences on physical activity and weight status in children from deprived multi-ethnic backgrounds in Coventry

Emma Lisa Jane Eyre

Supervisory Team: Dr M J Duncan, Dr V M Cox, Dr S L Birch

Submitted in partial fulfilment of the requirements for doctor of philosophy

Original date of submission: June 2014

Dedication

I wish to dedicate this thesis to my late grandmother, Ann Harrower. She made me the person I am today, teaching me the life skills (determination, hard work, appreciation, kindness and there's always someone worse off), which have become my character. She was an inspiration and always pushed me to be the best that I could be. I am grateful to have been her grandchild.

Acknowledgements

Firstly, I would like to thank the Department of Applied Science and Health at Coventry University for awarding me a faculty funded PhD. Without this I would not have been able to undertake this PhD.

I would like to show much appreciation to my Director of Studies, Prof. Michael Duncan. From beginning my journey in my UG degree, Mike has provided me with, guidance, continued opportunities to get actively involved in research and his never ending support. His role as my lecturer, director of studies and friend have been invaluable to me. It has been a true privilege to have worked with you and to have studied under someone with such dedication to what you do. Thank you for providing me with such an opportunity and for all you have done and continue to do.

I would like to thank my third supervisor Dr Valerie Cox for her continued support and advice throughout. Your thinking outside the box and purple pen attack on my grammatical errors have really enhanced the quality of my work. The time you have given me has been invaluable. It has been a privilege to work with a professional of your calibre and dedication to what you do. Thanks to Dr Samantha Birch, my 2nd supervisor for her professional guidance on the project.

Thanks to Dr Matthew Blackett for his professional guidance, knowledge and support with the use of GPS and GIS, Stuart Gill for his support in GIS software and the technicians, Susie Wilson and Roy Petticrew, for the preparation and maintenance of the equipment used in this thesis.

Thank you to my colleagues, fellow PhD students and now lifelong friends, Jason Tallis, Mathew Hill, and Dominic Langdon for your kind help, advice and humour throughout my PhD. Your friendship has made each day enjoyable and the days spent on GPS analysis a lot more interesting. To Lizi Bryant, words cannot not describe what your friendship and support means to me. It has been a pleasure undertaking this PhD journey alongside you, motivating each other, exercising together for a release and sharing ideas.

Thanks to the schools, teachers, children and parents involved in this project, without your co-operation, support and dedication this would not have been possible.

To my family

My parents, Louise Grainger and Andrew Grainger, I thank you dearly. Great mums will do anything for their children and she has truly proved her duties. She has supported all decisions I’ve made about furthering my knowledge and career prospects. She has spent endless nights listening to me practice conference talks and proposing questions from my academic audience, a topic she has no interest or knowledge in. She’s helped me prepare equipment for schools, I’m truly grateful for her support.

My Granddad, James Harrower has always supported my education, showing a real keen interest in what I am doing and where I am going next. He brought me my first computer, quickly introducing me to the world of IT.

To my partner Dean Barnwell it’s not easy being with someone when you see more of their laptop than them. He’s always been fully supported of the work I need to get done and has scheduled weekends days where I can get work done but equally planned days or walks where I can get a break also. He’s been a rock.

To my nieces and nephews (Chloe, Dylan, Paige, Lilly-Ann, Molly, Riley & Bethany) for the fun times we share together, every day is a happy day when it is a day spent with you.

PhD Declaration

This thesis makes an original and unique contribution to the literature for several reasons. Firstly, the thesis utilises a mixed method approach to address a multi-dimensional issue (low PA patterns). The thesis extends current understanding of GPS estimates of PA and the physical environment as assessed in the PEACH (Laschowitz et al., 2012; Wheeler et al., 2010; Cooper et al., 2010; Page et al., 2010) and SPEEDY project (Smith et al., 2012) by focusing on specialised populations (SA and low SES neighbourhoods in Coventry). The thesis provides insight into the physical and social environment influences in deprived neighbourhoods on PA from a child's perspective as well as a parental perspective. The thesis combines both the quantitative and qualitative evidence gained to apply a multi-dimensional base with theoretical grounding (open loop feedback and integrated curriculum interventions) to increase PA in a specialised population (SA children from deprived neighbourhoods). The thesis extends a contextualised model by Grow and Saelens (2010) applying this practically to a unique population (SA children from deprived environments) in a tailor made intervention.

Contents

Presentation of the results

Results of the present thesis have been published in peer review journals and presented at international conferences:

Chapter 2.0:

- **Eyre, E.L.J.,** & Duncan, M.J. (2013a) The impact of ethnicity on objectively measured physical activity in children. Review article. *ISRN Obesity* Article ID 75743.

Study one:

- **Eyre, E.L.J.**, Duncan, M.J., Birch, S.L., Blackett, M., & Cox, V. (2014) 'Physical activity in South Asian children from low socio-economic environments.' *Journal of Sports Sciences 7, 1-11.* **doi:** 10.1080/02640414.2014.934706
- **Eyre, E.L.J.,** Duncan, M.J., Birch, S.L., & Cox, V. (2013) Outdoors environments are important for health enhancing physical activity. Poster presentation at Coventry University Research Symposium (March 2013)
- **Eyre, E.L.J.,** Duncan, M.J., Birch, S.L., & Cox, V. (2013) Outdoors environments are important for health enhancing physical activity in deprived environments. Poster presentation at ECO 20TH European congress on obesity, Liverpool (12-15th May 2013).
- **Eyre E.L.J.,** Duncan, M.J., Blackett, M., Birch, S.L., & Cox, V**. (2013)** Environmental influences on physical activity behaviour in South Asian children from low socio-economic backgrounds. Oral presentation at BASES Annual Conference, University of Central Lancashire (3 – 5th September 2013).

Study two:

- **Eyre, E.L.J.**, Duncan, M.J., Birch, S.L., & Cox, V. (2013c) 'Environmental and school influences on physical activity in South Asian children from low socio-economic backgrounds: A qualitative study'. *Journal of Child Health Care, e-pub ahead of print* [online], available from: http://www.ncbi.nlm.nih.gov/pubmed/24270992 [30 December 2013]. doi: 10.1177/136749351350884
- **Eyre, E.L.J.,** Duncan, M.J., Birch, S.L., & Cox, V**.** (2012) Environmental Influence on physical activity in ethnic children: a qualitative analysis. Oral presentation at HEPA Europe 8TH Annual Meeting, Cardiff (26 - 27th September 2012).

Study three:

- **Eyre, E.L.J.**, Cox, V., Birch, S.L., & Duncan, M.J. (2014) 'Environmental influences on PA in ethnic children from low socio-economic backgrounds: a qualitative study from children perspectives'. *Preventive Medicine Reports, 1, 32 - 42.*
- **Eyre, E.L.J.,** Cox, V., Birch, S.L., & Duncan, M.J. (2014) Parental perspectives on the influence of obesogenic environments on physical activity in children from deprived areas. Under review at Association for the study obesity UK congress on Obesity, University of Birmingham 2014 (16th – 17th September 2014)

Study four:

Eyre, E.L.J., Duncan, M.J., Birch, S.L., & Cox, V. (Under Review) An integrated curriculum approach to increasing habitual physical activity in primary school children, UK: A focus on South Asian children from deprived backgrounds. *European Journal of Sport Sciences.*

- **Eyre, E.L.J., Duncan, M.J., Birch, S.L., & Cox, V. (2014)** An integrated curriculum approach to increasing habitual physical activity in primary school children, UK: a focus on south Asian children from deprived backgrounds. Oral presentation at European Congress of Sport Science 19th Annual Congress, Amsterdam (2nd – 5th July 2014).
- **Eyre E.L.J., Duncan, M.J., Birch S.L., Cox, V. (2013)** Increasing physical activity in South Asian children from deprived backgrounds through the school. Oral presentation at Coventry University Physical Activity Conference (13th November 2013).

List of tables

List of figures

List of appendices

Abbreviations

ALPHA – Assessing levels of Physical activity and fitness

BIA – Bioelectrical Impedance Analyser

BMI - Body Mass Index

CHD - Coronary Heart Disease

CT – Computer Tomography

CVD - Cardiovascular Disease

DEXA – Dual Energy X-ray Absorptiometry

GIS – Geographical Information Systems

GPS – Global Positioning system

HR – Heart Rate

MRI – Magnetic Resonance Imaging

MVPA – Moderate to Vigorous Physical Activity

NCD's- Non-Communicable Diseases

PA- Physical Activity

PEACH project – Personal and Environmental Associations with Children's Health project

PE – Physical Education

SA – South Asian

SES - Socio-Economic Status

T2DM – Type 2 Diabetes Mellitus

WC – Waist Circumference

ABSTRACT

Introduction: Children in the UK from South Asian backgrounds have increased risk of metabolic disease, increased body fat and engage in reduced physical activity (PA) compared to White children (Ehtisthan et al., 2000, 2004; Whincup et al., 2002). The mechanisms underlying the lower physical activity patterns are not fully understood in South Asian children. Ethnic groups cluster in deprived areas within the UK (Jayaweera et al., 2007; Williams et al., 2009) and thus the role of the physical environment and how children use this environment for PA, needs exploring in order to increase PA through interventions. The overall aim of the thesis was to assess the association between environmental factors and PA behaviour in deprived South Asian primary school children.

Methods: Following institutional ethical approval, children and their parents from two primary schools within deprived wards in Coventry were recruited. Objective assessments of PA (heart rate or pedometer, the physical environment (global positioning system)) and body adiposity (body mass index, waist circumference and body fat %) were obtained from children. Perceptions about the physical and social environment were obtained from focus group discussions with children and parents. The findings obtained from quantitative and qualitative evidence were combined to apply a multi-dimensional intervention increase PA in SA children from low SES environments.

Results: Quantitative results identified that children are more active in outdoors environments (non-greenspace) (P <0.01), but that South Asian children spend more time indoors (P = 0.03) and are less active indoors (P = 0.04). Qualitative findings identified the importance of the supportive physical and social environment at school on children's PA levels. Additionally, unsupportive physical (e.g. poor access, safety and quality) and social factors (e.g. anti-social behaviour) within the neighbourhood were identified as barriers to children's outdoor play, resulting in sedentary behaviours indoors. The multi-dimensional intervention provides evidence that modifying the physical and social environment through school can increase PA. The results indicated that average daily steps were significantly higher in the intervention group at 6 weeks post compared to baseline and the control group (mean change ± SD of change = 8694 ± 7428 steps/day vs. -1121 ± 5592 steps/day, 95% CI of difference, 6726, 7428 steps/day, P = 0.001, d = 1.76). No significant change from pre to post 6 weeks was found for the control group (mean change ± SD of change = -1121 ± 5592 steps/day, 95% CI of difference = -1301, 3004 steps/day, P= 0.42). In addition, significant decreases in South Asian children's body fat % (mean change ± SD of change = -4.46 ± 4.77% vs. -1.09 ± 2.77%, 95% CI of difference, -1.26, -0.34% , P = 0.001, d = 1.22) and WC (mean change = -1.73 ± 4.48cm vs. -0.21 ± 3.49cm vs. respectively, 95% CI of difference, -3.40, 0.36cm, P = 0.001, d= 0.44) were observed in the intervention group post 6 weeks compared to the control group.

Conclusion: To conclude, the findings confirm the importance of social and physical environments on children's PA patterns, which can be changed using an intervention to increase children's PA. Further research needs to examine the long-term sustainability of an integrated school based curriculum intervention and the effects this has on metabolic risk.

CHAPTER 1.0 INTRODUCTION AND THESIS OUTLINE

Globally, non-communicable diseases (NCDs) are the leading cause of death (WHO, 2011). From a total of 36 million deaths caused by NCDs, 18.3 million are associated with cardiovascular disease (Coronary heart disease (CHD), stroke, cardiomyopathy, heart failure & atrial fibrillation), and metabolic disease (diabetes, obesity, high blood pressure) (WHO, 2011). In the UK, 74,000 deaths per year in adults are caused by CHD , with a further 2.3 million people living with the disease (Townsend, 2013). Additionally, 2.6 million adults in the UK have been diagnosed with Type 2 diabetes mellitus (T2DM) with an estimated half a million undiagnosed (Diabetes UK, 2010).

The development of metabolic disease is reported in children (Brage et al., 2004b; Ehitisham et al., 2004; Zimmet, 1997), and shows some weak to moderate evidence of tracking into adulthood (Bao et al., 1993; Chen et al., 2005; Freedman et al., 1997; Raitakari et al., 2003; Nguyen et al., 2008). Prevalence figures in the UK in 2000 suggest 0.21/100,000 children under 16 years have T2DM (Ehtisham et al., 2004). Yet, in 2009, the prevalence was increased with 3.0/100,000 cases of T2DM per year for children under 17 years in the UK reported (Haines and Kramer, 2009). Specifically in the West Midlands, the prevalence of T2DM in children aged 0 - 17years is greater than in England (4.3/ 100,000 cases vs. 3.0/100,000 cases) (Haines and Kramer, 2009). Furthermore, the prevalence is increased with ethnicity (South Asian (SA)= 1.25/100,000 compared to 0.35/100,000 for White) (Haines et al., 2007) and obesity (Ehtisham et al., 2004). This is concerning given the increasing prevalence of overweight and obesity found in children (Year 6) in England, from 2006/07 to 2011/12 (boys = 33.2% to 35.4% and girls 30% to 32%) (Townsend, 2013). In England, children living in the most deprived areas also have increased prevalence of obesity. Coventry, a city in England is ranked 52nd out of 326 local authority districts for social deprivation (1 being most deprived) and has a greater prevalence of obesity compared to the national figures (11.2% obese in reception and 20.6% in year 6, vs. 9.5% and 19.2% repectively) (Coventry City Council, 2010).

Ethnicity is also a key factor in determining metabolic disease risk. Specifically, SA adults have an increased burden of metabolic disease compared to white adults (Bhopal et al., 1999; McKeigue et al., 1991; Wild et al., 2007; Williams et al., 2009). In addition, SA children show abnormal metabolic profiles at young ages (Bavekar et al., 1999; Ehtisthan et al., 2000, 2004; Whincup et al., 2002) compared to White children. The, prevelance of T2DM is increased in SA children compared to white (1.42/100,00 vs. 0.17/100,00 respectively, relative risk for SA = 13.7) and increased in obese (Ehtisham et al., 2004). This is a concern in Coventry because the ethnic population of Coventry is greater (17% Black and 6% Asian vs 26% Black and 12% Asian for England and Coventry respectively) with large ethnic populations residing in the most deprived areas (Coventry City Council, 2010). As a result of the growing burden of these NCDs, the WHO (2013) has called for a global action plan from 2013-2020, for their prevention and control. The third objective of the global action plan is to reduce modifiable risk factors for NCDs and underlying social determinants, through health promoting environments.

Physical activity (PA) is an important modifiable risk factor for cardiovascular and metabolic disease (Berlin & Colditz, 1990; Blair et al., 1989; Dabelea et al., 1999; Powell et al., 1987). In 2004, worldwide, physical inactivity was responsible for 3.2 million deaths per year and 20-30% of all-cause mortality (WHO, 2009). Regular PA is associated with reduced body fat (Biddle et al., 2014), and body fat is an independent predictor of triglyceride and blood pressure levels (Thomas et al., 2007). Increasing PA is therefore a research priority for the primary prevention of NCDs by the WHO global recommendations (WHO, 2010). Furthermore, Gillis et al., (2012) identified and ranked 29 international research priorities for children's PA and sedentary behaviour. In the top 10 were: to develop effective and sustainable interventions that can increase children's PA long term (1st priority), policy and/or environmental change and their influence on children's PA and sedentary behaviour (2nd priority), understanding the theory behind changing children's activity levels and behaviours (6th priority), how to create effective population based-interventions for the least active children (7th priority), cultural and parental practices related to PA and children's behaviours (10th priority).

Research has shown that adults and children in the UK and globally, do not engage in enough PA (Metcalf et al., 2008; Nader et al., 2008; Pate et al., 2002; Riddoch, 2004). It is apparent that SA adults and children engage in lower levels of PA (Eyre & Duncan, 2013a; Fishbacher et al., 2004; Khunti et al., 2007). In particular, the low adherence to PA guidelines in children from SA backgrounds is of concern. Owens et al., (2009) suggests that only 54% of SA children (compared to 70% White) meet the current daily PA guideline of 60 minutes of moderate-to-vigorous-PA (MVPA) (CMO, 2011). Eyre et al., (2013b) found that only 35% of SA children meet this guideline in Coventry.

Although, it is not known why adherence is lower in specific groups such as SA children, a number of reasons have been suggested. Firstly, there is a wealth of evidence concerning health inequalities and socio-economic status (SES) (Mackenbach et al., 2008) suggesting that people from low SES backgrounds experience poorer health (Mackenbach et al., 2008; Mitchell & Popham, 2008). Income and ethnicity/race are also key factors in determining the area where someone resides (Sampson & Sharkey, 2008; Nechyba & Strauss, 1998). In the UK, SA people are described as the most socio-economically disadvantaged and are likely to live in areas that are most deprived

(Jayaweera et al., 2007; Williams et al., 2009). In Coventry, the two most deprived wards have the highest proportion of ethnic groups (Coventry City Council, 2010). In the US PA facilities are unevenly distributed amongst different residential areas (Gordon-Larsen et al., 2006). Therefore, the area where a child lives (influenced by ethnicity and income) is likely to affect PA behaviours and is of research interest. A number of current studies have shown that features of the physical environment (e.g. greenspace, open space, school, walkability) affect PA (Bolte 2010; Fernandes & Sturm, 2010; Griew et al., 2010; Kimbro et al., 2011; Zhu & Lee 2008) but none have considered ethnicity (Boone-Heinonen et al., 2011) and few have considered socio-economic disparities. Therefore, the combined influence of SES, environmental features and ethnicity on PA patterns is not known. Secondly, the perceptions associated with physical environmental features and how these are modified by SES and ethnicity are not known.

The thesis will attempt to address the reported low levels of PA in SA children compared to White children (35 - 54% meet 60 mins a day guideline, Eyre et al., 2013b; Owens et al., 2009). Thus the aim is to assess the association between environmental factors and PA behaviour in SA primary school children in low socio-economic areas. The thesis does this by firstly seeking to objectively examine how youth from differing ethnic backgrounds utilise their built environment, within deprived areas, for PA. Secondly, the thesis will assess youth and parental perceptions of their built environment and how this affects their engagement in PA within their environment. The data from these studies will be used to inform an intervention, which is aimed at increasing PA in children from deprived ethnic backgrounds. This addresses the third objective of the global action plan (WHO, 2013) and 5 of the top 10 international research priorities for children's PA stated by Gillis et al., (2012).

CHAPTER 2.0 LITERATURE REVIEW: PHYSICAL ACTIVITY

In order to understand the relationship between PA and health, it is imperative to define PA. PA, exercise and fitness are words used interchangeably and although related they are three separate concepts. PA is defined as 'any bodily movement produced by the skeletal muscles that result in caloric expenditure' (Caspersen, Powell & Christenson, 1985). Haskell & Kiernan (2000) expanded on this definition, adding that the bodily movement produced consists of both mechanical (muscle contraction produces limb movement) and metabolic components (the availability of oxygen for aerobic and anaerobic processes). Exercise is planned, structured and involves repetitive bodily movements to improve or maintain components of physical fitness (Caspersen, Powell & Christenson, 1985; Howley, 2001). Exercise can be undertaken through activities of daily living (e.g. work, housework) or leisure activities. Physical fitness is thus a set of attributes such as cardiorespiratory endurance, muscular endurance, muscle strength and flexibility that are partly genetic and also a result of regular exercise. Agility, balance and coordination are skill based components of fitness (Haskell & Kiernan, 2000; Vanhees et al., 2005). Physical fitness remains fairly static on a daily basis because it takes time to improve key attributes; PA however, is very variable on a daily basis (Warren et al., 2010).

2. 1 Physical Activity and Health

It is well established that PA is beneficial for many components of physiological and psychological health (Field, 2012; WHO, 2010). Reviews have concluded that regular PA in adults is associated with the primary and secondary prevention of cardiovascular disease, T2DM, cancer, hypertension, bone and joint diseases including osteoporosis and osteoarthritis, musculoskeletal fitness, depression and cognitive functioning (Blair et al., 1989; Blair & Meredith, 1994; Paffenbarger, 1993; Lavie & Milani, 2011; Warburton, Nicol & Bredin, 2006). In particular, PA of 2.5 hours duration over 5 days a week has been shown to reduce all-cause mortality in adults by 19% (Woodcock et al., 2011).

In children, evidence suggests that PA provides fundamental health benefits (Biddle et al., 1998; Boreham & Riddoch, 2001; Malina, 1996; Janssen & LeBlanc, 2010; Strong et al. 2005; WHO 2010). PA is important for obesity management/prevention, cognitive development/achievement (Lambourne & Donnely, 2011), reducing metabolic abnormalities (Brage et al., 2004; Ekelund et al., 2006; Mota et al., 2010; Rizzo et al., 2007), psychological health (anxiety, depression and self-esteem) (Biddle & Asare, 2011) and bone strength and growth (Boreham & McKay, 2011). PA and specific health components in both adults and children are discussed in more detail below.

2.1.1 PA and psychological well-being in adults

Exercise and PA has shown a range of benefits on mental well-being in adults (Penedo & Dahn, 2005; Stephen, 1988). Specifically for PA, reviews have shown the effectiveness of PA as an anti-depressant, showing improvements in cognitive functioning, psychological well-being (e.g. mood, self-esteem and self-worth) and life satisfaction (Biddle, 2000; Carek, Laibsatin & Carek, 2011). The value of exercise (resistance and aerobic) as a therapy, which is as effective as psychotherapeutic interventions for depression, anxiety, mood and resilience to stress has also been concluded in review studies (Byrne and Byrne, 1993; Fox, 1999). A review concluded that a larger reduction in depressive symptoms was seen in exercise groups compared to psychological interventions (i.e. relaxation and meditation) or pharmacological treatment (Cooney et al., 2014). The mechanisms for this positive change in well-being can be explained by physiological and psychological responses. Physiologically, PA increases ß- endorphin response, especially in regions of the fronto limbic brain area, which are responsible for processing affective states and mood (McArdle, Katch & Katch, 2010). From a psychological perspective, engaging in exercise is associated with increased self-reported appearance, and thus self-esteem is improved (King et al., 1989).

2.1.1.1 PA and psychological well-being in children

Anxiety and depression are described as common disorders in children and adolescence (Biddle, 2000). However, there are few studies that explore the benefits of PA on psychological well-being in children. The studies that have considered this have shown beneficial effects of exercise. These associated psychological benefits of exercise in children have been confirmed in recent reviews (Brown et al., 2013; Field, 2012). Specifically, PA has yielded a beneficial effect on anxiety, depression and self-esteem of children (Biddle and Asare, 2011). Aerobic exercise interventions have also shown increased self-esteem and reduced depression (Crews, Lochbaum & Landers, 2004). In particular, Field's (2012) review reported that Yoga reduces anxiety and stress and also lowered cortisol levels, whilst Tai Chi improved mood and sleep. The desirable effects of exercise over psychological interventions like meditation are under researched in children. A review in adults suggests exercise has a greater effect of reducing depression compared to psychological interventions (i.e. meditation, relaxation) (Field, 2012). However, further studies need to compare the effects of exercise against psychological interventions (e.g. meditation, relaxation) on mood to confirm this in children. Despite this, it is thus possible to suggest that PA does improve psychological well-being in children, and could offer a desirable treatment over pharmacological alternatives.

2.1.2 PA and body fatness in adults

It is widely accepted that increased body fat results from an imbalance between energy intake and energy expenditure (Trayhurn, 2005). Engaging in PA or exercise increases energy expenditure and is negatively associated with body weight (Cooper et al., 2011). The total amount of energy that is expended is dependent on the activity type, intensity and duration. For example, engaging in 30 minutes of walking daily can result in 63kcal per day expenditure, increasing total energy expenditure by 5% (Dunford, 2012). Cross sectional studies have shown that overweight or obese people engage in less activity; spend less time in moderate to vigiorous PA (MVPA) and more time in sedentary activity (Ekelund et al., 2006; Scheers, Philipparts & Lefevre, 2012). Reviews of experimental studies have confirmed the effective improvements in fatness measures with exercise (Kessler, Sisson & Short's, 2012; Lara et al., 2011). A systematic review in overweight and obese adults proposed that exercise for 6 - 12 months results in a 2kg weight loss, but when exercise is combined with diet this weight loss was increased to 6.5 to 10.8Kg (Lara et al., 2011). However, it is important to consider that systematic reviews do not necesarily provide all the weight loss studies ever conducted and can suffer from publication bias and exclusion of grey literature (e.g. unpublished studies). Despite this, they aim to gather all the evidence systematically to summarise the findings collectively.

Regular PA and exercise improves cardiovascular fitness which reduces mortality even in overweight or obese individuals (Jakicic & Davies, 2011; M^{C}Auley & Blair, 2011). Reviews have confirmed this 'fat but fit' concept (Jakicic & Davies, 2011; M^{C}Auley & Blair, 2011). This is because exercise (aerobic and resistance) affects lipid metabolism, lowering triglycerides, increasing HDL-Cholesterol and improving both glucose and insulin metabolism (Goldberg & Elliot, 1987, Trayhurn, 2005). Cardiovascular benefits of PA are explored in more detail in section 2.1.3. Therefore, it is apparent that PA and exercise play an important role in weight management in adults. However, even in those who are overweight or obese, PA is important for improving health. This is important because obese children are more likely to become obese adults (Maffeis & Tato, 2001).

2.1.2.1 PA and body fat in Children

Increasing rates of physical inactivity is described as a causative factor for increased rates of obesity (Kennedy & Goldberg, 1995; Parikh & Stratton, 2001). In global cross sectional studies, overweight and obese children were reported as significantly more sedentary (increased screen time) than normal weight children (Herman et al., 2014). In UK studies, a small, significant positive relationship between TV viewing and body fat in children was reported (Marshall et al., 2004, Prentice-Dunn & Prentice-Dunn, 2012). Some of the mechanisms for this association relate to the small to moderate association of sedentary behaviour with less healthy diet, including lower fruit and vegetable consumption, higher consumption of energy-dense snacks, drinks and fast food and a higher energy intake (Pearson and Biddle, 2011). This evidence comes from cross sectional studies and thus reverse causality must be considered. Thus, it is not possible to conclude whether increased TV viewing results in increased body fat or if increased body fat results in increased TV viewing. Despite this, experimental studies focusing on reducing sedentary behaviour have shown small but significant effects on reducing body fat (Biddle et al., 2014). In review of reviews on sedentary behaviour (Biddle et al., 2014), the most effective strategies include family involvement, behavioural interventions and electronic TV monitoring devices.

The importance of PA in maintaining and reducing body fat levels in both obese and non-obese children is also recognised (Bar-or & Baranowski, 1994; Wilks et al., 2011). Body fat has been consistently negatively associated with PA in children (Ekelund et al., 2004;

2005; Janssen & le Blanc, 2010; Reilly et al., 1999; Riddoch et al., 2007; Sardinha et al. 2008). Reichert et al's., (2009) systematic review confirms the protective role of PA against fatness, but suggests the findings are limited in adolescents due to the lack of measurement validity. PA has also shown beneficial effects on fatness levels (Boreham et al., 1997; Gutin, 1995; Gutin & Owens, 1999; Robinson et al., 1993).

When the intensity of PA (e.g. moderate or vigorous PA) is considered, the findings are less consistent and dependent upon the quality of the studies and accuracy in measurement of PA and body fat (use of BMI). In studies where the assessment of PA and body fat has yielded greater methodological quality, the data has shown a moderate treatment effect of PA on body fat %, but no effect when BMI was measured (McGovern et al., 2008; Rowlands, Eston & Ingledew, 1999). A UK study in children (7 - 10 years) measured PA using accelerometry and body fat (Dual Energy X-ray Absorptometry (DEXA)) and reports that body fat predicted change in PA over three years (Metcalf et al., 2010). The study also proposed that a 10% increase in body fat was associated with four minutes per day decrease in MVPA (Metcalf et al., 2010). This is supported by Jimenez-Pavon et al's (2010) study, which reviewed 47 studies that objectively measured PA and fatness and found a negative association between PA and fatness (79% of studies overall). However, the Parikh & Stratton (2011) review concludes that it is vigorous intensity PA which is associated with reduced fatness not moderate PA. Some of this discrepancy might be based on the lack of universal cut points to determine MVPA across studies.

The majority of information on body fat and PA comes from cross sectional studies, which are not able to infer cause and effect. Metcalf et al's (2010) review suggests that it is body fat that predicts PA not PA predicting body fat. This suggests that having increased body fat is a barrier to engaging in PA and not caused by lack of PA. However, an intervention study in Chinese children (8-11 years) suggests that 20 minutes of daily PA significantly reduced BMI and body fat (Li et al., 2010). Parsons et al., (1999) also provide evidence for the protective effects of PA in childhood on later fatness. The mastery of functional and fundamental movement skills in children has been negatively associated with weight status and positively associated with PA (Bryant et al., 2013; Duncan and Stanley, 2012). Whether, weight status reduces PA and thus fundamental movement skills or whether not having mastery of functional or fundamental movement skills and thus being less physically active, consequently having a greater weight status, is not known. What is known though, is that the link between PA and weight is complex.

The link is complex because there are separate constructs to PA such as sedentary time and light, moderate or vigorous activity. Current research has focused on the clustering of PA instead of separate constructs. This clustering recognising that an individual can be sedentary and inactive or sedentary and active (i.e. spend a long time sitting but also engage in 30 minutes of activity). Leech et al., (2014) review reports that mixed activity and sedentary behaviours (e.g.a child meeting MVPA guidelines as well as spending increased time in sedentary behaviour) are commonly seen, which results in inconclusive associations of PA with fatness. Furthermore, this relationship was dependent on age, gender and SES. The evidence therefore seems to suggest that increasing body fat is a result of complex and interrelated behavioural patterns and not just merely a product of increasing sedentary time or not engaging in sufficient activity. This relationship is further complicated by gender, ethnicity, and SES. These factors are discussed in Section 2.1.2.2 to 2.1.2.3. Therefore, the evidence would suggest that objective measures of PA and additional measures of body fat with BMI should be sought to obtain the most valid measures of a complex relationship.

2.1.2.2. Physical activity, body fat and Gender

The protective effects of PA on body fat in both boys and girls are reported in research (Moore et al., 2003). Some research suggests that the relationship between body fat or BMI and PA is stronger in girls than boys (Abbot and Davies, 2004). From experimental studies, an increase in self reported PA per hour was associated with a 0.06 $kg.m^2$ decreased in BMI for girls and 0.22$kg.m^{-2}$ for boys, whereas physical inactivity was associated with a 0.55 $kg.m^{-2}$ increase in girls (Berkey et al., 2003). Despite this, a meta-analysis conducted by Rowlands et al., (2000) suggests no effect of gender on the strength of relationship between PA and body fat. Furthermore, they confirmed the small to moderate relationship between body fat and PA in all children.

2.1.2.3 PA, body fat and ethnicity

Studies that have measured fatness in children from non-White backgrounds have consistently reported differences in body size and fatness compared to White children (Boonpleung et al., 2012; Dugas et al., 2011; Eyre et al., 2013b; Nightingale et al., 2011; Stanfield et al., 2012; Whincup et al., 2002). US studies often consider differences between Mexican American, non-Hispanic White and non-Hispanic black. In UK based studies though, White Europeans are commonly compared against SA or Black groups, due to the increased SA and Black populations that reside in the UK. The mechanisms for differences in body size and fatness may relate to genetic, cultural and/or behavioural factors.

From a genetic perspective, Cardel et al., (2011) suggests there are ancestral genetic influences that contribute to differences in body composition between ethnic groups. Experimental studies provide evidence of biological programming during foetal life, which alters birth size resulting in permanent structural and functional changes (e.g.

homeostatic mechanism), possibly predisposing to diseases such as obesity and diabetes (Harding, 2001). Yajnik et al's (2002) research supports biological programming, evidencing that Indian babies are born lighter with more preserved fat mass and a tendency for truncal and central fatness during intrauterine development. The evolutionary role of thrifty genotype is argued by research (Neel, 1962) suggesting that a thrifty genotype enables fat storage during times of plentiful food and fat and is a useful survival mechanism in their country of origin during disasters, feast periods and famines. However, ethnic groups then face challenges in lifestyle risk factors such as diet and PA associated with their immigration experience (Liu et al., 2012). For instance, westernisation, globalisation and industrialisation have enabled a more plentiful supply of food. This increased supply of food might increase fat storage which is detrimental especially when coupled with the adoption of a less active lifestyle within westernised worlds, resulting in excess energy storage not being expended (Faggot - Campagna & Narayan, 2001; Zimmet, 2000). It is clear that genetic influences play a role but the interaction of genetic factors with environmental experiences such as a westernised lifestyle might enhance such risk.

In US based studies, gender, ethnicity and race differences in body fat have been reported. Dugas et al., (2011) reported that Mexican American children have a higher body fat (DEXA) compared to non-Hispanic White. Another study reported that Mexican American children have less lean soft tissue than non-Hispanic White or Black children (Borrud et al., 2010). Considering gender and ethnic differences, Mexican American boys weighed less than non-Hispanic White, but had a similar BMI. Mexican American girls, however, had higher body fat. Non-Hispanic Black boys had significantly lower body fat for BMI (Dugas et al., 2011). These differences were also described in Boonpleung et al., (2012) who identified gender, race and ethnic differences in 'adiposity rebound'. 'Adiposity rebound' or 'BMI rebound' is described as the point where BMI declines to a lowest point in infancy before increasing again into adulthood. This is also known as the second rise in BMI, typically occurring between 4 to 8 years of age (Woodward-Lopez et al., 2006). Adiposity rebound was earlier in girls compared to boys, and occurred earlier in non-Hispanic African American than non-Hispanic White children (Boonpleung et al., 2012). Longitudal study in children showed that earlier adiposity rebound was associated with increased risk of adult fatness compared to those who experienced adiposity rebound later in life (Rolland-Cachera et al., 1984; Whitaker et al., 1998). Understanding adiposity rebound in children from different ethnic groups thus may explain some of the differences in adult fatness and it is likely that PA interventions to reduce body fat can be targeted in those at increased risk.

In UK based studies, fatness differences have been apparent between SA and White children (Duncan et al., 2004; Ehtisham et al., 2005; Saxena et al., 2004). SA children are reported to be lighter (Eyre et al., 2013b; Nightingale et al., 2011; Whincup et al., 2002) shorter and have higher body fat compared to White children (Nightingale et al., 2011; Henderson et al., 2011). There is some evidence that this might relate to genetic differences or maternal physiology, as SA babies are born lighter with more preserved fat mass (Yajnik, 2002) and SA infants (6-12weeks) have greater fat free mass compared to White EU infants (Stanfield et al., 2012). Some sex and ethnic heterogeneity differences have also been observed. Females from Asian backgrounds have a greater tendency for central fatness compared to mixed/others and White ethnic groups (Morimoto et al., 2012). Yet, Gujarati Indian adolescent boys have been shown to have higher WC than Gujarati girls (Shaikh, Patel, Singh, 2011). Gujarati Indian adolescent girls had higher body fat % and fat mass index compared to Gujarati Indian boys (Shaikh, Patel, Singh, 2011).

Further ethnic differences in body fat have also been reported between Black and White children in the UK (Boonpleung et al., 2012; Wagner & Heyward, 2000). Black children were reported to be taller and heavier, thus having a higher BMI, higher body fat % but smaller sum of skinfolds, which is said to reflect lower limb skinfolds. In addition, the pattern of fatness was reported as similar between Black African and Black Caribbean children (Nightingale et al., 2011).

The mechanisms for increased fatness may also relate to lifestyle factors such as dietary intake and lack of PA. These lifestyle factors are affected by six key areas; child, family, culture, school, local environment, and macro-environment (Pallan, 2012). A study conducted in SA children in Birmingham, UK, using qualitative analysis, reported the influence of SA family structures, traditional cooking practices, social and religious practices and a perception around the lack of awareness of healthy lifestyles in these communities to affect unhealthy choices (Pallan, 2012). However, acculturation was also considered in terms of diet changes. There is a paucity of data examining dietary patterns within children from non-White backgrounds and its association with body fat. Additionally, obtaining valid and reliable dietary records from young children from ethnic backgrounds is a challenge.

For PA, studies in non-White children show that PA is negatively associated body fat (Eyre et al., 2012b; Patkar & Joshi 2011; McClain et al., 2011; White and Jago, 2012). In Indian adults, fitness (as a measure of PA) was also negatively correlated with body fat % (determined by calf skinfold thickness) (Patkar & Joshi 2011). In a study in African American and Latino children, accelerometer determined MVPA was negatively associated with fat mass but not sedentary behaviour (McClain et al., 2011). White and Jago (2012) reported that higher levels of PA were associated with lower levels of obesity in White adolescent girls but not Black girls, suggesting that Black girls may be less sensitive to the effects of PA. Patkar and Joshi (2011) reported that VO_2max was strongly associated with body fat % in young Indian adults. The relationship between PA, fitness and increasing fatness in SA pre-pubertal children is also identified in research (Eyre, 2012, MSc unpublished data). The wealth of evidence therefore suggests that PA or exercise is negatively associated with body fat in non-White children.

2.1.3 The effects of physical activity on cardio-metabolic risk factors

Regular PA is an effective non-pharmacological intervention for the prevention and treatment of cardiovascular and metabolic disease. The mechanisms for improved cardiovascular and metabolic health result due to numerous physiological responses (2.1.3.1 to 2.1.3.5) which result in improved cardiovascular fitness and cardiovascular health in adults (Berlin & Colditz, 1990; Paffenbarger, 1993, 1996, 2001; Powell et al., 1987; WHO, 2010) children (Owens, 1999), healthy and those with cardiovascular disease (Fletcher et al., 1996).

2.1.3.1 Cardiovascular effects of PA in adults

The cardiovascular functional capacity is improved with aerobic exercise because left ventricular (LV) mass and LV stroke volume is increased as a result of increased preloading and contractability (Gielen et al., 2010; Mahon, 2000), increasing cardiac ouput. The autonomic effects of the heart are also modified, sympathetic activation is reduced and parasympathetic activation increased, resulting in reduced heart rate at rest and in response to exercise, coupled with the increased ability of the heart to meet the metabolic demands of the exercise (Myers, 2003). In addition, regular exercise results in vascular related changes whereby an improved capacity of blood vessels to dilate in response to exercise is seen, as well as decreased aorta stiffness which improves the transportation of required oxygen (Myers, 2003). This results in decreased systolic blood pressure (Mahon, 2000).

2.1.3.2 Metabolic effects of PA in adults

Regular aerobic exercise reduces plasma fasting triglycerides, plasma low-density lipoproteins and increases high-density lipoproteins (HDL-C) (Leon, 2005). These findings are not limited to continuous aerobic exercise. In a review of 17 studies, the role of high intensity interval training (12 weeks duration) in reducing cardio-metabolic disease risk by improvements in HDL-C, and reduced blood pressure was supported (Kessler et al., 2012). In addition, aerobic exercise training results in improved cardiorespiratory endurance (as outlined in 2.1.3.1) and has anti-inflammatory effects (reduced C reactive protein levels) (Leon, 2005). Chronic inflammation plays a role in the pathogenesis of coronary artery disease and plaque stability. Therefore, reducing inflammation by regular engagement in aerobic exercise reduces the risk of cardiovascular disease (Leon, 2005).

Higher level of fitness is associated with lower risk Of T2DM (Wei et al., 1999). In a study of 380 healthy adults, aerobic capacity (VO_2) was the second strongest determinant of insulin sensitivity (response to glucose determining the body's ability to use insulin to control blood glucose) independent of body fat (Tonkonogi & Sahlin, 2002). Kessler et al's (2012) review of experimental evidence suggests that a minimum duration of 12 weeks of regular steady state or interval training is needed to improve fasting glucose in healthy and clinical populations.

2.1.3.3 The effect of PA on muscles in adults

The ability of skeletal muscles to extract and use oxygen from the blood is also increased with chronic exercise (Fletcher et al., 1996). Thus, a greater capacity for oxidative metabolism occurs as a result of increased muscle perfusion and the number of muscle mitochondria (Tonkonogi & Sahlin, 2002). Specifically, a three month low intensity exercise training program increased oxidation of muscle triglycerides (Schrauwen et al., 2002).

Acute exercise increases GLUT 4 translocation to sarcolemmal membrane and chronic exercise increases Glut 4 mRNS expression (Dohm, 2002). Therefore, exercise improves insulin sensitivity by increasing insulin sensitive glucose channels in skeletal muscle (Dohm, 2002). The skeletal muscle represents the largest mass of insulin sensitive tissue and so training reduces fasted blood glucose (Maiorana et al., 2002) reducing the risk of diabetic complications (Boule et al., 2001). This is because acute exercise causes increased insulin stimulated glucose uptake and use. Following prolonged training, increased glycogen synthase occurs, resulting in increased glycogen storage (Wojtaszewski, et al., 2000). In addition, an increase in mitochondria occurs as an adaptation to regular training, which increases the ability of the trained skeletal muscle to oxidise glucose and lipids (Hagberg et al., 1989; Hegarty et al., 2003; Pan et al., 1997).

For these reasons physical inactivity is described as a cause in the progression from normal glucose metabolism to T2DM (Albright et al., 2000; Blair et al., 1989; Dabelea et al., 1999; Helmrich et al., 1991; Redberg et al., 2002). Engaging in regular PA reduces the risk of T2DM from 6 to 33%, (Helmrich et al., 1991; Manson et al., 1991) and can hold back the progression from 1 stage pre diabetes of T2DM to another (Lamonte et al., 2005).. In those who have T2DM, regular exervise can reverse the process (Lamonte et al., 2005). To summarise, aerobic training reduce the risk of cardiovascular and metabolic disease in adults (Berlin & Colditz, 1990; Paffenbarger, 1993, 1996; Powell et al., 1987; WHO, 2010).

2.1.3.4 The effects of PA on metabolic risk factors in Children

The relationship between PA and metabolic health in children and the long term effects this has on adult health are not well known. This is because in children, metabolic disease is only manifesting and is not a clinical condition (Wedderkopp et al., 2003). Despite this, a number of longitudinal studies (Amsterdam Growth and Health, Youth Finns Study, Leuven Longitudinal Study, Danish Youth and Sports Study, Northern Ireland Young Hearts Study, European Youth Heart Study (EYHS)) in children have tried to examine PA and cardio-metabolic health and its development from childhood. The EYHS was designed to overcome problems in defining metabolic syndrome in children and to gain statistical power by pooling the data from Denmark, Norway, Portugal, Estonia, Iceland and Spain, collected every 6 years. EYHS report that PA was inversely associated with features of metabolic syndrome (Brage et al., 2004; Ekelund et al., 2006; Rizzo et al., 2007). EYHS developed a continuous composite score and found that children in the highest tertile for muscle strength and cardiovascular fitness had the lowest CVD risk scores (-1.42SD). In this instance the score of -1.42 refers to a z-score derived from measures of a continuous composite CV score, which includes waist circumference, mean diastolic and systolic blood pressure, triglycerides, high density lipoproteins and fasting glucose (Grøntved et al., 2015). The EYHS are currently working on a non-invasive simple screening technique (i.e. without blood sampling) to determine a composite CVD risk score, to screen unhealthy children (Andersen and Froberg, 2013), which may provide a useful clinical tool. The evolving evidence from these long term studies may provide a clearer understanding of the development of metabolic disease in childhood to adulthood and it's determinants.

However, until this new information is generated, the evidence relies on the association of PA with individual risk factors or cut points for a composite score in individual studies. From cross sectional studies, the association between metabolic risk factors and PA in children are well described (Brage et al., 2004b; Ekelund et al., 2004; Malina, 1996). Physical inactivity has been associated with increased risk of metabolic syndrome (i.e. insulin resistance, low HDL cholesterol, cholesterol-to-total cholesterol ratio, and elevated serum concentrations (Andersen et al., 2006; Ekelund et al., 2004; Ekelund et al., 2005; Mota et al., 2010; Ribeiro et al., 2004).

The beneficial effects of PA in reducing the risk of metabolic disease in obese children is confirmed from review studies (Andersen et al., 2011; Gutin & Owen, 2011; Tompkins et al., 2011) and experimental studies (Bell et al., 2007; Ferguson et al., 1999; Lau et al., 2004; Meyer et al., 2006; Stergioulas et al., 1998). Low MVPA was associated with increased metabolic risk (Gutin & Owen, 2011) and the independent effects of PA on insulin resistance risk were confirmed (Tompkins et al., 2011). Andersen et al., (2011) concluded that a minimum of 40 minutes of moderate PA, engaged in five days a week can improve lipid, lipoprotein levels (HDL-C) and reduce triglyceride levels. The importance of the intensity of this activity has been shown. In a meta-analysis by Ekelund et al., (2012), greater objectively measured (accelerometer) time in MVPA was associated with better cardio-metabolic risk factors (waist circumference, systolic BP, fasting triglycerides, HDL cholesterol and insulin), independent of sex, age, wear time and time in sedentary behaviour. However, sedentary time was not associated with any cardio-metabolic outcomes. A review by Gutin & Owens (2011) evaluating intervention studies confirmed the dose for favourable changes in biomarkers as 150-180 minutes/week of MVPA. For improved aerobic capacity and thus improved systolic and diastolic blood pressure, the dose of PA is 30 minutes, 3 times a week (Andersen et al., 2011).

Some of the inconsistencies in the reported PA dose across the studies mentioned above may relate to issues in the assessment of PA and metabolic syndrome risk. Firstly, there are no specific well validated cut points in children to determine metabolic syndrome (Kassi et al., 2011), the continuous composite score currently proposed by Andersen and Froberg (2013) might be more appropriate. Secondly, the accurate assessment of PA in children is a research challenge in itself. However, it is apparent that biomarkers of risk for adverse cardiovascular outcomes are apparent in children and adolescents and that the prevalence is increased with severity of obesity (Sinha et al., 2002) and physical inactivity (Brage et al., 2004; Ekelund et al., 2006; Mota et al., 2010; Ribeiro et al., 2004). Therefore, it is clear that PA is able to manage and reduce these risks (Ferguson et al., 1999; Gutin & Owens, 2011; Lau et al., 2004; Meyer et al., 2006; Stergioulas et al., 1998).

Furthermore, a fat but fit concept is identified in adults (Lee, Blair & Jackson, 1999; Lee et al., 2005) with research showing this concept might apply in children also, because fitness can modify the influence that fatness has on metabolic disease (Eisenmann, 2007). Studies have shown that overweight children who have a high fitness level have healthier cardiovascular profiles than their low fit overweight and normal weight peers (Ortega, 2013). The mechanisms for these differences in children are still to be discovered but several potential mechanisms have been proposed. Firstly, a genetic contribution is argued since several genes have been identified with aerobic fitness (Wolfarth et al., 2005) and/or fatness (Rankinen et al., 2006). In Wisloff et al., (2005) research in rodents with high aerobic capacity and low aerobic capacity evidenced a difference in cardiovascular risk factors between the groups. The low aerobic capacity rodents had an increased risk and these differences were attributed to differences observed in several mitochondrial proteins. Furthermore, genetic differences in training adaptations between high and low aerobic capacity rodents was also found (Bye et al., 2008). In the sedentary state, minor differences in soleus muscle gene expression (i.e. Atp2bs) were found, but the rats with higher aerobic capacity adapted better to exercise training because more genes were upregulated. Specifically, the low aerobic capacity group had an accumulation of cardiovascular risk factors, high levels of a transcript with a strong homology to human leucyl-transfer RNA synthethase, which is a mutation that is associated with mitochondrial dysfunction (Bye et al., 2008). This suggests that individuals may have different responses to the same exercise training.

Current research has also considered the biological role of adipocytes, suggesting that they secrete proteins in addition to being a place of storage for triglyerides (Eisenmann, 2007; Zou, 2005). The proteins secreted by the adipocyte are called adipocytokines or adipokines which are associated with aspects of the pathogenesis in metabolic syndrome (Ahima, 2006). In children and adolescents abnormal inflammatory markers (e.g. adipokine levels) have been shown in those who are obese (Eisenmann, 2007). Despite a paucity in research, the few experimental studies which have aimed to increase fitness and reduce body fat, evidenced reduced inflammatory markers in obese children (Nemet et al., 2013) and non obese children (Carrel et al., 2009). Further research is needed to confirm the mechanism underlying the fat but fit concept in children and the role of inflammatory markers.

2.1.3.5 The effects of physical activity and ethnicity on cardiovascular and metabolic disease in adults and children

The influence of ethnicity on metabolic disease and cardio-metabolic risk factors is also acknowledged. It is apparent that some non-European ethnic groups have increased prevalence of cardiovascular and metabolic disease than European groups (Tillin & Forouhi, 2012). Studies that have compared adults from African Caribbean backgrounds with White European have found that African Caribbean's have a higher risk of hypertension and T2DM (Cruickshank et al., 1991; Chaturvedi et al., 2003; Lane et al., 2002). Studies considering British SA's have concluded that they experience an increased risk of T2DM which is associated with increased cardiovascular mortality rates when compared to White Europeans (Balarajan, 1996; Bhopal et al., 1999; McKeigue, Shah & Marmot, 1991; Williams et al., 2011).

Studies have also begun to show evidence of early development of these diseases in children, which is strongly related to ethnicity and obesity (Berenson et al., 1998; Ehtisham et al., 2000; Whincup et al., 2002; Whincup et al., 2007). Ethnicity and obesity is previously discussed in Section 2.1.2.3. Ethnic differences in metabolic risk factors between non-Hispanic Black, Mexican American, and non-Hispanic White children have been reported (Casazza et al., 2009; Walker et al., 2012; Messiah et al., 2013). Non-Hispanic Black children have lower metabolic syndrome score compared to Mexican American and non-Hispanic White children in the National Health and Nutrition Examination Study (NHANES) outputs (Messiah et al., 2013; Walker et al; 2012). Higher levels of fasting insulin have been found in SA and Black children when compared to White EU children (Whincup et al., 2010). In prepubertal SA children especially, studies have evidenced metabolic profile differences. Bavekar et al., (1999) found that at 8 years, SA children who had a low birth weight had higher body fat (measured by skinfold thickness) and showed abnormalities in systolic blood pressure, fasting plasma insulin, total and LDL cholesterol concentrations than SA children with higher birth weights. Whincup et al. (2002) found that in 8-11 year old children from ethnic minorities, mainly Pakistani, had higher mean insulin, triglyceride and fibrinogen concentrations than age-matched White EU children (Whincup et al., 2002). Ehtisthan et al., (2004) concluded that children from SA origin living in the West Midlands were 13 times more likely to have T2DM than White EU children (Ehtisthan et al., 2004). Nightingale et al., (2013) reports that increased fatness is associated with increased insulin resistance and HbA1c and that a stronger association is seen in SA children (9-10 years) than White EU or Black. This suggests that SA children have abnormal metabolic profiles at young ages in comparison to White children. This has important implications on adult health as a number of studies (longitudinal and review) have reported that cardio metabolic risk factors track from childhood to adulthood (Camhi & Katzmarzyk, 2011; Chen et al., 2005; Nguyen et al., 2008; Raitakari et al., 2003; Bao et al., 1994).

2.1.4 Total dose of physical activity and health

The previous sections have outlined the impact of PA on various components of health. It is also important to understand the dose response relationship between PA and these health related variables in order to contextualise how much PA is needed for optimal benefit.

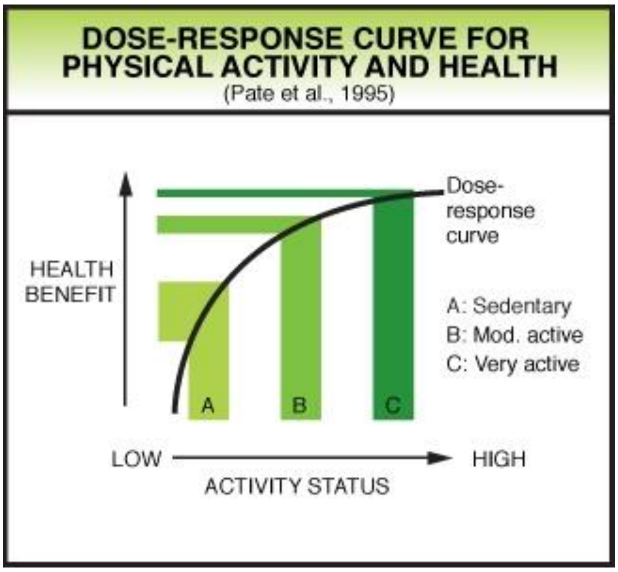


Figure 2.1 *the dose-response relationship between PA and health.*

Adapted from Pate et al., (1995). PA and public health: A recommendation from the Centre of Disease Control and Prevention and the American College of Sports Medicine. Journal of the American Medical Association, 273, 402-8

In adults, a graded dose response relationship between PA and health is evident (Chirula & Fitzhugh, 2011; Metcalf, 2008; Paffenbarger et al., 1986; Pate, 1995). All-cause mortality is associated with lower levels of activity because PA is associated with most health parameters in a graded fashion, but this relationship is linear or curvilinear depending on the health outcome (Haskell et al., 2007; Paffenbarger et al., 1986, Pate, 1995). It is apparent that those who are the least active, when they become more active, receive the most benefit (Pate, 1995). The volume, intensity and domain of PA are thus important. People who engage in the greatest volume of PA are less likely to have metabolic syndrome compared to sedentary, according to Chirula and Fitzhugh (2011).

However, it is apparent that high activity is not necessary to improve most dimensions of health. Studies have found significant reduction in heart disease with moderate exercise (Figure 2.1) like gardening (Leon et al., 1987), walking and stair climbing (Paffenbarger et al., 1986). The greatest benefits in cardiovascular risk have been shown in people who are less fit and smaller benefits evident in the fittest people (Blair et al., 1989b). This could be because they have less scope to improve since they are at the peak of the curve for health improvements (Figure 2.1). There are also individual differences in training adaptability using exercise interventions (Timmons al, 2010). Timmons et al., (2010) found that PA increases during the intervention resulted in VO_2 benefits for some but that some individuals achieve less benefit from the same increases in PA. In sedentary people, a gain of 40-60% in maximal oxygen uptake is associated with engaging in more activity (Pate et al., 1995).

For children, the positive association between PA and health is also reported. Metcalf (2008) reports a positive relationship between time spent in MVPA and changes in metabolic scores. Greater time spent in MVPA (measured by accelerometry) was associated with better cardio-metabolic health (reduced WC, fasting triglycerides and diastolic blood pressure and increased HDL cholesterol) in children, independent of sedentary time (Chaput et al., 2013; Ekelund et al., 2012). Additionally, cardiovascular risk was lowest in children who spent more than 103 minutes in PA compared to less than 43 minutes (Nguyen et al., 2010). Maintaining PA also seems important for metabolic health in children. Metcalf (2008) found sustaining PA over a period of years was associated with improved metabolic health in pre-pubertal children. Thus, the evidence suggests that by being more active both children and adults can experience health benefits, but engaging in more activity, specifically if the individual is sedentary, can yield the most health benefits.

2.1.4.1 Duration of PA bouts

Several studies have found that health benefits can be achieved by accumulation from several relatively short bouts of activity (Hardman, 1999; Murphy et al., 2000). Another, large study in over 2700 children aged 6-19 years investigated the effects of continuous bouts of PA versus sporadic PA using accelerometry. The study concluded that the odds for increased cardiovascular risk factors were reduced in a dose response relationship to both sporadic (0.25 odds ratio, 95% CI, 0.10, 0.60) and bouts (>5 minutes (0.17 odds ratio, 95% CI, 0.09,0.34) or 10 minutes (0.19 odds ratio, 95% CI, 0.11, 0.34)) of MVPA (Holman et al., 2011). This suggests that cardiovascular benefits can be equally achieved from short or longer bouts of activity. This information is important in children because children’s activity patterns are highly transitory and are characterised by intermittent bursts of activity (lasting on average less than 10 seconds) (Baquet et al., 2007) rather than continuous activity of 30 minutes in duration.

2.1.4.2 Types of physical activity and health

There are a number of health benefits of PA as described in Section 2.1 to 2.14 (Lubans et al., 2011). Specifically, the wealth of current evidence has focused on the activity type and the effects this has on cardio-metabolic risk factors. A European review of aerobic training programmes, found that 9 of the 12 randomised control trials showed improvements in at least one cardio-metabolic marker in overweight children (Blohm et al., 2012). The evidence also suggests that the intensity of this PA for cardiovascular and metabolic health is important. Sedentary time, independent of any other measure of activity, is not associated with any cardio-metabolic outcome (Ekelund et al., 2012). In another study, where the breaks in sedentary time were considered, shorter sedentary bouts (1 – 4 minutes) reduced cardio-metabolic scores. For boys, increased time on computers or video gaming was positively associated with cardio-metabolic risk, TV viewing was positively associated with cardio-metabolic risk for girls (Saunders et al., 2013). Time spent in MVPA is associated with all cardio-metabolic outcomes independent of sedentary time (Ekelund et al., 2012, Janssen and Leblanc, 2010, Chaput et al., 2013). In another study, where MVPA was divided into moderate and vigorous, the findings suggest that it was vigorous activity that was associated with lower WC, BMI z-scores, systolic BP and increased cardiorespiratory fitness (Hay et al., 2012). A dose-response relationship between vigorous activity and cardio-metabolic health outcomes two years later from a longitudinal study were found (Carson et al., 2014). The evidence relating to the effects of resistance training on cardio-metabolic risk factors in children is less known. However, it is apparent that aerobic exercise of moderate but particularly vigorous intensity is important for cardio-metabolic health in children.

2.1.5 Physical activity guidelines for children

With the development in the assessment of PA and consequently the wealth of evolving evidence, the PA guidelines for children have become more specific. In 2008, the first evidence-based comprehensive guidelines for American children were published (Wargo et al., 2008). Following this, in 2010 the WHO published international PA guidelines. It is also acknowledged that a dose-response relationship exists in which engaging in additional PA will provide additional health benefits (Janssen and LeBlanc, 2010). The guidelines (Wargo et al., 2008; WHO, 2010) suggest that activity should be aerobic in nature because aerobic activity stresses the cardiovascular and respiratory system which results in greater health benefits than non-aerobic activity (Janssen & LeBlanc, 2010). However, the inclusion of bone and muscle strengthening activities is also highlighted (Boreham & Riddoch, 2001; Janssen & LeBlanc, 2010; WHO 2010).

The publication of these updated international guidelines based on experimental research and the differences that existed in UK guidelines, called for a collaborative approach in updating UK guidelines. The revisions focused on the inclusion of vigorous activity and sedentary advice for young children (under 5 years). Start Active, Stay Healthy: a report on PA for Health from Four Home Countries Report (CMO, 2011) describes PA of moderate intensity when an adult or child breathes harder, heart rate increases but that they can talk while doing the activity. Vigorous PA is described as breathing much harder, heart beating rapidly and conversation difficult. Muscle and bone strengthening activities are described as those which use body weight or work against a resistance. Reducing sedentary time advice focuses on limiting time spent watching TV, playing computer or video games and breaking up sedentary time such as breaking up a car journey with a a walk. The current UK guidelines (CMO, 2011, pp. 7) for children are as follows:

Children and young people (5 - 18 years)

1. All children and young people should engage in moderate (e.g. bike riding) to vigorous intensity (e.g. chasing games and skipping, running and sports) PA for at least 60 minutes and up to several hours every day.

2. Vigorous intensity activities, including those that strengthen muscle and bone, should be incorporated at least three days a week such as hopscotch, skipping, and gymnastics

3. All children and young people should minimise the amount of time spent being sedentary (e.g. sitting) for extended periods.

Young children (up to 5 years for children who are not able to walk)

1. PA should be encouraged from birth through floor-based play and water based activities in safe environments

2. All under 5 years should minimise the amount of time spent being sedentary (e.g. being restrained or sitting) for long periods, except during sleep time.

Young children (up to 5 years for children who are able to walk)

1. Children of pre-school age who are capable of walking unaided should be physically active for 180 minutes throughout the day.

2. All under 5 years should minimise the amount of time spent being sedentary.

The guidance on how this can be achieved relates to unstructured play but can include structured activities that are light or energetic activities using large muscle groups such as bike riding, climbing, running, chasing games, walking, skipping, and park play. Advice on reducing sedentary time related to reduced time spent watching TV, computer games and spent sitting in car seats or a pushchair, by breaking these periods up.

2.1.6 Contribution of physical activity domains to overall PA

Children's PA patterns are mainly made up of school, travel, sport, leisure and play. The contribution of each of these sub-domains of activity varies depending on the individual (i.e. age, sex, and ethnicity) and their environment (e.g. SES, school, physical and social environment). However, few studies have considered the quantity of these sub-domains on daily MVPA (see Table 2.1). The wealth of literature evolves from the USA and focuses on the role of active transport on PA in children >11 years, as can be seen in Table 2.1. In previous studies, active travel has contributed 21% to total MVPA time (approx. 18 minutes, Table 2.1). From objectively measured PA and Global Positioning System (GPS) devices in the UK, journeys to and from school made up a great proportion of daily MVPA (between 25- 41% for boys and girls) (Southward et al., 2012, van Sluijs et al., 2009). PA accumulated at School made the biggest contribution to MVPA time, providing 38% of total MVPA, most of this came from PE (24%) followed by recess (21%) (Table 2.1). The contribution of afterschool clubs on total PA has not been assessed in previous literature. Clearly identifying the important contribution that school PA and active journeys to school makes on overall daily MVPA internationally and weekday MVPA and in the UK is of importance (Telford et al., 2013).

Much less work that has focused on the contributions to PA outside of school. In the studies that have examined this, leisure time PA made the smallest contribution to total PA (Table 2.1). Klinker et al., (2014) considered the patterns of children throughout the day and reported that MVPA is not accumulated in playgrounds or when shopping, they highlighted how boys spend more time in MVPA at school and leisure with less than half of the girls not engaging in club or sports facilities. A UK stud found that children accumulated more MVPA during school break times and less MVPA in PE or outside of school (Sleap, 1996).

From experimental studies, (a summary can be found in Table 2.2) break time and PE interventions have been successful in increasing MVPA by a mean of 11.5% (break) and 37% (PE) (Table 2.2). In a review, the findings suggests that an intervention around the school break period can contribute between 17-60% of MVPA but that travel and after-school interventions had no effect on MVPA (Jago & Baranowski, 2004). This is likely to reflect the interaction between social and physical environments on PA patterns. The physical environment at school has been positively associated with MVPA (6-10 years), contributing to approx. 20 minutes more MVPA for children at schools with more facilities (Button, Trites & Janssen, 2013). In a school intervention, children are surrounded not only by a positive physical environment (e.g. PE lessons, playground) which is supportive of PA, but additionally a positive and supportive social environment (behaviours and perceptions of the teachers) for PA. However, outside the school environment, PA behaviour is influenced by a less controlled social environment and by parental perceptions and practices (see Figure 3.3). The physical environmental influences on PA are discussed in further detail in Section 3.1. For example, children who are allowed out in the neighbourhood to ride their bike had increased MVPA time (5 - 7 minutes) (Moore et al., 2013). In addition, some global studies have proposed a compensation theory, suggesting that increases in MVPA (10 minutes) on one day results in reductions in time spent in light PA (25 minutes) and MVPA (5 minutes less) the following day (Ridgers et al., 2014). The mechanisms for this compensatory effect, if it is true are still under explored but may in part relate to a biological basis. Findings from the Early Bird study suggest that PA is biologically and thus is centrally controlled (Wilkin et al., 2006). Wilkin et al. (2006) proposes that children have different set points of an activity set and so increasing PA in one component will cause children to reduce their PA in other components of the day because total PA is set. Similar findings have been shown in animal studies where mice who were forced to run, rested more (Lightfoot et al., 2004). Furthermore, heritability studies suggests genetic factors explain 47-78% of the variance in PA, 31% of the variance in sedentary behaviour, with the rest of the variance being explained by environmental factors (den Hoed et al., 2013; Joosen et al., 2005).

Collectively, the evidence suggests that school contributes a large proportion of PA to total PA and that school based interventions targeting components of the school day, can be an effective means for increasing PA.

However, none of these studies have examined the contribution of PA components to daily PA or explored mechanisms for increasing PA in SA children or those from low SES backgrounds. Given that children from low SES and ethnic backgrounds (SA) show the lowest PA engagement, this would be useful for increasing PA in targeted interventions.

Table 2.1 Contribution of subdomains of PA to overall MVPA time

Author /country	Population	MVPA	Travel	PE	School recess	School total	Leisure
Klinker et al., 2014	11-16 years	75.2% B	12.7% B	19.5% B	8.3% B	24.9% B	21.8% B
Denmark		54.9% G	12.3% G	14.4% G	6.0% G	18.8% G	11.7% G
Lee and Li, 2014	7-12 years		11.2% (11mins)				
US	Walkers vs non walkers						
Southward et al., 2012	11-12 years		33.7% (22mins) B				
UK			35.6% (31.3mins) G				
Faulkner et al., 2013	8-11 years		7.6mins				
US	Walkers vs non walkers		*1000-16000m distance				
Robinson et al., 2014				59% (14 mins)			
USA				of PE time			
Meyer et al., 2013	9.3 ± 2.1 years			32.8% of PE time			
Scandanavia				16.1% of day			

Chen, Kim & Gao, 2014 USA	11.75 years (B)				9.5% 1mins increase in PE MVPA = 2.4mins increase in daily MVPA			
Ridgers et al., 2013 USA	Overweight (OW) and obese (OB) normal (N)					16.9% (N) 16.3% (OW) to school MVPA		
Guinhouya et al., 2009							>70%	
Long et al., 2013	6-19 years						1min extra school time = 1.14mins to total MVPA	
Han et al., 2013 USA								Park 14% (within 0.5 miles) 4% (within 1miles)
Mean ± SD		**54.9% G**	**75.2% B**	**21 ± 12%** **18 ± 11mins**	**24 ± 20%** **8 ± 8 mins**	**10 ± 6%**	**38 ± 28%**	**13 ± 2%**

<u>Abbreviations: </u>B – boy**, G-** girl**, mins** – minutes, **MVPA** – moderate to vigorous PA**, N** – normal**, OB** – obese**, OW** – overweight**.**

Table 2.2 A summary of interventions increasing overall MVPA time

Author/country	Intervention	population	baseline	Post intervention	Change in MVPA%
Ridgers et al., 2007	Playground intervention	6-10 years	C. 33B, 27G	C.	
UK			I. 31B, 22G	I.	+5.95%
Verstraete et al., 2006	Game equipment during school	10-11 years	C. 44% M 11%V	C. 39%, 5% V	-5% M, -6%V
UK	playtime		I. 38% M, 10% V	I. 50% M, 11% V	+12% M, +1% v
Stratton & Mullan, 2005	Playground intervention: multi-colour	4-11 years	C. 40%	C. 33%	-7%
UK	markings		I. 37%	I. 50%	+13%
Erwin et al., 2013	Indoor dance video during break times				22%
Huberty et al., 2013	School break time (staff training (ST),	Primary school			ST & E= 14.1%
	recreational equipment (E),				ST= -13.5%
	combination (ST & E))				
			Mean change in MVPA as a result of school break time interventions		**11.5% ± 3.7%**

Fairclough, 2005 UK	PE intervention				27 - 47%
Bohn-Goldbaum et al., 2013	Playground improvements in recreational spaces	<13 years	C. 1.17 I. 2.86	C. 0.67 I. 1.98	-0.5 -0.88
Chen et al., 2005	PE days				1min increase = 2.04 minutes increased in daily MVPA
			Mean change in MVPA as a result of PE interventions		**0.58 ± 2.06 minutes** **37% ± 14%**
Jago & Baranowski, 2004 REVIEW	Review				
	School break periods				17-60% (3 studies)
	Travel				No change (1 study)
	After school				No change (2 studies)
	Summer camps				

Abbreviations: **B-** boy**, C** – control**, I** – intervention**, G** – girl**, M** – moderate**, MVPA** – moderate to vigorous PA**, V** – vigorous

2.1.7 Tracking of physical activity

High PA in childhood increases the likelihood of being active as an adult and thus enhances health (Blair & Meredith, 1994; Malina, 1996; Rowland, 1996). Specifically, research has shown moderate associations between adolescent and adult activity (Malina, 1996). Subjectively measured PA showed the probability of remaining active over six years was between 29-57% for highly active girls and between 41-54% for boys. This is still fairly high considering that childhood activity is symbolised by play and that there are many factors that influenc PA such as seasons, day to day behaviour, stages of the life course, changing school, moving job, new house and illness (Malina, 2001; Raitaikari, 1994). The evidence suggests that the probability of remaining sedentary is stronger than the probability of remaining active (Rataikari, 1994). Thus, adaptation of a sedentary lifestyle in young children seems to have a detrimental effect on latter activity patterns. Limited PA in childhood may predispose children to develop sedentary lifestyles in adulthood (Malina 1996; Telama et al., 1997). Thus, health promotion in children is important.

2.1.8 Prevalence of physical activity in children

There are several studies that have assessed whether children meet current PA recommendations (60 minutes of MVPA daily) but there are large inconsistencies in these results. A review examining 31 European studies objectively assessing PA in children, reports that 87% of European children are considered physically active (>2000 cpm) (Guinhouya et al., 2013). Table 2.3 Summarises UK studies assessing adherence to PA guidelines. The discrepancies in the measurement tool (subjective/objective measures), the criteria for determining the intensity (MVPA) of PA, as well as age and gender differences, makes it very difficult to draw conclusion.

A recent review of both subjectively and objectively measured PA suggests that approximately 30 - 40% of children are meeting PA guidelines (60 minutes MVPA daily) (Ekelund, Tomlinson and Armstrong, 2011). From Table 2.3, the mean percentage of children meeting the PA guidelines was 39% for self-report assessed PA (ranges from 28 - 60%) and 54% for objectively assessed PA (ranges from 3% - 99%, Table 2.3). Noticeably, a higher percent of boys meeting these guidelines across all studies (Table 2.3). Some of this variation seems dependent on age, gender differences, recall ability and the cut points used, which make it difficult to draw conclusions from study results (Ekelund, Tomlinson & Armstrong, 2011). The effects of age, gender and ethnicity on PA are explored in more detail in Section 2.1.8.1 to 2.18.4.

Specifically, for objectively measured PA, the majority of studies consider children between 8-10 years. Generally, the lower the cut point used to determine MVPA, the higher the adherence to the guidelines. On average 98% of all children aged 5 - 11 years achieved the lowest cut points (<2000cpm). For higher cut points, 50% achieved a <3000 cut point and 4% <4000 cut point (Table 2.3). This highlights the need for defined and well validated universal accelerometer and pedometer cut points that relate to the PA guidelines for children. In addition, it highlights the limited range of information known about PA adherence at specific ages and the need for data examining other age groups (younger than 8 years and older than 12 years). Table 2.3 also highlights the paucity of data which has assessed the adherence to PA guidelines in children from differing ethnic backgrounds in the UK.

Table 2.3 The proportion of children that meet PA guideline (60 minutes MVPA daily)

Author	Measuring Instrument/ cut-point MVPA	Age (years) or school grade	All children	Gender		Ethnicity		
				Boy	Girl	White	SA	Black
		SUBJECTIVE MEASURES						
HSE, 2008	Survey 60 minutes MVPA daily	2 - 15	28	32	24			
Craig, Mindell & Hirani, 2008	Survey 60 minutes MVPA daily	2 - 15		32	24			
Gregory & Lowe, 2000	Survey 60 minutes MVPA daily	7 - 10	60	70	49			
NI statistics and research agency, 2007	Survey 60 minutes MVPA daily	8 - 12		19	10			
Roberts et al., 2004	Survey 60 minutes MVPA daily	11 - 15	34					
Guthold et al., 2010	Survey 60 minutes MVPA daily	13 - 14	36	24	15			
Gregory & Lowe, 2000	Survey 60 minutes MVPA daily	15 - 18		40	31			

Li, Treuth & Wang, 2010	Survey 60 minutes MVPA daily	15 - 18	35				
	Mean ± SD		**39 ± 12**	**36 ± 18**	**26 ± 14**		
OBJECTIVE MEASURES							
Metcalf et al., 2008	Accelerometer >2500 (60 sec)	5 - 8	28	42	11		
Basterfield et al., 2008	Accelerometer >3200cpm (15 sec)	6 - 8	6				
Eyre et al., 2013b	HR and accelerometer 60minutes MVPA (MET >3) daily	8 - 9		77	44	73	35
Fisher et al., 2011	Accelerometer >4000cpm (60 sec)	8 - 10	1				
Trayers et al., 2006	Accelerometer >1000 (60 sec)	8 - 12	100	100	100		
Cooper et al., 2003	Accelerometer >1000cpm (60 sec)	9 - 10	98	83			

Mclure et al., 2009	Accelerometer >1100cpm (60 Sec) >3200cpm	9 - 10	97 7	97 13	97 2			
Owen et al., 2009	Accelerometer >2000 (5 sec)	9 - 10	64	76	54	70	56	69
Steele et al., 2009	Accelerometer >2000 (5 sec)	9 - 10	69	82	59			
Van Suijs, 2008	Accelerometer >2000 (5 sec)	9 - 10	69	80	60			
Corder et al., 2010	Accelerometer >2000 (5 sec)	9 - 10	70					
Fairclough & Ridgers 2010	Accelerometer >2000 (5 sec)	10 - 11	45	63	30			
Riddoch, 2007	Accelerometer >3600 (60 sec)	11	3	5	0.4			
	All cut points Mean ± SD	**5 - 11**	**54 ± 39**	**65 ± 32**	**46 ± 36**	**72 ± 2**	**46 ± 15**	**69**
	<2000		**98 ± 49**	**93 ± 47**	**99 ± 26**			
	<3000		**50 ± 27**	**55 ± 32**	**36 ± 26**	**35 ± 49**	**56**	**69**
	<4000		**4 ± 2**	**9 ± 6**	**1 ± 1**			
	>3METS			**77**	**44**	**73**	**35**	

		Mixed ages of primary and adolescent children			
HSE, 2008	Accelerometer	2 - 15	27	33	21
Pate et al., 2002	Accelerometer	6 - 16	69	100	100
	>3 -5.9 METS	6 - 9	10	34	25
	>6-8.9 METS	15 - 17	26	42	11
Riddoch, 2004	Accelerometer	9	98	97	98
	>3600 (60 sec)	15	72	82	62
	Mean ± SD	**Mixed**	**50 ± 34**	**65 ± 32**	**53 ± 40**

Abbreviations; HSE – Health Survey for England**, METS** – metabolic equivalent, **MVPA** – moderate to vigorous PA, **NI** – National Institute, **Sec** – seconds**.**

2.1.8.1 Age differences in PA

There are few studies (Table 2.3), which consider adherence to PA guidelines (60 minutes MVPA) across childhood. The wealth of studies that have considered PA have focused on pre-pubertal children, especially around 9 - 10 years. They suggest between 50- 64% of children meet the guidelines. However, it is clear that age related differences in PA patterns exist with more pre-pubertal children meeting the guidelines than adolescents (Gregory & Lowe, 2000; Pate et al., 2002; Riddoch, 2004, Table 2.3). In studies where PA was measured but the adherence to PA guidelines was not considered, the differences in accelerometer counts were seen in elementary children (5 - 12 years) compared to middle and high school (12 – 18 years) (Pate et al., 1994; Trost et al., 2002). These findings are not limited to UK studies and can be seen in children in European and international studies (Edwards et al; 2013; Gortmaker et al., 2012). The decline in PA from childhood to adolescence, emerging between 11-12 and 14-15 years is confirmed in longitudinal studies in the UK, US and Europe (Brodersen et al., 2007; Kimm et al., 2002; Telama & Yang, 2000; van Mechelen et al., 2000). Particularly in the UK, low PA patterns and increased sedentary behaviour were evident in ethnic groups (White and Black) and low SES (Brodersen et al., 2007). Further research has shown that having high PA levels in young childhood tracks through childhood, resulting in increased PA, aerobic fitness and gross motor control at age 10 years than those who were sedentary or unfit (Souza et al., 2013). The findings thus highlight the importance of promoting high PA in children, to minimise the expected decline between 11 - 12 years of age (Souza et al., 2013).

2.1.8.1.1 Biological maturity and PA

During adolescence, children of the same chronological age undergo biological changes resulting in biological maturity (Malina & Bouchard, 2004). Girl's biological maturity occurs approximately 2 year's (chronological age) prior to boys (Armstrong, 2007). The rate of decline in participation in PA is greater in girls than boys (Cairney et al., 2014). Some research suggests these sex differences are diminished when biological age is adjusted for in free play activities but not organised sport (Cairney et al., 2014). These findings suggest that biological maturity may in part explain the sex-related differences but that other factors which affect organised sport need to be established.

The Avon Longitudinal Study showed that at 11 and 13 years, maturity in males was inversely associated with accelerometer counts and positively associated with sedentary time (Cumming et al., 2013). Guinhouya et al., (2013) reports a significant relationship between age at peak height velocity and MVPA in boys suggesting that pre-pubescent children who were on time according to age of peak height velocity, were the most active. However, this was different in females, where maturity at 11 years of age was inversely associated with accelerometer counts (Cumming et al., 2013). This is contrary to the subjective self-report data in girls which reports that early maturity was positively associated with PA (Fawkner et al., 2013). Dumith et al's (2012) study supports this notion in Brazilian adolescents aged 11-15 years, reporting that later maturation in boys and later menarche for girls was associated with positive PA change. The evidence thus suggests that later maturation in girls and average to later maturity in boys is associated with increased PA.

2.1.8.2 Gender differences in physical activity

Gender differences in PA have been consistently reported across studies with more boys than girls meeting PA guidelines when assessed subjectively (36% boys vs. 26% girls) and objectively (65% boys vs. girls 46%, Table 2.3). These gender differences were apparent for weekdays and weekends (Riddoch, 2007). For the most commonly reported accelerometer threshold (>2000cpm), a gender difference (19%) was observed with boys engaging in more activity than age matched girls (9 to 10years). These gender differences have been reported across all age groups including preschool (Brasholt et al., 2013), prepubescent (Eyre et al., 2013b; Fairclough & Ridgers, 2010; Pate et al., 2002) and adolescents (Pate et al., 2002; Riddoch, 2004).

When PA data have been transformed to consider the intensity using metabolic equivalents, studies have found that girls are more sedentary, spending less time in light and MVPA (Owens et al., 2009). Eyre et al., (2013b) supported these findings and expanded upon them, evidencing that girls were less active, spending less time in MVPA during wake hours for all days, weekdays and weekends. When within day differences were considered they found that girls were less active during school, break, lunch, PE and afterschool (Eyre et al., 2013b). Time engaged in sedentary activities was also less for girls on weekdays but both boys and girls engaged in similar amounts of sedentary activities on weekend days and light PA. Consequently, it was apparent that girls expended less energy on week and weekend days compared to boys (Eyre et al., 2013b). PA tracking data has also shown that young boys (3 years) who engage in high levels of PA maintained significantly higher PA at all ages measured up to 7 years. However, this pattern was not observed in girls (Edwards et al., 2013).

It is therefore apparent that girls are more sedentary and less active than boys. The mechanism for these differences is discussed in section 2.1.8 and might relate to biological maturation. Additionaly, there are numerous sociological factors that affect girl's participation in PA which are further discussed in 2.1.8.2.1.

2.1.8.2.1 Mechanisms for gender differences in PA

There are some biological differences between males and females that may result in differences in sport participation. Females have more body fat than men and this is distributed differently (i.e. gluteus, thigh and tricep region). Increasing body fat is negatively associated with PA (Section 2.1.2.1). Additionally, the pelvic region has a larger inlet and outlet to allow for childbirth. In males, muscle size and development is increased due to testosterone (Smith & Smith, 2002). Whereas in females, relaxin affects ligament and tendon laxity, so generally females are more supple than men (Smith & Smith, 2002). These biological differences might influence the sports that boys and girls engage in but this is difficult to determine because gender socialisation will also influence the type of sports that boys or girls engage in.

Gender socialisation in relation to sports participation relates to the ideologies about what is considered to 'be female' (femininity) and 'male' (masculinity). These ideologies can begin from a young age, whereby gender appropriate toys are purchased and children are supported or encouraged in playing with these gender appropriate toys. For example, girls may be nurtured into looking after babies and dressing up, while boys may be encouraged to play with cars and engage in 'rough and tumble' play. There is some suggestion that boys are enrolled in more clubs because parents feel they are more interested in sport, while girls were more interested in reading (Choi, 2000; Yiannakis & Melnick, 2001). Yet, Sport England suggests that 42% of boys and 31% of girls aged 14-

15 years play a sport once a week (Sport England, 2013). Despite larger numbers of boys engaging in sport compared to girls, it is apparent that girls do engage in sports also. Given that schools offer many opportunities to be involved in sports clubs as part of the extra curriculum, this figure is likely to be higher. However, it is acknowledged that generally participation is lower in girls than boys.

Secondly, when engaging in sports it is viewed that the female should be feminine (hegemonic feminity) and the male as a masculine athlete (hegemonic masculinity) (Choi, 2000). With this type of ideology, there are a number of related effects relating to the sporting types, media coverage and support for sport (Choi, 2000). If a female athlete does not appear feminine and engages in sports perceived as 'male sports' she is generally viewed as a 'tom boy, butch or a lesbian'. For a male, the engagement in sports that show strength, speed and endurance (e.g. boxing or rugby) are encouraged as masculine. However, generally sports such as dance, netball or aerobics are viewed as feminine (Choi, 2000).

The concept that sport is not designed for females originates from the history of sport. Traditionally, many sports (e.g. rugby, football) originated from boys public schools (Green, 2003) and thus were designed by men for men to play. Since then school based PE programmes have been grounded on sports skills and participation in competitive sports (Green, 2003). Therefore, it is perhaps not surprising that in the 1896 Olympics, only men participated. It was 32 years later (1928) that women were allowed to compete in track and field events, and even then there was controversy about long distance running events, suggesting that female bodies were not made for endurance events (Choi, 2000). In today's modern era, both males and females are allowed to compete in the same events at Olympics but still some variation exists. For example, males compete in the decathlon whereas females compete in heptathlon and floor gymnastics is competed with music for females and without music for males. Despite this increase in overall equality in sport, the reporting of female success and the opportunities are still less in females, thus reinforcing stereotypes that sport is made for men (Billings, 2011). For young aspiring and watching girls this can reinforce their ideologies that this is sport is not for females.

Adolescent girls report enjoying PE a lot (50%) (Barr-Anderson et al., 2008). However, the decline in participation in adolescence (Section 2.1.8.1) is well reported. It is seen that the feminine ideology is not concerned with sport but appearance. For males in their teenage years, it is viewed as a process of validating masculinity (Choi, 2000). There is some research that suggests social constructs and ideologies of gender are developed and reinforced in the PE curriculum, where stereotypical expectations of 'girls' and 'boys' are reinforced by the lesson content and organisation (e.g. netball for girls, football for boys) (Stidder & Hayes, 2012). Therefore, it is apparent that age and gender related differences may in part relate to biological and societal ideologies that are reinforced.

2.1.8.3 Ethnic differences in PA

The influence of ethnicity on objectively measured PA has been explored in a number of studies. A summary of these studies can be seen in Table 2.4. A systematic review conducted by Eyre and Duncan (2013a) reports ethnic differences in Black and SA children compared to White. In the review, the majority of studies were on Black compared to White children, conducted in the US. There were some inconsistencies across studies with some reporting no ethnic differences (Casazza et al., 2009; Newton et al., 2011; Kelly et al., 2010) and other suggesting that Black children were less active, spending less time in MVPA (Treuth et al., 2000; Pate et al., 2006) and recording fewer steps (Johnson et al., 2010). However, the majority of large, multi-centre studies suggested that Black children were more active, spending more time in MVPA (Owens et al., 2009; Belcher et al., 2010; Pfeiffer et al., 2009; Gortmaker et al., 2012). The evidence also suggests that despite Black children being more active, they are more sedentary than White children (Belcher et al., 2010; Owens et al., 2009) (Table 2.4).

There were a number of studies conducted in the USA, which objectively measured PA in children from Mexican American/ Hispanic backgrounds versus White. However, the review concluded that the findings were less consistent due to methodological limitations and failure to account for influencing factors (Eyre, & Duncan, 2013a, Table 2.4). Some studies found that there were no differences in total PA (total and time in MVPA) of all children (Casazza et al., 2009; Byrd- Williams et al., 2007; Gortmaker et al., 2012) and girls (Kelly et al., 2010; Treuth et al., 2000). In contrast, Mexican American children have been found to be less active (less steps and time in MVPA in some studies (Casazza et al., 2009a,b; Johnson et al., 2010) and more active (less sedentary, increased MVPA time) in other larger studies (Belcher et al., 2010; Pate et al., 2006; Matthews et al., 2007). There are many influences such as age, gender, obesity and socioeconomic status which these studies have failed to account for which may explain some of these inconsistencies. These populations (Mexican American and Hispanic) do not reside in the UK and thus are not the focus of this thesis, however there is a larger residing population of SA's in the UK.

Studies assessing PA in SA children have consistently reported lower PA for self-reported PA (Duncan et al., 2008; Erens, Primatesta & Prior, 2001; Fishbacher et al., 2004; Rogers, Adamson & McCarthy, 1997; Williams and Sham, 1998) and objectively measured PA (Eyre and Duncan, 2013a; Eyre et al., 2013b; Owens et al., 2009; Duncan et al., 2012) compared to White children. It was reported that Indian children participated in fewer sports (HSE, 1999) and were less likely to walk to and from school (Khunti et al., 2007). Objectively measured PA has confirmed that SA children are less likely to meet PA guidelines, record fewer steps, spend less time in MVPA and more time in sedentary activity (Duncan et al., 2008; Eyre et al., 2013b; Owens et al., 2009; Duncan et al., 2012, Table 2.4). Eyre et al., (2013b) considered within day differences which might explain these differences in PA. They found that SA children were less active, expend less energy and spent less time in MVPA on both week and weekend days. For weekdays, these differences were due to engaging in less PA afterschool. On weekends, SA's engaged in more sedentary activities. However, SA and White children engaged in similar amounts of time in light activity. No heterogeneity differences were reported between Indian, Pakistani and Bangladeshi (Owens et al., 2009).

The reasons for this difference in PA are not widely acknowledged. Some research in adults suggests cultural differences affect PA adherence (Rai & Finch, 1997). For instance, religious practice such as praying, limits the time available for PA (Rai & Finch, 1997). Additionally, an inappropriate dress code to suit their culture or religion and mix sex facilities, family presences were more important than personal perceptions and the perception that education was more important and PA wasn't important (Rai & Finch, 1997). Despite some cultural mechanisms to PA, it is acknowledged that people from ethnic minority groups are more likely to reside in deprived environments (McGarrigle & Kearns, 2009), which may also influence PA and is discussed further in Section 3.1

Table 2.4: A summary of studies showing the association of ethnicity on objectively assessed PA.

	Black				**Mexican American/ Hispanic**				**SA**			
	Total PA	**Sedentary**	**Light**	**MVPA**	**Total PA**	**Sedentary**	**Light**	**MVPA**	**Total PA**	**Sedentary**	**Light**	**MVPA**
>White	Newton et al., 2011 Belcher et al., 2010 Gortmaker et al ., 2011 Owen et al., 2009	Belcher et al., 2010 Owen et a 2009	Belcher et al., 2010 Owen et al 2009	Newton et al., 2011 Belcher et al., 2010 Gortmaker et al., 2011 Owen et al., 2009 Pfeiffer et al., 2009	Belcher et al., 2010	Belcher et al., 2010				Eyre et al., 2013b Owen et al 2009		
Total	**4**	**2**	**2**	**5**	**1**	**1**	**0**	**0**	**0**	**2**	**0**	**0**
No difference	Casazza et al., 2009a Casazza et al., 2009b	Newton et al., 2011 Pate et al., 2008 Casazza et al., 2009b		Pate et al., 2008 Casazza et al., 2009a Kelly et al., 2010	Byrd-Williams et al., 2007 Casazza et al., 2009a Casazza et al., 2009b Treuth et al., 2000	Byrd-Williams et al., 2007 Casazza et al., 2009b	Byrd-Williams et al., 2007	Belcher et al., 2010 Gortmaker et al., 2011 Kelly et al., 2010				
Total	**2**	**3**	**0**	**3**	**4**	**2**	**1**	**3**	**0**	**0**	**0**	**0**
< White	Treuth et al., 2000	Matthews et al., 2007		Pate et al., 2006	Johnson et al., 2010			Casazza et al., 2009a Casazza et al ., 2009b Pate et al., 2006	Duncan et al., 2012 Eyre et al., 2013b Duncan et al., 2008 Owen et al., 2009			Duncan et al., 2012 Eyre et al., 2013b Owen et al., 2009
Total	**1**	**1**	**0**	**1**	**1**	**0**	**0**	**3**	**4**	**0**	**0**	**3**

Abbreviations: **MVPA-** Moderate to vigorous PA**, PA -** Physical Activity. Blue highlights where differences are shown.

Adapted and updated from Eyre and Duncan 2013a; The impact of ethnicity on objectively measured PA in children. ISRN obesity.

2.1.8.4 SES differences in PA

The influence of SES on body fat is reported in international studies (Bohr et al., 2013; Hardy et al., 2013). The strong and consistent relationship between low SES in early life and high body fat adulthood is confirmed in a systematic review (Parson et al., 1999). The role of SES on PA is less well established, with some research suggesting higher PA in low SES children and others reporting low PA. Interestingly, no research shows any association between SES and PA (Table 2.5). The conflicting findings might relate to the role of the interaction between the surrounding physical and social environment, which is affected by PA and SES but need further exploration. Furthermore, the evolving evidence is from international studies so its application to UK studies may differ. The determinants underlying SES from an environmental perspective are explored further in Section 3.1.

Table 2.5 A summary of findings from studies assessing the association of SES on PA.

Nature of association between PA & SES	All children	Boys	Girls
Increased PA in low SES	**LIGHT** Baquet et al., (2014) **MVPA** **VIGOROUS** Baquet et al., (2014)		
No difference			
Reduced PA in low SES	**Total PA** Carlson et al., 2014 Hardy et al., 2013	**MVPA** Baquet et al., (2014)	

Abbreviations: MVPA – moderate to vigorous PA**, PA –** physical activity**, SES –** socio-economic status.

2.1.9 Summary statement

It is apparent that not all children meet the current recommendations for PA and that this may be even fewer when chronological age, biological maturity, gender, culture and ethnicity is considered. Despite the wealth of information on children's PA, some of the limitations in previous research have yielded the conclusions that can made due to methodological issues. Section 2.2 will discuss the measurement of PA in children in more depth. Secondly. it is not clear what determines PA behaviour and it is not possible to construct effective intervention strategies without understanding these influences. Section 3.0 will explore environmental determinants of PA in children in detail.

2.2 The measurement of physical activity in children

Having accurate information about childrens' PA is paramount to understanding the relationship between PA, sedentary behaviour and health (Reilly, 2008). The complexity in measuring PA with accuracy in children is a research challenge because PA is a multidimensional behaviour with varying domains (e.g. type and intensity such as sedentary, light, moderate or vigorous) (Wareham & Rennie, 1998). For adults, PA takes place in many different forms including active transport, domestic tasks, recreational activity, sport or exercise (Wareham et al., 2005). However, the context of PA is different for childhood age groups. For young children especially, PA includes predominantly intermittent, spontaneous bouts of play activities (Riddoch, 2004) as well as games, sports, transport, recreation, PE or planned exercises. The sporadic and varying domains of children's PA, make it extremely complex to measure.

There are currently a wide variety of measures that can assess PA in children. These include subjective measures (e.g. self-report diaries, questionnaires) and objective measures (e.g. monitoring, physiological markers (e.g. heart rate) and exercise testing) (Haskell & Kiernan, 2000). To appropriately assess the effects of PA, reliable and accurate measures are needed to make comparisons with health outcomes. The development of such measures is still a research priority (Baranowski et al., 1992; Reilly, 2008) in order to precisely document frequency, quantity and intensity and to evaluate interventions against health markers. A summary of the benefits and limitations of current measures available are provided in Table 2.6

Table 2.6 The measurement of physical activity: benefits and limitations in measurement types

PA MEASUREMENT	BENEFITS	LIMITATIONS
SUBJECTIVE		
Questionnaires **Diaries** **Logs**	▪ Practical in large field studies ▪ Low cost	▪ Recall bias ▪ Validity, reliability & accuracy ▪ Subject intensive/inconvenience
OBJECTIVE: SINGLE MEASURES		
Heart rate monitoring	▪ Measure time spent in intensity ▪ Low respondent burden	▪ Indirect estimate of physiogical response to physical activity ▪ Missclaffication at low and heart rate due to other influencing factors
Pedometers	▪ Measures volume ▪ Cost effective for field settings ▪ Don't interfer with everday physical activity	▪ Accuracy and validity at low and fast walking speeds. ▪ Provides no information about frequency, intensity and duration ▪ No specific valid cut points in younger children
Accelerometers	▪ Provide information on duration, time and intensity ▪ Avoid bias and low respondent burden	▪ No univsersal acceptanve on Accelerometer points applied to the data ▪ Data labour intensive
OBJECTIVE: COMBINED MEASURES		
Combined heart rate and accelerometer	▪ Greater accuracy in capturing all activities and determining energy cost of activity ▪ Small/portable now for field settings ▪ Reusaeble	▪ Data labour intensive ▪ Cost
Combined heart rate and global positioning system	▪ Greater accuracy in providing a location with physical activity ▪ Ability to estimate speed, time in activity. ▪ Small, portable and reusable	▪ Data is labour intensive ▪ Short battery life (10 hours)

OBJECTIVE: LAB MEASURE		
Doubly labelled water	▪ Gold standard ▪ Accurate assessment of energy expenditure	▪ Only provides measure of total energy expenditure not activity patterns ▪ Expensive
Indirect calorimetry	▪ Accurate assessment of energy expenditure	▪ Only provides measure of total energy expenditure not activity patterns ▪ Expensive and requires 24 hour in closed chamber = unsuitable for children

2.2.1 Subjective measures

Self-reported questionnaires can be used to capture children's PA patterns; these require children or their parents to recall activity, ranging from one day up to one week). They are pratical for assessing activity in large populations (Caspersen, Powell & Christenson, 1985; LaPorte et al., 1985). A systematic review has confirmed the high construct validity of PA questionnaires completed by parents and teachers for children aged six to 11 years (Chinapow et al., 2010).

Diaries provide a detailed account of all PA that was performed. Diaries are most commonly used for 1-3 days, a time frame which questions whether this is indicative of long-term PA (LaPorte et al., 1985). Diaries require intensive effort from the subjects and may result in a change of PA behaviour while being monitored (Caspersen, 1989; LaPorte, Montoye & Caspersen, 1985). They are able to produce a wide array of data which can be time consuming in data processing stages.

Finally, PA logs provide an ongoing record of whether the subjects have participated in certain types of PA. Activity is reported at time of onset and end, or recalled and recorded at the end of the day. Logs are different from diaries because behaviour during the day is generally not recorded. Logs can be time consuming and inconvenient for subjects to complete accurately, they also influence the subject's behaviour but can be useful for recording specific activities (Haskell & Kiernan, 2000).

Subjective measures are useful in large populations because they are cheap in comparison to other methods. However, self-report measures are particularly imprecise and challenging with children who may lack cognitive ability to accurately recall details of activity pattern and report them without bias (Baranowksi et al., 1984; Pate et al., 1994; Sallis, 1991, Table 2.6). A study suggested that children younger than nine years of age are unable to recall PA information reliably (Sallis et al., 1996). Additionally, people overestimate their activity because of social desirability and recall bias (Pate, 1993; Sallis et al., 1991). Using parents and teachers to recall also produces limitations and errors in recall (Corder et al., 2008). Basterfield et al., (2008) also suggested that parents over report PA of their children by almost 100 minutes (self-report = 122 minutess per day vs. objective = 24 minutes per day). The study concluded that public health surveillance should not rely on this measure. Ekelund, Tomlinson and Armstrong (2011) conducted a review of self-report versus objectively measured PA and evidenced a low to moderate relationship. The study found that self-report measures overestimate the intensity and duration of PA. Other studies have reported the limited ability of self-report tools to assess intermittent PA (Baqet et al., 2007; Berman et al., 1998).

The majority of children's physical activity is characterised as play, which can also make self-reporting and the interpretation of these patterns difficult (Riddoch, 2004). In addition, these methods need to be considered carefully in ethnic groups because they are culturally dependent and the cultural adaptability may not be appropriate or valid between populations, groups and religions (Warren et al., 2010). For example, common terminology about PA may not mean the same concepts across cultures or be understood. For these reasons self-report measures are not appropriate in ethnic populations.

2.2.2 Objective estimate of physical activity

The objective measurement of PA includes direct observation and motion sensors (i.e. pedometers, heart rate monitors, accelerometer and GPS). The application of each of these techniques varies greatly but they are unlikely to produce biased information on PA in comparison to self-report measures. Objective monitoring provides practical, accurate and reliable measures to quantifying activity amount and intensity (Corder, Brage & Ekelund, 2007; Rowlands, 2007; Trost et al., 2007, Table 2.6). There are currently a large range of monitors which are able to objectively estimate PA in field settings. These include pedometers, accelerometers and combined monitors which use heart rate and accelerometers.

2.2.2.1 Pedometers

Pedometers assess steps by sensing the impact the foot makes with the ground when a step is taken, providing a measure of the total volume of activity (Sirard & Pate, 2001). Rowland et al. (1997) review, suggests that pedometers are accurate at mid-range speeds but that the accuracy is compromised at slow or very fast walking speeds. Yet, it is argued that speed related pedometer issues are not a problem in children because their self-selected pace (i.e. 2 miles per hour) is faster than slower speeds applied on treadmills (Beets et al., 2005; Duncan et al., 2007; Mitre et al 2009). Convergent validity between pedometers with accelerometers and other measures of PA is also reported in a review of 25 articles (Tudor Locke et al., 2002). The review also evidenced a moderate correlation with measures of energy expenditure and highest agreement with walking or running (r =

0.86). However, algorithms for EE are derived in adults and are not appropriate for children (Trost, 2001).

Different mechanisms are used within pedometers to assess this movement. In a suspended lever arm pedometer, a pendulum or swing arm system is used, which makes contact with a post when vertical acceleration occurs (i.e. a step is taken) (Crouter et al., 2005; Montoye, 1996; Schneider et al., 2004). In a piezoelectric pedometer, a horizontal beam with a weight on the end which compresses piezo-electric crystals with acceleration (Nakae et al., 2008; Schneider et al., 2004). Currently, Yamax (spring levered) pedometers are most commonly used for measuring children's PA (Clemes & Biddle, 2013). Yet, piezo-electric (NL-2000) pedometers are more accurate (Beets et al., 2005; Crouter et al., 2005; Nakae et al., 2008) in children's self-paced walking than Yamax (Nakae et al., 2008). The NL-2000 is the most accurate in peizo-electric pedometer and is accurate at slow moderate and fast paces (Duncan et al., 2007). Age, BMI, WC and body composition does not compromise pedometer accuracy (Nakae et al., 2008).

The reporting of the data is most common as a volume of activity such as mean steps per day. Some researchers have used cut points and determine how many children meet PA guidelines. A summary of these cut points can be found in Table 2.7. For children, the cut-points range from 11-12,000 for girls and 10,000-15,000 for boys, depending on the study and age of the children (Table 2.7). Thus, it is apparent that there is no single steps/day cut points that spans across all ages of children and adolescents and are based on dose response relationship with steps counts and various health parameters (Tudor-Locke et al., 2011) but that for children 6-12 years 13,000- 15,000 (boys) and 11-12,000 (girls) are most commonly reported (Table 2.7). Despite this, additional work is still needed to establish the appropriate age specific step counts a minute for younger children, that correspond to MVPA (Tudor-Locke et al., 2011). Therefore, the ability of pedometers to accurately capture PA patterns in younger children that relate to public health guidelines is still questioned. For these reasons, the raw data obtained should still be reported in studies and caution needs to be applied when interpreting findings in terms of the proportion that achieve a particular step count (Clemes & Biddle, 2013).

Table 2.7 Pedometer cut points for children

Author	Age (years)	Pedometer cut points	
		Boy	**Girl**
Vincent &Pangrazi, 2002	6-12 years	13,000	11,000
Tudor-Locke et al., 2004	6–12 years	15,000	12,000
Tudor-locke et al., 2011	Primary	13,000- 15,000	11,000-12,000
	Adolescents	10,000-11,700	10,000-11,700
Colley et al., 2011	6-19 years		12,000

A review by Clemes and Biddle (2013) highlighted some additional concerns for the accuracy of pedometer data. Firstly, because no single criterion for wear time protocol is available. Furthermore, they reported that it was common practice among research for the participant to record (diary or logs) non-wear time and establishing a wear time protocol is needed. On days when the pedometer was removed for more than 1 hour, the data was treated as missing data (McNamara et al., 2010; Duncan et al., 2006, 2007, 2008; Schofield et al., 2009; Johnson et al., 2010). Upper and lower cut-off limits have also been applied to identify outliers. Rowe et al (2004) suggest that data less than 1000 and greater than 30,000steps/day should be treated as missing data. It is important that wear time, data treatment techniques and hours of monitoring is reported in study methodology in order to make study comparisons to improve the wealth of data on children's PA patterns (Clemes & Biddle, 2013).

An additional concern regarding reactivity was also raised by Clemes and Biddle's (2013) review was participant reactivity. Unsealed pedometers provide no restriction on viewing steps and as a result participant react to knowing this information. It is suggested that if steps are higher on the first few monitoring days relative towards the end of monitoring, then reactivity has occurred. Yet, having sealed monitors can minimise these effects but Clemes and Biddle (2013) argue that only when a child is unaware that they are being monitored can a true investigation into its effects be conducted. Ling et al's (2011) research supported these claims, showing that steps were higher in the first week compared to the third week when sealed pedometers were worn over 3 weeks. Additionally, studies which have assessed for the effect of reactivity, reported no effects (Rowe et al., 2004, Craig et al., 2010: Ozdoba et al., 2004). In the context of interventions which promote PA change, being able to view steps acts as an open loop feedback tool, increasing PA (Lubans et al., 2011).

Pedometers offer a cost effective, useful and valid tool for collecting information on the volume of activity from large samples without interfering with every day activities (Clemes & Biddle, 2013; Kilanowski et al., 1999; Rowlands et al., 1997; Nakae et al., 2008). They are reusable, objective and require minimal research burden (Sirard & Pate, 2001) with a high compliance rate between 46 - 99% (Clemes & Biddle, 2013). However, they do not provide a record of the frequency, duration or intensity of PA (Trost, 2001). They only provide the number of steps for the time measured and thus this cannot be broken down day to day. These problems might make it more difficult to explain the full diversity of PA that children engage in (Owen et al., 2009). In particular, they are insensitive to non locomotor forms of movement (Rowe et al., 2004; Trost, 2001). There is also a risk of data integrity in which participants can tamper with the data i.e. shaking it, hitting the reset button and losing data (Graser et al., 2007). Despite these issues, it provides a cumulative record over a day, which is suitable to track PA in children, specifically in interventions. McClain and Tudor Locke (2009) suggests that public health targets are the accumulation throughout a day, thus pedometers provide the cumulative record.

2.2.2.2 Accelerometers

Accelerometers are based on the principle that motion results in acceleration of the trunk or limbs and that motion combined with acceleration is associated with increased energy expenditure (Welk, 2002). Accelerometers measure acceleration in one or more planes of motion as counts during specified time domains (15, 30, 45 or 60 seconds). These counts can be transformed to metabolic equivalents using accelerometer cut points in order to provide a biological understanding of PA (Welk, 2002). Activity patterns are most commonly stored in a memory system which is then downloaded for analysis. There are many varieties of accelerometers available but MTI actigraph (MTI Florida) appears to be the most widely used (Reilly et al., 2008). Reilly et al's (2008) review of objective measures of PA suggests that accelerometry increase the accuracy in quantifying PA duration and intensity in children, which enables researchers to understand the association with health.

Accelerometers are reusable and objective (Sirard & Pate, 2001). They extend beyond pedometers by making it possible to determine when and for how long the activity took place. Accelerometer counts can be converted using accelerometer cut points to determine time spent in moderate or vigorous PA (MVPA). This provides greater biological and clinical meaning to public health targets (DOH, 2004; Reilly et al., 2008; Strong et al. 2005). An accelerometer cut point is a unit of counts per minute that enables the researcher to explore the intensity of the activity. For instance Trost et al., (2002) validation study using a treadmill suggests that an activity count above 1638 counts/min in eight year old children is representative of moderate PA. Trost et al., (2002) appears to be the only study considering age differences with reference to the energy cost of activities/intensity in children. Yet, a major limitation is that they may misclassify activity because different accelerometer cut points are used and there appears to be no universal criterion (Ekelund, Tomlinson & Armstrong, 2011; Reilly et al., 2008).

A systematic review of objective assessment of PA, re-analysed all PA data in children using the three most popular accelerometer cut points (Reilly et al., 2008). They found significant differences in the amount of sedentary behaviour and MVPA when different accelerometer cut points were used; suggesting that the assessment of MVPA is dependent on the accelerometer cut points applied to the data (Reilly et al., 2008). Trost et al., (2011) compared accelerometer cut points for their ability to predict activity intensity in youth. A summary of the cut points used in the study are displayed in Figure 2.2. The authors concluded across intensity levels (sedentary, light, moderate and vigorous) that only Evenson et al's (2008) cut points provide acceptable classification across all levels of activity and intensity in children of all ages. Therefore, the authors recommended these cut points should be used. However, it is apparent that global criterion measures are needed for consistency between studies.

In addition, accelerometers are positioned at the hip and thus they lack the ability to capture all activities equally. In particular activities that involve upper body movement like weight lifting and throwing can be underestimated and they lack the ability to assess cycling and locomotion on a gradient (Sirard & Pate, 2001, Table 2.6). Thus, the required energy of these activities is difficult to determine from accelerometers (Freedson & Miller, 2000; Welk, 2002).

Author	Sample	Activities	Equation/Cut Points
Freedson et al.	$n = 80$ Range = 6–18 yr Mean age = 11.3 yr 41 girls, 39 boys	Laboratory-based. TM walk and run. One common speed: 4.4 $km{\cdot}h^{-1}$ other two TM speeds varied by age (5.6–9.7 $km{\cdot}h^{-1}$)	METs = 2.757 + (0.0015 × counts per minute) − (0.08957 × age (yr)) − (0.000038 × counts per minute × age (yr)) Cut points age-dependent For a 12-yr-old: SED: ≤100 LPA: >100 MPA: ≥2220 VPA: ≥4136
Puyau et al.	$n = 26$ Range = 6–16 yr Mean age = 10.7 yr 12 girls, 14 boys	Walk, run, free-living activities such as computer games, playing with toys, aerobics, skipping, jump rope, soccer.	AEE = 0.0183 + 0.000010 (counts per minute) SED: <800 LPA: ≥800 MPA: ≥3200 VPA: ≥8200
Treuth et al.	$n = 74$ Range = 13–14 yr Girls only	Walk, run, free-living activities such as computer games, household chores, aerobics, shooting baskets.	METs = 2.01 + 0.00171 counts per 30 s SED: ≤100 LPA: >100 MPA: ≥3000 VPA: >5200
Mattocks et al.	$n = 163$ Mean age = 12.4 yr 90 girls, 73 boys	Lying, sitting, slow walk, brisk walk, jogging, hopscotch.	EE ($kJ{\cdot}kg^{-1}{\cdot}min^{-1}$) = −0.933 + 0.000098 (counts per minute) + 0.091 (age (yr)) − 0.04(sex) (M = 0, F = 1) SED: ≤100 LPA: >100 MPA: ≥3581 VPA: ≥6130
Evenson et al.	$n = 33$ Range = 5–8 yr Mean age = 7.3 yr 21 girls, 12 boys	Sit, watch TV, coloring books, slow walk, stair climb, basketball, brisk walk, jumping jacks, running.	ROC curve analysis (no equation) SED: ≤100 LPA: >100 MPA: ≥2296 VPA: ≥4012

Cut points are reported as counts per minute for comparison purposes and rounded where appropriate; TM, treadmill.

Figure 2.2 *Summary of accelerometer (Actigraph) cut points used in children adapted from Trost et al., (2011).*

2.2.2.3 Heart rate monitoring

Heart rate (HR) monitoring is described as the most convenient physiological parameter for assessing PA in field settings (Janz, 2002). Monitoring of HR provides a continuous recording of physiologic processes (stress placed on the cardiovascular system) that can be interpreted as proxy measure of activity reflecting both the duration and intensity of PA (Armstrong et al., 1990). There are a couple of considerations when using HR monitors, the first during low intensity exercise (sedentary and light activity) the relationship with HR is affected by factors other than bodily movement (Sirard & Pate, 2001) such as stress, caffeine and medication (Emons et al., 1992). HR also lags behind movement so it can remain elevated after movement has finished (Janz et al., 2002; Rowlands, 2007; Strath et al., 2000; Trost, 2000). HR monitors are worn at the chest measuring HR at a given interval.

Researchers have used the information gathered from HR monitoring in many ways including: percentage of time spent during daily activities at various HR zones (Armstrong et al., 1990; Gilbey & Gilbey, 1995; Gilliam et al., 1981; Janz et al., 1992; Sallo & Silla, 1997), time spent at a specific HR (i.e. 139 bpm) (Armstrong et al., 1990), the difference between mean daily HR and resting heart rate (Sallis et al., 1990). Most commonly a HR greater than 140bpm in children is representative of MVPA. This cut point (i.e. 140bpm) has been validated, applied in children and used within school settings (Collins et al., 2012; Fjortoft et al., 2010; Ridgers et a., 2007; Simons & Morton, 1988). Other studies have looked at HR reserve to estimate time spent in MVPA.

HR monitoring is useful, cost effective in large studies and requires minimal participant and experimenter burden (Sirard & Pate, 2001). A summary of the cut points for PA from HR monitoring is provided in Table 2.8. The cut points determined by Reilly et al., (2004) and Ridgers et al., (2007) do not account for any inter individual differences such as resting heart rate. However, Ridgers and Stratton (2005) account for individual differences in resting HR, and working out percentages of HR reserve.

Table 2.8 HR monitoring cut points for PA

AUTHORS	HR (bpm^{-1})	PA INTENSITY
Reily et al., 2004	<120	LPA
Collins et al., 2012, Fjortoft et al.,	120-140	Low to moderate PA
2010, Ridgers et al., 2007	140-160	MVPA
	>160	VPA
Ridgers & Stratton, 2005	50% of HRR	Moderate
	75% of HRR	Vigorous

Abbreviations: bpm – beats per minute**, HRR –** heart rate reserve**, LPA –** light physical activity**, MVPA –** modertaae to vigorous physical activity**, VPA –** vigorous physical activity**.**

2.2.2.4 Combined motion sensors

Research has now explored the uses of combining monitors of PA to provide the most accurate information on PA. The first considers combined HR and accelerometry measurement called the actiheart, the second considers combined GPS and HR monitoring.

2.2.2.4.1 Combined HR and accelerometer monitoring

Technology advancements have meant that HR and accelerometers are now small, portable and suitable for use in field settings (Barreira et al., 2009). The benefits and limitations of accelerometers are already discussed in section 2.2.2.2 Simultaneously recording HR and motion using multiple sensors and calibrating the outputs with oxygen uptake can provide an accurate estimate of energy profile for PA (Freedson & Miller, 2000; Haskell, 1993; Luke et al., 1997; Sallis & Saelens, 2000). This reduces problems associated with single monitoring such as the inability to capture all movements and MVPA which are inherent with single monitors (i.e. HR, accelerometers). Treuth (2002) reviewed six studies that used combined measures of PA and found that using HR monitors and motion sensors together improved the accuracy of monitoring PA. Actiheart (CamNtech, UK) is the only integreated device, which combines both HR and accelerometer monitoring together and is a new and promising tool. Combining HR and activity data in children has shown to increase the accuracy in assessment of MVPA (De Bock et al., 2010).

Combined monitoring is the best method currently available for measuring PA in field settings. The step test calibration procedure also makes it possible to provide an estimation of maximal oxygen consumption between ethnic groups, which is a more stable component compared to PA. Having combined PA and HR monitoring also enables the monitor to determine energy expenditure based on branched equations. Thus, the monitor does not rely on accelerometer cut points to determine the intensity of activity (MVPA). However, although reliable and valid in adults (Brage & Wareham, 2005; Barreira et al., 2009; Crouter et al. 2007), the the validity of branched equations in children is not explored and thus estimates of MVPA might not be inaccurate. The reliability of the Actiheart to estimate PA energy expenditure in children during lab based treadmill and walking was found by Corder (2005), but no validation is evident in free living activity.

The monitor is also attached at the chest using two electrodes, which requires the children to prepare the skin and attach these accurately during long monitoring periods, which might sacrifice the validity of the measurement if not fitted correctly or prepared properly. For a Field based study, the monitors are costly (approximately £800 per unit). Finally, the monitor does not provide any information on where the activity may have taken place or it's context, which is not useful for intervention planning.

2.2.2.4.2 Combined global positioning systems and physical activity monitoring

GPS monitoring is essential in obtaining objective information about the environment. It is a relatively new, novel and developing approach to the measurement of PA because it is only objective measure, which can assess the environment because of its ability to provide visualisation of patterns of behaviour. The monitors provide an objective measure of location, speed, distance travelled, elevation, pace and calories expended. The GPS element in addition to a PA monitor makes it possible to understand the location of PA, providing greater understanding of activity behaviour unlike other motion sensors available. Maddison and Mhurchu (2009) review proposed that portable GPS devices are reliable measures of PA and that the contextual nature of the GPS monitors enable researchers to understand how people interact with their environment.

Combined monitoring in children is viewed as feasible and benefits from being able to link GPS data into GIS to examine where children engage in PA (Duncan et al., 2009). Several studies have also used GPS and accelerometers (Almanza et al., 2012; Coombes et al., 2013), however this can be problematic, impractical and time consuming because it requires manual syncing of GPS and accelerometer data points. GPS with integrated HR monitoring are a recent renovation which allows researchers to explore PA place and its intensity. This information can be incorporated into GIS to understand the context of the environment with greater accuracy (discussed further in 4.2.3). The feasibility of these measures in children is reported (Duncan et al., 2008, Jones et al., 2009, Telford et al., 2010; Collins et al., 2013) and with GIS (Fjortoft et al., 2009; Fjortoft et al., 2010) especially in younger children where self-reporting may be limited to the cognitive ability to recall information (Baranowksi et al., 1984; Sallis, 1991). Having the two measures wirelessly connected as oppose to two single measures is more effective because it reduces data handling, making it less time consuming and increases its accuracy that the PA monitor matches the GPS locations, as opposed to single measures combined together afterwards, thus making it a more practical solution.

The Garmin Forerunner 305 has particular advantages for measuring PA because it is synchronised and wirelessly connect to HR monitors, which participants wear around their chest, providing PA intensity (benefits of HRM are already outlined in 2.1.2.3) Obtaining information about HR monitoring and GPS can be implemented into GIS, which enables the assessment, visualisation and analysis of movements patterns as well as site specific elements of activity (Fjortoft et al., 2010). The feasibility and validity is supported in many studies in children (Collins et al., and Fjortoft & Kristoffersen, 2009, Fjortoff et al., 2010; Duncan et al., 2009; Maddison et al., 2010; Jones et al., 2009).

In comparison to other measures of PA monitoring, the short battery life in GPS monitoring requires the monitor to be charged daily if measuring for more than 10 hours. In addition, there can be problems with data loss most commonly associated with lost signal, but also including loss of device power and poor adherence (Krenn et al., 2010). Satellite signal acquisition time and downtime is important, shorter signal acquisition to complete phases or establish satellite fixes result in fewer data lost (Duncan et al., 2013). Krenn et al's (2010) systematic review suggests that data loss is positively associated with the measurement period ($r = 0.81$, $P < 0.01$). For these reasons, monitoring over a shorter period may provide better quality of data or maximising participant adherences is key to improving data quality over longer durations.

Specifically, the spatial accuracy has been reported across studies and GPS monitors, a summary can be found in Table 2.9, identify a mean error of 3.8m. When in clear view of satellites, the spatial accuracy is 3m but when signal is poor, inaccurate locations can be given (Coombes et al., 2013). In other studies, spatial error is reported between 2-3m outdoors and 4-5m indoors (Elegethum et al., 2003) and in unobstructed conditions ranging from 1-10m dependent on the monitor (Rodriquez et al., 2005; Townsend et al., 2008; Rainham et al., 2008). Duncan et al's (2013) study reports that GPS monitors can accurately measure spatial locations across various sites including obstructed satellites and that the accuracy is dependent upon the model. They report however that signal is poorest at high rise sites.

Table 2.9 Summary of spatial error in GPS monitors

AUTHOR	MONITOR	ERROR
Elegethun et al., 2003		Spatial error 2-3 outdoors 4-5 indoors
Rodriquez et al., 2005	Garmin Foretrex	Static conditions (mean distance GPS and geodetic) 3.02 ± 2.51 81.1%- 97.8% of observation occurred within 5-10m of geodetic points
Townsend et al., 2008	Wonde Proud GPS-BT55	Average error : 1.08 ± 0.34 86.5% -99.9% withing 1.5 - 2m of known points
Rainham et al., 2008	Custom made GPS Heralogger	2.82 ± 0.4m 95% observation less than 5.88m
Duncan et al., 2013	Garmin Foretrex 201 Garmin Forerunner 205 Qstarz BT-Q10000XT I-gotU GT 600 Globalsat TR-203 FRWD B100 StarsNav BTS-110	Positional error range 12.1 ± 19.6 –to 58.8 ± 393.2m Mean error 7.3 ± 27.7
	MEAN ± SD	**3.8 ± 2.4m (Indoors 4 – 5m, outdoors 3 - 4m)**

Abbreviations: M - metres

2.2.3 Monitoring days for physical activity

Day to day fluctuations in PA are not random and can be explained by behaviour (e.g. attending school, engaging in PE or after-school clubs). The most appropriate frame is not known and for the purpose of research, a reliable estimate of behaviour is needed without participant burden. A summary of the measurement periods used and their reliability is provided in Table 2.10. Although, there appears to be no validation studies in GPS monitoring, there are various validation studies on other objective monitors suggesting that 7 days provides the most accurate assessment in children, but that acceptable and reliable data can be obtained from 4 days monitoring (Table 2.10).

Table 2.10 Summary of studies confirming days of objective monitoring of PA

Author	Measure of PA	Age (years) Number (n)	Days of monitoring	Reliability
Strycker et al., 2007	Pedometer	10 - 14	5	≥ 0.8
Vincent & Pagrazi, 2002	Pedometer	7 - 12	5	
Rowe et al., 2004	Pedometer	10 - 14	6 (week/ weekend)	
Craig et al., 2010	Pedometer	5 - 19 n =11,477	2	
Dollman et al., 2009			7	
Corder et al., 2010	Accelerometer		4-9 (2 weekend)	
Clemes & Biddle, 2013	Pedometer	All children	7 (weekends)	
Drenowatz et al., 2010	Pedometer	9-11	4 (1 weekend) 10 hours	
Sigmund et al., 2009	Pedometer	5-7	7 8 hours	
Trost et al., 2000	Accelerometer	n =381 Grades 4-12	7	r = 0.76 to 0.87
Penpraze et al., 2006	Accelerometer	n =76 5.6	7 10 hours	r = 80%
Janz et al., 1995	Accelerometer	n=13	4 or more	1 r = 0.42 to 0.47 4 r = 0.75 to 0.78 6 r = 0.81 - 0.84

2.2.4 Summary of physical activity measurement

The measurement of PA in children is a challenge but the development in the objective field has enabled more reliable information about children's PA. Given that children's activity patterns are sporadic, the assessment of total energy expenditure (DLW or indirect calorimetry) will not provide information on children's activity patterns. There are a range of PA monitors enables researchers to minimise recall bias that is present in self-report measures in children (Pate, 1993; Sallis et al., 1991). They offer precision in activity frequency, duration and intensity (Baranowksi et al., 1984; Pate et al., 1994; Sallis, 1991) in younger children who lack the ability to report accurately. Children and parent reported PA is likely to present an element of social desirability bias in which children or parents are likely to present a more favourable impression of their PA behaviour. However, monitoring devices are able to provide more precise, valid and reliable estimates of amount and intensity of PA (Corder, Brage & Ekelund 2007; Metclaf et al., 2002; Rowlands, 2007; Trost et al., 2007). They also reduce error in interpretation of PA in which questionnaires may be culturally dependent and the cultural adaptability may not be appropriate or valid between populations, groups and religions (Warren et al., 2010). The focus of this study is to assess PA and the environment and thus for the purpose of this investigation combined GPS and HR monitoring is the only device available to measures this with accuracy and minimal research burden. It is the only device available with an integrated HR monitor, which will provide valuable insight into PA and its context.

Studies using GPS and GIS information in children have been able to identify specific distances from school and home environments where PA takes place (Maddison et al., 2010) as well as places associated with increased PA (Fjørtoft et al., 2010). The information has also found that the intensity of PA is greater outdoors and in greenspacess (Wheeler et al., 2010). This information is useful for intervention planning. However, this is still a developing concept and there are not many studies that have used GPS and GIS to explore environmental influences. The need to understand environmental influences between different population groups such as ethnicity, gender and age is important because PA patterns are different in these groups (Riddoch, 2004; Riddoch, 2007; Owens et al., 2009). There are not many studies that have considered these differences. Given the inconsistencies in deprivation and limited information regarding ethnic groups but also that ethnic minorities are more likely to live in these area, the use of GPS and GIS might prove useful in considering environmental barriers. However, during the intervention (study one) the children will be required to wear a monitoring device for 6 weeks. For these reasons a pedometer would be most suitable and be able to provide open loop feedback on their activity patterns to increase their PA to meet their daily challenge (Lubans et al., 2011).

2.3 The measurement of body composition

The human body is made up of fat mass, water, minerals and protein (Figure 2.3). Body composition is complex to measure, due to the range of influencing factors (Hemysfield & Wang, 1996). This is particularly difficult in children due to changes in influencing factors (i.e. atomic, molecular, cellular, tissue system and body differences) as a result of growth and maturation, which occurr at different points in individual children. However, once assessed accurately it can provide valuable information on health for individuals and population groups (Wells & Fewtrell, 2006). There are a number of different measures that can be undertaken to estimate body composition but each of these has varying degrees of accuracy, applicability and assumptions associated with them.

The gold standard assessment of body composition is conducted using chemical assay in cadaver (Wells & Fewtrell, 2006). The knowledge gained from this assessment has provided a reference point for development of other assessments (Ellis, 2000). Though important in research, such a technique is not practical or ethical *in vivo*. Therefore, methods that can assess and monitor body composition in living organisms despite their lower accuracy are more useful. In humans, all measures are indirect (Goran, 1998), which causes methodological errors and errors in the assumptions made. Determining what measure is most suitable, is dependent upon resources and the purpose of assessment. However, it is acknowledged that single techniques for assessing body composition are not optimal and thus combining measures improves the accuracy (Wells & Fewtrell, 2006). A summary of measurement advantages, disadvantages and relevance to clinical or community settings can be found in Table 2.11.

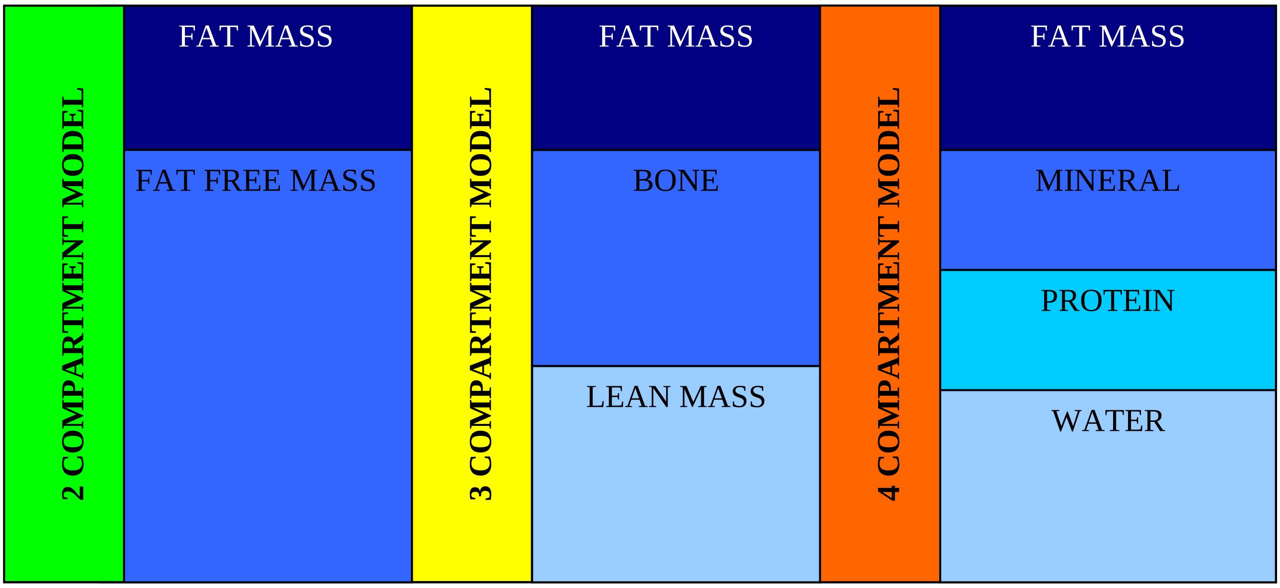


Figure 2.3 *Compartment models for assessment of body composition*

Table 2.11 A summary of the measurement of body fat and the associated advantaged and disadvantages.

MODEL	MEASURE	ADVANTAGES	DISADVANTAGES	SUITABLE FOR
4-C	**Multi-compartment models**	▪ Most accurate approach.	▪ Assumes constant density of protein, and minerals and constant mineral composition ▪ Reference data not available ▪ Expensive, specialist research approach.	Research
RADIOGRAPHIC TECHNIQUES: density is assessed based on the attenuation of x-rays passing through tissues				
3-C	**Computer tomography** *-density of tissues assessed based on x-rays passing through tissues*	▪ Accurate for regional subcutaneous and visceral adipose tissue ▪ Have capability to estimate muscle mass ▪ 3 dimensional image of anatomy	▪ Radiation exposure ▪ Estimates adipose tissue not fat ▪ Expensive	Research
3-C	**Magnetic resonance imaging (MRI)**	▪ Accurate for regional subcutaneous and visceral adipose tissue ▪ Have capability to estimate muscle mass ▪ 3 dimensional image of anatomy	▪ Assumes electromagnetic properties ▪ Estimates adipose tissue not fat ▪ Expensive ▪ Limited availability ▪ Reference data not available	Research
3-C	**DEXA**	▪ Gold standard ▪ 3 compartment estimate of body composition ▪ Accurate for limb lean and fat	▪ Ironising radiation exposure ▪ Low cost ▪ Assumes constant attenuations of fat free mass and fat mass ▪ Reference values not available	Research
DILUTION METHODS: volume of compartments determined by the dilution of tracer dose				
	Isotape dilution	▪ Only technique which is acceptable in all	▪ Assumes the hydration of fat free mass is	Research

	- *volume of a compartment is defined by the ratio of dose of a trace administered:*	age groups	constant ▪ Delayed results ▪ Inaccurate if disease affects the hydration of fat free mass. ▪ Reference data not available	
	Total body potassium	▪ Measures functional component of body composition	▪ Assumes potassium in cell mass is constant ▪ Poor accuracy for fatness ▪ Rarely available	Research
DENSITOMETRY: Body density is assessed by submersion in water or air.				
2-C traditionally 3-C , 4-C models also although not routinely used	**Hydro-static weighing** -body density by submersion in water.	▪ based on Archimedes' principles ▪ often referred to as gold standard ▪ the assumption that the density of fat is constant is viable ▪ 3-C and 4-C models for UWW have been developed to estimate water, protein and mineral in FFM.	▪ Practicalities in children (underwater, hold breath) ▪ Cost ▪ Density of fat free mass influenced by many factors (sex, ethnicity, growth, maturation, PA) and not constant ▪ Limitations in estimation of body volume and residual lung volume	Research
2-C	**Air-displacement plethymography (BODPOD)** -body density by immersion in a closed air filled chamber.	▪ Minimise some of the practicalities of hydro-static weighing ▪ Based on Archimedes' principles ▪ Acceptable technique	▪ Strict pre testing criteria and practicality in children ▪ Density of fat/fat free mass influenced by many factors ▪ Assumes constant densitometry of fat and fat free mass ▪ Reference data not available ▪ Effects of disease on lean mass reduces the accuracy of the assessment	Research
BIOELECTRICAL IMPEDANCE AND CONDUCTANCE METHODS: body composition is determined by electrical resistance and conductivity				
1-C	**Leg to leg BIA**	▪ quick, portable scale available for field assessments ▪ validated against DXA	▪ Hydration states may affect assessment because it assumes conductivity represents body water	Mass screening

			▪ Equations validated in White children thus population's specific. ▪ Poor accuracy in individuals and groups	
2-C	**Total body electrical conductivity**	▪ Acceptable 2 compartment technique ▪ Non-invasive	▪ Assumes conductivity represents total body water ▪ Accuracy unknown ▪ No reference data available and rarely available	Mass screening
SIMPLE MEASURES				
1-C	**Body Mass Index (BMI)**	▪ Quick, simple, cheap and easy, high availability ▪ Used for public health surveillance and reference values are available ▪ Age percentiles available	▪ Body mass in inclusive of fat and fat free mass. Fat free mass weighs heavier ▪ Lack of consideration for ethnic groups ▪ Assumes that weight is equally to fat	Mass screening
1-C	**Waist Circumference**	▪ Quick, simple, cheap ▪ Assess central fatness ▪ Able to detect small changes over time ▪ Reference values are available and high availability in measurement	▪ Reference values not validated for use in children ▪ Assumes that waist measurement represents central fat ▪ Estimate of internal visceral fat isn't as accurate.	Mass screening
1-C	**Skinfolds**	▪ Quick, portable, cheap and highly available ▪ Gender, and ethnicity considered in some equations thus reference data is available ▪ Simple measure of regional subcutaneous fat	▪ Specific equations are population specific and not validated for SA children. ▪ Equation have poor accuracy in individuals and certain groups ▪ Measurement precision and technique ▪ No information on lean mass ▪ Assumes that skin protein content is constant and that skinfolds are equivalent to whole body fat.	Mass screening

Abbreviations: 2-C: 2 compartment model (fat mass, fat free mass), **3-C:** 3 compartment model (Fat mass, lean mass and bone), **4-C**: 4 compartment model (fat mass, protein, mineral and water).

2.3.1 Multicomponent models

In vivo, multicomponent models (e.g. combining measures such as DEXA and deuterium dilution) are described as the gold standard for many reasons. Firstly, they minimise assumptions made my simple models such as 2-C models. Secondly, they address the variability in lean mass by measuring key components such as hydration, density and mineralisation of fat free mass as oppose to assuming them. In children, this is particularly important (Wells & Fewtrell, 2006). Due to the cost, lack of availability, strict testing procedures and lack of reference data available, some researchers and clinicians routinely use more simple methods such as BMI or WC for large studies in paediatric populations instead of multicomponent models. These methods are more cost effective to use in field based studies in children and thus will be described in further detail below. A brief description of more sophisticated techniques (i.e. MRI, CT, and DEXA, dilution methods and densitometry) their advantages and disadvantages are presented in Table 4.7 and not presented further as they are expensive and not practical for use in large groups of children. Also, to the authors knowledge, reference data for these methods are not available. Given that body composition is not the primary concern of the study and that the study is based in a field setting, more portable measures are suitable and field based methods are cheaper and more feasible for the outcomes of this study.

2.3.2 Bioelectrical Impedance Analysis (BIA)

Bioelectrical impedance analysis (BIA) is a method for assessing body composition, which can be utilised in both lab and community studies. It is based on the assumption that the electrical resistance is representative of body shape and the volume of conductive tissues in the body because tissues and the body conduct an electrical current. Therefore, it provides a measure of total body water that is then transformed to fat and fat free mass. It is based on the notion that electrical conductivity through body fluid is greater in fat mass because fat free mass contains all body fluids and electrolytes (Sung et al., 2001). BIA assumes the body is one geometric shape, a cylinder of length is thus equivalent to height, and that height is proportional to total body weight. This is considered feasible because the relationship between height (^{2})/ resistance and total body water is robust across childhood ages (Kushner et al., 1992). However, this does require prior knowledge regarding hydration status of fat free mass (Fomon et al., 1982) because hydration status affects the conductivity of tissues (Kushner 1992; Schoeller, 2000). Goran et al (1993) cross validation paper suggests that the equations used for estimating body composition in children using bioelectrical resistance is considered reliable (>0.99) (Goran et al., 1993). Validation for different ethnic groups is still needed though (Goran, 1998).

Traditionally, BIA required electrodes to be placed on upper and lower limbs in order to assess body composition but there are more portable, quicker and less invasive techniques now available (Kushner et al., 1990; Segal et al., 1988; Utter et al., 1999) which are more appropriate for field studies. Foot to foot impedance scales is one of these measures. The mean bias reported is similar to four compartment measures of body fat (DEXA) in adults (Jebb et al., 2000). In children, this method has been validated, and is a reliable and acceptable method (Sung et al., 2001). A validation study in prepubertal children concluded that foot to foot bio impedance provided a better estimation of fat free mass, fat mass and percentage body fat than anthropometric indices and that it was accurate to measure body composition in children (Tyrrell et al., 2001). The built in equations have been validated in mainly White populations (Jebb et al., 2000; Frisard et al., 2005; Sun et al., 2003) and these seem to provide mean bias in ethnic populations (Haroun et al. 2010). Due to its portability, ease of use and inexpensive cost, these are frequently used in field settings (Ellis, 2002). The scales are already being used to measure weight, have correlated well against skinfold measure in White (r = 0.76) and SA children (r = 0.77, P >0.01) (Eyre, MSC data unpublished), it thus seemed feasible to measure body fat at the same time as obtaining an assessment of mass.

2.3.3 Body Mass Index (BMI)

BMI is a quick and portable measure for epidemiological that correlates strongly with total body fat (Pietrobeli et al., 1998), percent fat and fat mass scores derived from the gold standard assessment DEXA (Lindsay et al., 2001). However, BMI fails to account for muscle mass (Dishman et al., 2004; Roche, Heymsfield & Lohman, 1996), which can result in problems with growth when there is a conversion between lean mass and fat mass (Deurenberg et al., 2001; Malina & Katzmarzyk, 1999). This results in an underestimation in obese and lack of precision during different stages of growth (Deurenberg et al., 2001). Using children from the same age group and using BMI-for-age and sex percentiles can minimise some of these errors. BMI-for-age and sex percentiles is a well-established method in children (Must & Anderson 2006; Reilly, 2006b, NICE, 2006).

BMI is described as not being an accurate guide to child body fat at low to medium range of BMI distribution (Reilly et al., 2006b). A number of studies have shown that SA children are smaller and lighter (Whincup et al., 2002; Saxena et al., 2004; Haroun et al., 2010; Nightingale et al., 2011) but have higher body fat at lower BMI scores (Barnett et al., 2006; Ehtisham, 2005; Nightingale et al., 2011; Shaw et al., 2007; Whincup et al., 2005). Duncan, Duncan and Schofield (2009) also highlighted that BMI has low sensitivity for South and East Asians. BMI alongside additional body fat measures will provide a more accurate assessment. In the future, ethnic specific equations would improve the accuracy in BMI reporting in SA children but systematic reviews (Reilly et al.., 2002; 2003) have concluded that the currently recommended definitions of obesity do successfully identify those children and adolescents who are at greatest risk of conditions associated with fatness (Reilly, 2006b). Given that BMI is a quick and portable and assessment used across many research studies and health surveillance (e.g. National Child Measurement programme) it seemed feasible to use this approach.

2.3.4 Waist Circumference

Similar to both BMI and leg to leg BIA, waist circumference (WC) is a quick and simple method for assessing body composition in epidemiological settings in a large sample. The prognostic value of WC to determine obesity is viewed as similar to BMI-for-age and sex, based on a review of 10 studies by Reilly et al (2006). However, unlike BMI, WC has the potential to assess central fat distribution and is shown to correlate well with intra-abdominal fat mass (Lean et al., 1995). Studies in SA children suggest that they have higher levels of central fatness (Ethisham et al., 2005); even SA's with smaller waist circumferences have higher levels of visceral fat mass compared to White children (Banerji et al., 1999; Raji et al., 2001). Abdominal fat distribution as measured by fat distribution was associated with adverse metabolic risk factors in children aged 5 to 17 years by the Bogalusa heart study (Freedman et al., 1999). It is suggested that the risk of metabolic disease is already increased at a lower level of waist circumferences in SA ethnic groups (Misra et al., 2005). The assessment of WC in addition for BMI was thus deemed as appropriate to detect these differences. Yet, the ability of WC to diagnose obesity adequately in all children is not validated, and thus there is a lack of validated reference values existing (NICE, 2006). Despite this, Reilly et al's (2006) review assessed whether WC-for-age can provide improved diagnosis of obesity over BMI-for-age. In all 10 studies the diagnostic accuracy of BMI and WC for age was similar. Reference data is available from a nationally representative sample in UK children (McCarthy et al., 2001). WC does have the ability to detect small changes in the population over time (McCarthy et al., 2003) and is thus important for the monitoring aspect pre and post intervention during the study. In addition, given that SA children have increased abdominal fatness and WC is a robust index of abdominal fat and useful index of visceral fat (Brambilla et al., 2006), it seems imperative to assess.

2.3.5 Summary of assessment of body composition

In order to measure the complex phenomenon of body composition with accuracy as the primary concern, then multi-compartment models should be used. However, for field based testing in large populations, the practicality in children, cost, time and resources are not appropriate. Two-compartment models can quantify fat and fat free mass with the accuracy derived from multi-compartment models. Yet, for routine testing, lab measurements are costly, impractical (e.g. strict testing procedures) and reference values and testing within ethnic children are scarce. Finally, the measurements relate to whole body fat and provide little information about regional variability. For SA children, obtaining measures of regional fatness (abdominal fatness) is of importance. Regional obesity is not only associated with obesity but also increased risk of metabolic diseases (Rabkin, 2013). Obtaining WC measures is simple, cheap, effective in capturing abdominal fatness and can provide an informative assessment. BMI and BIA are simple, quick and informative assessments, which can provide insight into whole body fat in large populations (Prentice & Jebb, 2001; Janssen et al., 2005). Caution is needed when assessing fatness amongst different ethnic groups due to lack of validation in ethnic studies (Dietz & Beltizzi, 1999) but combining these measures of fatness provides the most accurate and cost effective assessment (Wells & Fewtrell, 2006).

CHAPTER 3.0 LITERATURE REVIEW: ENVIRONMENTAL EFFECTS ON CHILDRENS PHYSICAL ACTIVITY

Physical activity patterns in children vary by age, gender and ethnicity (Riddoch, 2004; Riddoch, 2007; Owens et al., 2009). Understanding how and what might be causing these differences is useful for planning interventions. Over the last five to six years, research has begun to consider the role of the environment on PA. This chapter reviews the literature on physical and social environmental effects on PA patterns and addresses the limitations of these studies.

3.1 Defining the physical environment and social environment

In Davidson and Lawson (2006) review, examining the influence of the physical environment on PA, the physical environment is defined as ‘objective and perceived characteristics of the physical context which children spend their time (home, neighbourhood or school) including urban design (footpaths) traffic density, speed, distance to and design of venues for PA (e.g. playground, parks and school yards), crime, safety and weather conditions ‘(pp. 3). Thus physical environments are either natural (e.g. open spaces, weather, climate or vegetation) or built (e.g. buildings, transports routes, density and intensity) (Davidson and Lawson, 2006; Handy et al., 2002; Sallis, 2009). A full list of physical environmental factors is presented in Figure 3.1 based on gathered evidence from Grow and Saelens (2010) and from Table 3.1.

There is much less research that has defined what a social environment is. However, the impacts of the social environment on PA are documented (Brockman, Jago & Fox, 2011; Jones et al., 2009; Loureiro et al., 2010; Moore et al., 2010; Veitch et al., 2010, Table 3.1). Barnett and Casper (2001) define a human social environment as ‘encompassing the immediate surroundings and cultural milieus within which a defined group of people function and interact’ (pp. 465). The social environment includes the structure, practices and beliefs about the place or community, which can change over time (Barnett and Casper, 2001). Considering both physical and social environmental influences, there are some components which are not exclusively physical or social such as safety, crime and aesthetics (highlighted by the crossover of components in figure 3.1), which can make relationships between the environment and PA complex.

PHYSICAL ENVIRONMENT	**SOCIAL ENVIRONMENT**
Accessibility (e.g. proximity, use and availability).	Parental modelling, commitment, perceptions and constraints
Quality (e.g. trees, abandoned buildings, graffiti) Safety (crime, lighting, dark nights)	Aesthetic (e.g. appeal, attractiveness, ‘trampy’, ‘run down’) Safety (e.g. feelings of unsafe, antisocial behaviour)
Weather Home environment (e.g. equipment, access) School environment (e.g. facilities, equipment, PE co-ordinatior, PE lessons)	Peers Religious practice

Figure 3.1 *Components of the physical and social environment based on Grow and Saelens (2010) and Table 3.1*

3.1.1 Physical environment and physical activity

The neighbourhood in which an individual lives plays a significant role in PA engagement and determines the availability of local facilities (e.g. parks, sports facilities), the walkability (e.g. street connectivity and footpaths) and perceptions (Table 3.1) and can account for 7- 9% of variance in MVPA in boys and girls (van Loon et al., 2014). A range of cross sectional surveys have found that facilities are important determinants of

PA, such as the availability of recreational space or public open spaces such as park, playgrounds, playing fields or courts (Loureiro et al., 2010; Nielsen et al., 2010; Timperio et al., 2008; Veitch et al., 2010; Veitch et al., 2011). Proximity to these sites has also been associated with increased activity (Grow et al., 2008) (Table 3.1).

In research that has considered specific features of the physical environment with PA, cul-de-sacs and greenspace were associated with objectively assessed PA in prepubertal children (Brockman, Jago & Fox, 2011; Veitch et al., 2010). Children were found to be more active outdoors (Cleland et al., 2008; Jones et al., 2009) engaging in unstructured PA in open spaces (Spengler et al., 2011) and more health enhancing PA (MVPA) (Dunton et al., 2011). The PEACH project revealed that a third of total weekday MVPA occurs in greenspace and 40-57% of weekend MVPA (Laschowitz, et al., 2012). In addition, they reported that time outdoors was associated with higher PA (35%) but that only 15% of time after school was spent outdoors and that specifically, children spent most of this 15% of time in non-greenspace areas (Wheeler et al., 2010). A review by McCurdy et al., (2010) also concluded that children, who exercise outdoors for a greater amount of time, engage in more MVPA. The wealth of information on neighbour influences comes from self-report measures.

3.1.1.1 School

Children spend a considerable amount of their time during the week at school (approx. 30 hours). Therefore, the role of the school environment and PA engaged in at school makes up a large component of weekday PA (Table 2.1). The PEACH PROJECT objectively measured PA in children 10 to 11 years from the UK using accelerometers and reported a school effect on PA (Griew et al., 2010). The school in which the child attended accounted for 14.5% differences in their overall PA achieved at school (Griew et al., 2010). The mechanism of the school affect relates to the opportunities available at school. Firstly, the school day is structured to offer opportunities to be active within the day such as break times (Bassett et al., 2013), PE, walking to school policies, and after-school clubs, which are discussed further below. Secondly, the facilities available during these structured opportunities (e.g. removable play equipment, school playground markings during break times) affect PA engagement (Cohen et al., 2008; Haug et al., 2010). Specifically, during break times, children who attend schools which provide fixed play equipment (e.g. adventure frames) and moveable play equipment (e.g. skipping ropes) in the school playground, are more likely to be active (Sallis et al., 2001). Interventions aimed at improving the physical environment during break time to increase PA have been successful and are discussed in Section 3.1.5.

Participation in school PE also has a positive effect on activity patterns (Gordon-Larsen et al., 2000). Specifically, the facilities within PE (e.g. increased grassed area per student and sporting apparatus on the grass) and fitness sessions during PE, is associated with increased MVPA (Martin et al., 2013). The social environment is also important because having a physically active PE co-ordinator or a trained specialist is also associated with increased MVPA (Martin et al., 2013). Interventions aimed at improving PA through PE have yielded successful results (section 3.1.5). The beneficial effects of after-school activity programmes on PA patterns is also confirmed from a meta-analysis (Beets et al., 2009).

3.1.3.2 Active travel to school

Active travel to school is another important contributor to health behaviours. Specifically, Walking to school is associated with increased PA (Saksvig et al., 2012; Trapp et al., 2013) smaller waist circumference, and better metabolic profiles in adolescents than non-walkers (Pizarro et al., 2013). Active travel (especially cycling) was associated with lower body fat (skinfolds) and better fitness (cardio and muscular) in adolescents (Ostergaard et al., 2013). The PEACH project reports that active travel to and from school provides 33.7% of total daily MVPA (Southward et al., 2012). Changes from non-active commuters to active commuters in the SPEEDY longitudinal study were associated with an increase in daily minutes spent in MVPA for pre-pubertal boys and girls (Smith et al., 2012). This was supported by the PEACH project who examined the change in active travel behaviours from primary to secondary school. They found that those who reverted to car journeys after active travel in primary school, showed a significant decreased in MVPA (15%) and those who walked at secondary after car journeys at primary school resulted in 16.1% more time in MVPA (Cooper et al., 2012).

A total of 49% (Department for Transport, 2010) and 51% of primary school children in the West Midlands walk to school and 1% cycle (School census, 2011, sample = 404). Given the important contribution that walking to school can have on MVPA, it is importance to understand ways in which active travel to school can be encouraged. Giles-Corti et al., (2011) found that regularly walking to school was higher in children who attended a school in a highly walkable neighbourhood (high street connectively, low traffic volume). They concluded that connected street networks provide direct routes to school but when these are designed for heavy traffic, then the potential for children to walk to school is reduced. Active travellers were also found in schools in highly dense neighbourhood, intersectional densities, on street parking, food outlets and taller continuous buildings (Dalton et al., 2011). Yet, Wong et al's (2011) systematic review of 14 studies on environmental correlates of active school transport, found that only distance was consistently associated with active school travel. A distance of less than 15 minutes is indicative of walking behaviours (Cooper et al., 2003). Other studies reported the influence of other environmental effects (i.e. SES and weather) on active transport (Dalton et al., 2011; Rodriquez-Lopez, 2013). A European study reported that children whose parents didn't work engaged in higher levels of active travel (Rodriquez-Lopez, 2013). Dalton et al's (2011) study found that active school travel varies by season with less active travel to school occurring in winter months.

3.1.3.3 Active travel outside of school

Active transport in both children and adults is widely studied specifically relating to the walkability of environments (D'Haese et al., 2011; Faulkner et al., 2010; Hume et al., 2009; Rodriquez et al., 2009; Zhu et al., 2011), as already discussed above. From parental surveys, access (D'Haese et al., 2011), distance, traffic, pedestrian crossings, time saving (Faulkner et al., 2010; Rodriquez et al., 2009; Hume et al., 2009) and parent's personal barriers relating to personal safety (Zhu et al., 2011) were determinants of active travel behaviour.

A systematic review of electronic databases in children aged 5 to 18 years concluded that there were no consistent findings on land use and residential density due to methodological limitations (Won et al., 2011). The review reports that this is because of the inconsistencies in spatial concepts and makes recommendations that future studies should consider standard buffer size, access to street network database and explore further attributes linked to safety. A review by Ferdinand et al., (2012) of 169 articles suggests that 89.2% report a beneficial relationship between the environment and PA but that this is limited to observational designs and thus causality cannot be assumed.

Recent work, using geocoding databases, enabled US researchers to explore these factors in more detail. Lovasi et al., (2011) found that indicators of walkability were land use mix, subway and stop density, traffic safety, and park access and increased street trees)

Using geocoding enables researchers to explore in detail exactly what it is about a neighbourhood that might make it feel more safe, which individuals might not report or be aware of. A further study by Giles-Corti et al (2001) also reported the role of walkability neighbourhoods and found increased street connectivity and reduced traffic volume, influenced walking. Observational studies have supported these findings, reporting that safe travel relating to sidewalks and residential density was associated with active travel (Dalton et al., 2011). GIS and accelerometer data found that traffic, and traffic calming measures (i.e. pedestrian lights, slow zones and speed bumps) were associated with active transport in young children as well as increased MVPA (Carver et al., 2010). This finding is supported by a systematic review which considered only objective measures of environmental factors and found similar findings for cycling to that of Carver et al (2010). Cycling was associated with traffic safety, distance, population density and greenspace (Fraser and Lock, 2011). So it is apparent that a range of environmental features are determinants of active travel but these are most accurately determined using objective assessments of both the environment and PA.

3.1.2 Social environment and physical activity

Physical environmental factors are likely to contribute to parents' fears regarding safety. A number of studies have highlighted that safety concerns are a major barrier to PA and may limit engagement in outdoor PA (Table 3.1). From parental surveys and interviews with children, it was apparent that parental perceptions regarding the child's safety constrained PA (Brockman, Jago & Fox, 2011; Veitch et al., 2010), making children of concerned parents less active (Jackson et al., 2008). Children also feel that their parental constraints limit their PA, but that being contactable to parents (mobile phone) enables them to engage in more PA, assessed objectively (Brockman, Jago & Fox, 2011). The PEACH project is a large (13,000 boys and girls aged 10-11 years (83.3% White, 23 schools) on-going UK study assessing environmental influences using parental and child surveys with objectively measured PA. The findings suggest that independent mobility is associated with increased play (1.5 increases in likelihood of playing out every day), PA and active travel in children (Page et al., 2010). The findings also suggest that parental constraints are experienced differently amongst genders, with boys having greater independent mobility compared to girls (Page et al., 2010). Another large study using GPS monitoring and accelerometer was able to explore this is in more depth and found that boys were more likely to roam outside of neighbourhoods whereas girls used the garden and street spaces for PA (Jones et al., 2009).

Fears of safety (crime and danger) are also expressed as barriers for PA in children (assessed using focus group discussion with children) (Loureiro et al., 2010; Moore et al., 2010). It is not known whether the knowledge of belief around safety is formed from parent's own perceptions or whether children actually do feel unsafe playing in particular environments. The mechanism for which parents, let alone children, might feel safe with an environment is not directly explored or accurately assessed. Some subjective (parental questionnaires) evidence suggests children's PA was higher in areas that parents perceived as satisfactory and that area satisfaction included having more sidewalks and parks (Carson et al., 2010). Despite the wealth of evidence showing safety fears as a barrier for children's PA (Table 3.1), the reasoning behind what enables children to feel safe in their local neighbourhood is not well explored in children. Particularly, this is under explored in ethnic children.

3.1.3 Socioeconomic Status

Neighbourhood deprivation may also be related to access and opportunities for PA (Crawford et al., 2008; Fernandes et al., 2010) but the results are conflicting. Some research suggests that living in poorer neighbourhoods was associated with more unstructured time, which was filled by outdoor play or TV viewing (Kimbro, Brooks-Gunn & McLanahans, 2011). Others research shows that deprivation is associated with poorer playground facilities, provision (Fernandes et al., 2010) and less public open spaces with associated amenities, which promote PA (e.g. cycle paths, trees) (Crawford et al., 2008) and thus reduced PA (Griew et al., 2010; Pabayo et al., 2011; Spengler et al., 2011). For walkability the findings are also inconsistent. Low SES has been associated with more walking, shorter distances, greater sidewalks and lower volumes of traffics, encouraging PA (Zhu & lee, 2008). In other research (assessed using GIS), people were less likely to walk in deprived areas, but having higher density roads and street lighting was associated with safer walking environments (Panter et al., 2010).

A systematic review assessing inequality among children found that children in low SES suffer from multiple and accumulative experiences (Bolte et al., 2010). Low SES was associated with increased traffic volume, pollution, inadequate housing, residential conditions and less opportunity for PA (Bolte et al., 2010). While gender differences were considered in only one study, the results suggest that greater area deprivation was associated with increased MVPA in boys measured objectively, but for girls this was reversed (Pabayo et al., 2011).

In general, SA people are the most socio-economically disadvantaged and are likely to live in areas that are the most deprived (Jayaweera et al., 2007; Williams et al., 2009). One US study considering ethnicity used a survey of neighbourhood characteristics with observed PA and found that poverty is increased in non-White neighbours (Franzini et al., 2010). However, these neighbourhoods actually had better access but felt their neighbourhood was less safe, less comfortable, and less pleasurable for outdoor PA (Franzini et al., 2010).

The need to assess ward deprivation in ethnic groups to establish if this is a factor contributing to the low PA patterns observed particularly in SA children is needed. This has not been assessed in previous studies and the majority of evidence is from US studies or Australian studies where the physical environment is likely to differ greatly from the UK. The conflicting findings of the overall effect of SES on PA, are likely to be due to the different study aims (i.e. different aspects of the environment, and different components of PA) and the complex interaction between physical and social environmental influence. A holistic approach (considering both physical and social influences) might provide more meaningful conclusions in the future.

Table 3.1 Physical and social environmental facilitators and barriers to PA

ENVIRONMENTAL FACTOR	FACILTATIVE TO PA	BARRIERS TO PA
NEIGHBOURHOOD		
Physical environment	**Greenspace (park, open space, fields): n = 10** **(**Brockman et al., 2011; Veitch et al., 2010, Chomitz et al., 2011; Nielsen et al., 2010; Loureiro et al., 2010; Timperio et al., 2008; Spengler et al., 2011; Laschowitz et al., 2012, SPEEDY STUDY Coombes et al., 2013; Rainham et al., 2012) **Non-greenspace (built land such as hard surfaces): n = 2** Wheeler et al., 2010; Coombes et al., 2013) **Cul de sacs: n = 2** (Brockman et al., 2011; Veitch et al., 2010) **Proximity to facilities : n = 4** (Gomez et al., 2004; Grow et al., 2008, Sallis et al., 1993; Timperio et al., 2004) **Residential density: n = 1** (van Loon et al., 2014) **Commercial density: n = 1** (van Loon et al., 2014) **Number of parks : n =1** (van Loon et al., 2014) **Low street connectivity: n = 1** (Tappe et al., 2013) **Walking or cycle paths : n = 4** (Boarnet et al., 2005; Ewing et al., 2004; Tappe et al., 2013; Trapp et al., 2011a) **Street connectivity: n = 3** (Braza et al., 2004; Norman et al., 2006; Trapp et al., 2011a)	**Distance to school: n = 3** (Cohen et al., 2006; Ewing et al., 2004; Timperio et al., 2006) **Number of road to cross : n = 1** (Timperio et al., 2006) **Traffic : n = 1** (Carver et al., 2005)

	Low traffic = 1 (Trapp et al., 2011b)	
Social environment	**Independent mobility : n = 3** (PEACH PROJECT Page et al., 2010, Jones et al.,., 2009; Stone et al., 2014) **Being contactable by mobile : n = 1** **(**Brockman et al., 2011) **Aesthetics / Area satisfaction : n = 3** (Carson et al., 2010; Tappe et al., 2013; Mota et al., 2005) **Safety from crime : n = 1** (Tappe et al., 2013)	**Safety concerns from parents : n = 3** (Brockman et al., 2011; Jackson et al., 2008; Veitch et al., 2010) **Parental fears of stranger : n = 2** (Foster et al., 2014; Molnar et al., 2004) **Crime and danger concerns from children: n = 2** (Moore et al., 2010; Loureiro et al., 2010) **Dogs not on a lead: n = 1** (Carver et al., 2005)
SES		
Overall SES status of neighbourhood	**Low SES: n = 1** (Kimbro et al., 2011) **High SES: n = 1** (Stone et al., 2012)	**Low SES : n = 6** (Bolte et al., 2010; Duncan et al., 2012; Duncan et al., 2008; Griew et al., 2010; Pabayo et al., 2011; Spengler 2011)
Physical environment Facilities associated with low SES	**Increased open spaces : n = 2** (Crawford 2008; Zhu & Lee 2008**)** **Increased cycle paths, sidewalks : n = 1** (Zhu & Lee 2008) **Close proximity: n = 1** (Zhu & Lee 2008) **Reduced traffic: n = 1** (Zhu & Lee, 2008) **Street Lighting : n = 1** (Panter et al., 2010)	**Poor playground facilities/provision : n = 1** (Fernandes et al., 2010) **Greater access to media in bedroom: n = 1** (Tandon et al., 2012) **Lack of portable play equipment n = 1** (Tandon et al., 2012)

	High density roads : n = 1 (Panter et al., 2010)	
Social environment Facilities associated with low SES		**Less safe: n = 1** (Franzini et al., 2010) **Pleasureable: n = 1** (Franzini et al., 2010)
SCHOOL		
Physical environment	**Facilities (equipment, play structure): n = 5** (Cohen et al., 2008; Griew et al., 2010; Haug et al., 2010; Sallis et al., 2001; Stratton and Mullan, 2005) **PE co-ordinator: n = 1** (Martin, 2013) **Mandatory PE : n = 2** (Bassett et al., 2013; Martin 2013) **After-school PA : n = 2** (Bassett et al., 2013 Beets et al., 2009) **Classroom breaks : n = 1** (Bassett et al., 2013) **Modified playground : n =1** (Bassett et al., 2013) **Active travel : n =1** (Bassett et al., 2013)	
ACTIVE TRAVEL		
Physical environment	**Short distance : n = 1** (Wong et al., 2011) **Dog ownership : n = 1** (Christian et al., 2011)	**Weather (winter) : n = 1** (Dalton et al., 2011) **Walkability : n = 1** (Laxer et al., 2013)

		Low density cul de sacs : n = 1 (Laxer et al., 2013)* findings opposite to other studies.
HOME ENVIRONMENT		
Physical environment	**Portable play equipment : n = 1** (Tandon et al., 2012)	**Media access: n = 1** (Maitland et al., 2013; Tandon et al., 2012)
Social environment	**Parental activity involvement: n = 1** (Hendrie et al., 2011) **Role modelling: n = 1** (Hendrie et al., 2011) **Parental support for PA : n = 1** (Hendrie et al., 2011)	**Parents watching TV with children: n = 1** (Tandon et al., 2012)
OTHER PHYSICAL ENVIRONMENT		
		Weather: n = 1 (Brodersen et al., 2005; Dalton et al., 2011)

3.1.4 Conceptualising socio-economic factors affecting environmental influences

The information outlined above highlights the range of environmental influences that can impact upon PA behaviour in children. However, what is apparent is that there is no single determinant; instead there is a complexity of interrelationships between factors which affects PA. Figure 3.2 Illustrates how socio-demographic factors interact with both social and physical environmental factors to affect PA of the individual child (Grow and Saelens, 2010). This complex interaction is evident in many research findings already outlined above. For example, in studies by Brockman, Jago & Fox, (2011) and Veitch et al's (2010) children's PA was low because they were not allowed outdoors to play. This was because of some physical factors (e.g. crime) but also because of parents fears about their child's safety (i.e. social factors). Figure 3.3 Expands on these concepts, specifically broadening to the impact on obesity and providing a conceptual model for SA individuals (Pallan et al., 2013). In the model, Pallan et al., (2013) identified the multi-factorial and interactive effects of the macro-environment, local environment, school, parents and family, and the child and culture in determining health behaviours. Interventions aiming to increase PA in children from low socio-economic backgrounds thus need to be attentive to the interaction between these determinants. It is imperative to understand how the environment affects PA as this information is key to developing interventions where the environment is a main feature. ………………………………………………………..

.

Figure 3.2 *A conceptual model of how physical, social and socio-demographics factors interact to affect youth PA by Grow & Saelens (2010).*

Figure 3.3 *Conceptual models of determinants of obesity in SA children from Pallan et al., (2013).*

3.1.5 Physical environmental interventions

Taking the available current evidence on physical environmental influences as outlined in Section 3.1. to 3.14, some researchers have designed interventions aimed at increasing PA through changing the physical environment.

3.1.5.1 Physical environmental interventions

Some research has attempted to improve the physical environment to increase PA patterns, and has been successful. Some evidence suggests community interventions have been successful at increasing PA through the physical environment (Cohen et al., 2009; Henderick et al., 2009). For example, increasing the safety and opportunities for walking and cycling, increased PA (Henderick et al., 2009). Changing the physical environment of local parks was less successful in increasing PA, but they did improve the perception of park safety (Cohen et al., 2009). However, a review of environmental interventions in the community and family concluded that beneficial effects on PA were indeterminate due to study quality (van Sluijs, Kriemler, McMinn, 2011).

Some studies changing the school environment have also yielded positive changes in PA behaviours (Huberty et al., 2011; Lanningham-Foster et al., 2008). Huberty et al., (2011) study changed the school environment by using activity zones, increasing playground equipment as well as providing staff training, which increased objectively measured PA. Lanningham-Foster et al's (2008) study provided children with an active permissive school environment and found that children were more active in this environment compared to the control group.

However, none of these intervention studies tracked whether the reported changes in PA continued 6 or 12 months later. Ridgers et al's (2010) study in the UK considered the school playground as a target for intervention. Ridgers et al's (2010) redesigned the school playground using more markings to encourage PA in White children. The intervention successfully increased PA for up to 6 months after the interventions as measured by heart rate and accelerometer. No significant reductions in BMI were observed with the intervention. However, at 12 months no intervention effect on PA (minutes spent in MPA and VPA) was observed between the control and intervention group. The effects of school and playground interventions on PA in SA children are not known, as the evidence has focused on a large white sample of children. Secondly, the wealth of data on the environment is focused on the physical environment, failing to consider or modify social environmental influences.

3.1.6 Measurement of the environment

The majority of information obtained about environmental influences on PA is drawn from cross sectional studies but limited information from longitudinal studies exists. Dunton et al's (2009) systematic review found few consistent findings regarding the environment and suggests that environment influences vary depending on a range of factors relating to population and SES. The review concluded that there is no strong empirical evidence for most environmental factors and so additional studies are needed. This review has highlighted the range of environmental components that might influence PA. The relationship is likely to be extremely complex and studies have not considered this. Therefore, there is a need for studies of specific areas (i.e. deprived areas) to examine environmental effects. The measurement and evaluation of environment features are still in its early stages (Brownson et al., 2009) but are discussed in detail below and a summary can be found in Table 3.2.

Table 3.2 A summary of tools to assess the environment: benefits and limitations in measurement type.

ENVIRONMENT MEASURE	BENEFITS	LIMITATIONS
SUBJECTIVE		
Interviews/surveys	▪ Cost effective for large samples ▪ Minimum participant/research burden ▪ Test re test reliability reported	▪ Individual perceptions differ and are interpreted based on past experience/personality ▪ Poor construct validity ▪ Inter item reliability is not reported ▪ Cultural appropriateness
OBSERVATION TOOLS		
Tools/instrument	▪ Provide information on context of environment (e.g. trees) ▪ Range of validated tools are available	▪ Labour intensive / Time consuming ▪ Paper based ▪ Training/experience
Direct observation	▪ Provides contextual information	▪ Training and experience ▪ Not possible to assess all environments ▪ Time consuming ▪ Limited number of people can be assessed at one time.
OBJECTIVE		
GIS	▪ Ability to assess a range of factors ▪ Draw on a range of database information	▪ Database information can be out of date ▪ Lack of information to clean, manage and analyse GIS data and minimal consistency across studies
GPS	▪ Objective assessment of location, speed, distance, elevation and pace. ▪ Portable and reliable ▪ Data can be linked to linked to GIS systems	▪ Spatial error particularly indoors ▪ Data loss through signal

3.1.6.1 Self-report

The measurement of the environment comes mainly from survey methods, which might not capture the full range of influences. Self-report measures explore ways that individuals perceive the environment, measured either by interviews, telephone surveys or person/mail surveys. Sallis et al., (1997) was the first self-report survey which conceptualised the home, neighbourhood and frequent travel routes. Moderate-to-high test, test-retest reliability was reported but findings relating to construct validity were less consistent (Sallis et al., 1997). Since this, further scales have been developed such as the systematic pedestrian and cycling environment scan (SPACES) (Pikore et al., 2002) and the neighbourhood walkability scale (NEWS). NEWS is reported as the most commonly used measure and has yielded good reliability especially for physical environmental features, yet, social environment (crime, safety) features were less reliable (Brownson et al., 2009). The European Environmental Questionnaire for Assessing Levels of Physical Activity (ALPHA) is a validated questionnaire assessing features of the environment that are supportive or unsupportive of physical activity behaviours, which is available in several languages (Spittaels et al., 2009; 2010).

There are some limitations with self report measures though, firstly, the test re-test reliability (Durant et al., 2009) are lower than expected because contextual errors can be made (DeBate et al., 2011). Secondly, concurrent validity between questionnaire and GIS is not found for all features (e.g. traffic information) (Adams et al., 2009). Gaining validity is a challenge as there is no gold standard because environmental features relate to an individual's perception such as safety and thus these perceptions are reality for the individuals who are reporting (Brownson et al., 2009). However, it must also be considered that each individual's perception of reality might be different from each other. In addition, individual perceptions are interpreted with reference to past experiences and personality characteristics, which are extremely difficult to account for. Surveys can be useful to gain information from a large population with minimum cost and research burden. However, response rate can be low on surveys and especially longer questionnaires in which respondents may lack concentration (Brownson et al., 2009). The cultural appropriateness of these surveys is not assessed (Table 3.2). Thus, it is apparent that objective assessments can provide a more accurate, reliable and valid assessment of the physical environment.

3.1.6.2 Observational measures

An observational measure is where the physical environment is directly observed. This can be done either by tools such as instruments or protocols as a checklist or using GIS/aerial pictures. Using observational tools makes it possible to collect information that might not be available from GIS databases (e.g. street, trees). However, this can be time consuming and labour intensive because the researcher has to drive or walk through the environment and systematically code characteristics compared to GIS databases (Brownson et al., 2009). Tools generally consider the areas land use, street, traffic, sidewalk, public spaces, architecture or building characteristics, parking, driveways, maintenance, or indicators related to safety for example. There are many tools developed to aid this process, these include the PA resources assessment (PARA), for schools settings, the system for observing play and leisure PA in youth (SOPLAY) or parks, the system for observing play and recreation in communities (SOPARC). Inter observed reliability and test re-test reliability are reported (Brownson et al., 2009). The reliability of social disorder (graffiti), tidiness, and safety related features are less reliable.

Direct observation has also been used to assess PA within different settings for children. The behaviour of eating and activity: children health evaluation survey (BEACHES) (Mckenzie et al., 1991) children's activity rating scale (Puhl et al., 1990) and system for observing fitness instruction time (SOFIT) (Mckenzie et al., 1991) are a couple of examples of these assessments. Sallis (2009) reported that reliability of these items is high. Direct observation in children can provide more reliable information than surveys on children's activity in respect to the environment but they can lack detail. PDA devices and computers can be used to reduce the burden and error (Brownson et al., 2009; Sallis et al., 2009) from paper based tools. Despite this, specific skills are needed to carry out observations such as knowledge of the content area such as urban planning and the ability to carry out technical methods of direct observation (Brownson et al., 2009). Furthermore, observation is a timely assessment, only a limited number of people can be assessed at one time and it is not possible to assess children in all environments (e.g. home, school, recreation) via direct observation, GPS monitoring can overcome this barrier.

3.1.6.3 Geographic information systems (GIS)

GIS is a combination of software, hardware and data storage that is able to analyse and display components of geographically references information for instance a researcher is able to explore greenspace and calculate greenspace within areas/neighbourhoods. GIS is an objective way of characterising the environment.

GIS and PA has most commonly been used in PA studies to assess travel related behaviours. GIS measures for PA can be used to assess a range of factors, which include population density, land use mix, access to recreational facilities, street pattern, sidewalk coverage, vehicle traffic, crime, building design and green-ness (Brownson et al., 2009). Brownson et al's (2009) review highlights that measures of land mix use, access to recreational facilities, street patterns and population density are most commonly used factors from GIS databases. Information can be drawn from a range of sources such as the yellow pages (recreational facilities), employment records, local policies (crime, traffic), and aerial photos (sidewalks). Studies have combined multiple indicators provide one single composite index of the environment with PA, enabling the inter relatedness of many physical environment features (Brownson et al., 2009). For recreational features and PA it is suggested that GIS would enable a more sophisticated measure of proximity based on spatial data which can be calculated for both small and larger areas, which would extended self-reported data (Sallis, 2009).

However, there are a few issues that need to be considered when using GIS data. The first is that the data might be old and generally areas don't remain constant over year. In addition, the data could be incomplete and thus it must be acknowledged how this will be dealt with. GIS information can also come from many different data sources and is sometimes combined together. Firstly, the accuracy of each of these data sets is not known as well as the ability to identify errors when emerging data sets (Brownson et al., 2009). Thus, there is a need to explore how different data sources compare in order to provide some consistency in measurement across studies. Secondly, the area of choice might also provide variation in measurement. For example, using standardised buffers such as 400 metre or 3200 metre buffers, which are most commonly used may minimise some variation across studies (Brownson et al., 2009).

Brownson et al's (2009) review suggests that more research is needed to assess reliability, validity and comparability of GIS measures. Test re-test reliability can be achieved by measuring a single area at two different time pointsbut can depend on how quickly the environment changes and how these databases are maintained. Information on how to clean, manage or analyse GIS based data has reached no consensus and thus makes it difficult to compare between studies (Brownson et al., 2009). Combining objective assessments of the environment using GPS monitors and combining this information with GIS, minimises some of these limitations, as the data is reliant on current information, not old databases.

3.1.6.4 Global Positioning Systems (GPS)

Global positioning systems (GPS) with integrated heart rate monitoring are recent innovations, which allow researchers to explore PA location and its intensity. This information can be used alongside GIS to understand the context of the environment with greater accuracy. The feasibility of these measures in children is reported (Duncan et al., 2008; Collins et al., 2012) especially for younger children who may have limited cognitive ability to recall information (Baranowksi et al., 1984; Sallis 1991).

Studies using GPS and GIS information in children have been able to identify specific distances from school and home environments where PA takes place (Maddison et al., 2010) as well as places associated with greater PA (Fjørtoft et al., 2010). The information has also found that the intensity of PA is greater outdoors and in greenspacess (Wheeler et al., 2010). This information is useful for intervention planning. However, this is still a developing concept and there are not many studies that have used GPS and GIS to explore environmental influences. The need to understand environmental influences between different population groups such as ethnicity, gender and age is important because PA patterns are different in these groups (Riddoch, 2004; 2007; Owens et al., 2009). There are few studies that have considered these differences. Specifically, given that SA people are less active and more likely to live in deprived areas, the use of GPS and GIS might provide a stronger basis to understand any PA differences between ethnic groups within the same geographical area.

Using GPS monitoring and GIS will enable researchers to explore all environmental determinants objectively and to relate these with activity patterns. It will enable objective assessment between population groups. How the physical environment is perceived among ethnic groups is not known and can also affect PA patterns. The role of social environment is also important and thus perceptions and social influences can be explored with the support of interviews.

3.1.6.5 Summary of environmental measures

The complexity of the physical environmental constructs presents a real challenge for environmental research with PA. Most commonly survey methods are used to capture the perceived environment however these might not capture all features accurately and is dependent on individual perceptions (Table 3.2). This might be useful if obtaining information about how people perceive the environment. In some cases, survey measures have been used with objective measures of PA. A study reported that survey methods can provide information on environmental influences but that contextual errors are made (DeBate et al., 2011). In addition, the test re-test reliability for some survey methods is lower than expected (Durant et al., 2009) but concordance validity was reported (Adams et al., 2009). Focus group interviews can help to add context to the constructs of perceptions in questionnaires and are discussed further in 4.8.

It is apparent that perceived and observed environmental variables are difficult not only to analyse but also to validate and provide reliable findings. Perceived environmental influences are able to describe how these variables are viewed by the population such as aesthetics, safety and proximity, whereas GIS and direct observation do not provide this information when looking objectively at variables. There are a number of factors that affect both PA and the environment such as age, ability and cultures, low to high income communities and the way the environment might be viewed as barriers and facilitators. Using these measures in specific population groups may be able to provide insight into these factors, and combining environmental research with PA, psychology, social factors, cultural environments and geography, may aid the research.

Considering the appropriateness of techniques used to gather this information, observational measures require the need to train staff in data management and analysis. The ability of the children to be able to report proximity and environmental features accurately might be questioned, and for this reason objective measures are considered most appropriate for children. Given that the study is already collecting information regarding the environment using GPS, it is felt that linking this information to GIS information will provide further insight and be the most practical.

It is also acknowledged that the lived experience is important in determining PA behaviour. Children are not autonomous in their decision making, gaining information from parents about their perceived environmental features and its affects may provide further insight on children's activity patterns. Therefore, this research will consider both perceived and objectively measured environmental features by combining both self-report and objective measures. This enables information to be obtained not only about the physical environment but also to assess social factors and perceptions relating to both the physical and social environment.

Using GPS monitoring and GIS will enable researchers to explore all environmental determinants objectively and to relate these with activity patterns. It will enable objective assessment between population groups. How the determinants then affect perceived determinants is not well known and can be explored with the support of interviews and survey methods (ALPHA environment questionnaire). Specifically, given that SA people are less active and that they are more likely to live in deprived areas, this information could provide a large basis for understanding these activity differences more accurately. The information found can then be used to aid ethnic or gender specific interventions to improve health in children.

3.2 Justification of research

PA is important in children because it is associated with a range of benefits associated with health and well-being (WHO, 2010). The current UK guidelines suggest that children should be active for 60 minutes daily, which should be moderate to vigorous in intensity for health benefits (CMO, 2011). However, current research which has objectively measured PA in children aged 8-9 years has shown that not all children meet these guidelines (Eyre et al., 2013b; Owens et al., 2009). Owens et al (2009) evidenced that adherence is lower in SA children and that as few as 54% of SA children are not active enough for health benefits (70% White and 69% Black). Eyre et al., (2013b) reported that this was as low as 35% for SA's and that they were less active, expended less energy and spent less time in MVPA for week and weekend days. It is also known that both SA adults and children have poorer cardiovascular and metabolic health when compared to White (Bavekar et al., 1999; Bhopal et al., 1999; Ehtisthan et al., 2000, 2004; McKeigue et al., 1991; Whincup et al., 2002; Wild et al., 2007; Williams et al., 2009). Research has shown that regular PA and exercise can improve metabolic health in both adults and children (Berlin & Colditz, 1990; Paffenbarger, 1993, 1996; Owens, 1999; Powell et al., 1987; WHO, 2010). PA alone explained 21% of the difference in cardiovascular disease risk in SA's (Williams et al., 2011). PA and health tracks low to moderately from childhood to adulthood (Malina, 2001; Raitaikari, 1994; Twisk, Kemper & van Mechelen, 2000), so it is important to increase PA patterns in children as especially those from SA backgrounds, given the greater risk of disease apparent in these groups.

However, to the authors knowledge no research has explored why SA children might be less active. Current research shows that the environment where individuals reside is important for determining PA. Given the current interest in environmental influences, a number of studies have explored these influences and have concluded that environmental features are associated with PA behaviours (Wong et al., 2011). Particularly, the role of outdoors and greenspace (Dunton et al., 2011; Lazchowitz et al., 2012; McCurdy et al., 2010), the walkability of neighbourhoods (Dalton et al., 2011; D'Haese et al., 2011; Faulkner et al., 2010; Ferdinand et al., 2012; Giles-Corti et al., 2001; Hume et al., 2009; Lovasi et al., 2011; O Rodriquez et al., 2009; Zhu et al., 2011; Wong, et al., 2011) for enhanced PA and health benefits is found. In the UK, the PEACH project has provided good insight into environmental influences on PA but has limitations. The study includes schools from a range of different socio-economic backgrounds but fails to account for differences based on deprivation status. The study is also based on a predominant White sample and thus findings are limited based on ethnicity. Finally, the study uses a self-report questionnaire for establishing environmental information.

Yet, studies examining the combined effect of deprivation, environmental influences and PA are conflicting. Some studies report that living in deprived environments increases PA (Crawford et al., 2008; Kimbro, Brooks-Gunn & McLanahans, 2011) and others have reported that deprivation is associated with physical inactivity (Bolte et al., 2010; Griew et al., 2010; Pabayo et al., 2011; Spengler et al., 2011). However, no studies have considered ethnic differences in environmental influences. In addition, it is apparent that large numbers of people from ethnic backgrounds live in the most deprived areas (Jayaweera et al., 2007). SA people are the most socio-economically disadvantaged and are likely to live in areas that are most deprived (Jayaweera et al., 2007; Williams et al., 2009). PA in SA people is thus likely to be affected by both socio-economic and environmental factors, but no research studies have examined this. In order to increase PA patterns in SA children, influences on PA behaviours need to be explored. Questionnaires are unreliable in young children (Sallis et al., 1996) and the complexity of environmental features is one which children might not understand. Therefore, objective measures of both PA and the environment in children will provide the most reliable evidence. It is also important to consider facilitators and barriers to PA from the children's perspective in order to design ethnic and child specific interventions. This can only be achieved by talking to children and exploring these facilitators and barriers. The information will be used to design an intervention whereby environmental features are changed in an attempt to increase PA in SA children.

3.3 Aims and research questions

Aims:

Specific aims for each study are already described in Chapter 1.0. The overall aim of the research was to assess the association between environmental factors and physical activity behaviour in SA primary school children, in low socio-economic areas. To address this aim, individual study aims and research questions were identified, which are reported in detail below.

Study one: PA patterns of ethnic children from low socio-economic environments in Coventry, UK.

Aims: The primary aim was to develop current understanding of how children from a low SES area within the UK use their surrounding built environments for PA by using advanced technology (GPS). The secondary aim was to consider how ethnicity might influence this PA pattern or behaviour.

Research questions: (1) How do children from deprived backgrounds use their surrounding environments for MVPA? (2) Do SA and White children use their surrounding environment similarly for MVPA? (3) Is time spent in specific environments associated with BF?

Study two: Environmental influences on PA in ethnic children from low socio-economic backgrounds: a qualitative study from children's perspectives

Aim: To explore environmental influences on PA from a qualitative perspective in children with a specific focus on ethnic differences in low SES areas.

Research questions: (1) Do environmental factors facilitate or provide barriers to children's PA? If so, what are they? (2) Are environmental barriers and facilitators for PA the same for White and SA children?

Study three: Physical environmental influences on PA in SA children from low socio-economic backgrounds: a qualitative study from parental perspectives

Aim: To follow on from study two by exploring how the environment affects the utilisation of their surrounding environment for PA by children from low SES neighbourhoods, from a parental perspective. The study thus aimed to examine how parental perceptions may facilitate or provide barriers to their childs' PA.

Research question: (1) Do parents' perceptions of the environment facilitate or provide barriers for childrens' PA? If so, what are they?

Study four: Examining the effectiveness of a school based and integrated curriculum to increase PA in SA children from a low SES area.

Aim: The aim of this study was to ascertain whether manipulating the physical and social environment in school can increase PA behaviours in SA children from deprived backgrounds.

Research question: (1) Can PA be increased in SA children by changing the physical and social environment?

CHAPTER 4.0 GENERAL METHODOLOGY

4.1 Overview of Study Designs

A mixed-methods approach obtained both quantitative data and qualitative behavioural information from primary school children (study one and two; Years 3/4 (ages 7 – 9 years), study four; Years 4-6 (8 – 11 years) study and their parents (study three). Study one, two and three used an observational design to obtain information on current behaviours in ethnic children from the two most deprived wards of Coventry (Foleshill and St Michaels ward, 1.2 miles apart) in the winter. The information collected was combined and used to inform the experimental study (study four).

In study four, a quasi-experimental design was employed to explore whether changing environmental features could increase PA in SA children. A randomised experimental design could not be employed because randomising children within the same class would not have been possible due to cross over effects of class teaching, thus it would be difficult to conclude the treatment effects. Therefore, a non-equivalent comparison group design was employed based on similar characteristics (i.e. attending same school and living in similar socio-economic environments and SA child). This enabled greater fidelity of the results by ensuring that there was no implicit cross over effect of the integrated curriculum intervention from intervention to control group. In this design the control and intervention group were measured pre and post intervention. However, given that the children are in the same proximity (i.e. same school) there could be some issue of diffusion bias. A large study sample was used to try to counteract this and it was felt that this type of environment is representative of their natural environment.

4.2 Sampling/recruitment strategy

The sample was obtained through cluster sampling at ward (i.e. two most deprived) and school level (1 out of 5 schools per ward cluster, total number = 2), based on the high proportions of ethnic minorites of children at these schools. Cluster sampling enables the results from children within the selected schools within ward clusters to be generalised to the whole. It is also a cost effective method to obtain an ethnic sample (Marsden & Wright, 2010).

For ward sampling, Foleshill and St Michaels wards were selected. Foleshill is ranked as the most deprived ward, with the highest proportion of SA people than any other ward in Coventry (Coventry City Council, 2010). Of the people living in this ward, 49% are from Asian/ British Asian backgrounds and 31% from White. St Michaels ward is the second most deprived ward, which consists of a population of 51% White and 23% SA (Coventry City Council, 2010). Therefore, recruitment at these wards enabled comparisons of children residing in the same geographical locations to take place. Further information on study area characteristics is presented in section 5.3.

For school sampling, the second schools within the two clusters were selected based on their high ethnic proportions in accordance with the advice from the advisory PE teacher at Coventry City Council. The school's selected represented half (113 out of 225 available) of the primary school within the geographical area. The schools identified by cluster sampling, performed similarly in school performance. Both schools had 86% of pupils who achieved English level 4 or above and 82% vs. 74% for maths level 4 or above, giving them average point scores for school performance of 26.5 and 28 respectively (The Telegraph, 2012). This score is based on the number of children achieving each level i.e. level 2, 3, 4 or 5 (each level is awarded different points) and the total is divided by the number of children who sat the exam.

Recruitment at school level took place by contacting the head teacher and PE co-ordinators in written form and inviting them to take part in the study. A meeting was arranged with the head teacher, PE co-ordinators and year 3/4 leaders to inform them of the study in more details demonstrating how the equipment works and answering any questions. At this point, schools were asked if they were happy to still be involved in the study. Following this, letters addressed from the school were sent to every child and their parent in Year 3/4 outlining the study. The letter also invited them to attend a study information session at which a convenient time for the parent/child was identified. A study information session was arranged when all school letters had been returned.

At the study information session a PowerPoint presentation was delivered to all Year 3/4 children and their parents during assembly. This presentation communicated the study information and provided a demonstration of any equipment (HR variability and GPS with HR monitoring). The children and their parents were given the opportunity to ask questions. At the end of the information session, each parent was given a parental information sheet and consent form and each child was given a children information sheet and assent form. The information sheet provided gave full information on the purpose of the study, outlined that participation was voluntary, the advantages/disadvantages of taking part, what would happen with their data, and provided with contact details. Children were again informed that participation in the study was voluntary and that they had the right to withdraw at any point without providing any reason. Informed consent and assent was obtained from children and their parents. The protocol and procedures were reviewed and approved by Coventry University Ethics Committee.

A sub-purposeful sample from this large sample was then selected for the qualitative element (study two). For the quasi-experimental design (study four) the school selected from Foleshill ward was used, this was used to minimise other factors influencing PA between the children.

4.2.1 Considerations during sampling

In order to minimise selection bias in the sampling method, all children inYear three and four from the recruited schools were given the opportunity to take part. Consent forms were available in English and Urdu with researchers and school teachers available to explain the study and consent forms. Urdu was selected by the teachers at the schools as a language that would be easy to interpret if parents/grandparents originated from South Asia. Translators were also available to address language barriers, however this was not needed. PowerPoint presentations were provided in order to provide visual and verbal information to address any differences in understanding information.

4.2.2 Study area characteristics

Foleshill and St Michael's wards in Coventry were selected due to their ethnic and socio-economic composition. Foleshill is the most deprived ward in Coventry with a population of 19,935 persons (51.7 persons per hectare) of which 69% are from Black or ethnic minority backgrounds. The average household income is 37.2% below the city average (Foleshill average household income £23,350). St Michaels ward is the 2nd most deprived ward in Coventry and has a population of 24,119 persons (63.3 persons per hectare), 49% are from Black or minority backgrounds. St Michael's average household income is £26, 327 and 18% lower than the city wide average. A total of 44.4% of Foleshill have no qualifications and 31.8 % in St Michael's, which is higher than the average for Coventry. Death by circulatory disease is also higher in Foleshill at 156.1/100, 000 population, than 136.8/100,000 for St Michaels, followed by 91.7/100,000 for Coventry (Coventry City Council, 2010)

The total area of Foleshill is 366.4 (54.4 persons per hectare vs. Coventry average 32.1 persons per hectare) and 389 (55.8 persons per hectare) hectares for St Michael's ward. They have the highest population density scores (Foleshill: 54.4persons per hectare, St Michaels: 55.8 persons per hectare, Coventry: 55.8 persons per hectare. People in both wards are similarly satisfied with their area as a place to live (Foleshill = 80% and St Michaels = 81%) which is slightly lower than the average for Coventry (88%). The percentage of the population who claim out of work benefits, children who depend on out of work benefits, people claiming job seekers allowance, households earning less than 15, 000 and the percentage of homes over crowded in Foleshill and St Michaels are all above the average figures for Coventry and England. Car ownership is also lower, in Coventry 22.7% households own two or more cars whereas in in Foleshill it is 10.5% and in St Michaels 9.1% (Coventry City Council, 2010).

Recorded crime in Foleshill and St Michael's were higher than those recorded for Coventry as a whole (121.4 and 270.6 crimes per 1,000 population vs 91.5 crimes per 1,000 population). Reported anti-social behaviour is 98.6 offences per 1,000 in Foleshill, 257.9 per 1,000 in St Michael's and 70.7 per 1,000 for Coventry. In Coventry, overall a greater percentage of children (71%; 11-16 years) feel safe after dark compared to Foleshill and St Michael's (67% and 57% respectively). In Foleshill, the top three problems reported were rubbish lying around, people dealing or using drugs and dogs fouling or barking. In St Michael's, the top 3 problems include; rubbish lying around, people hanging around and people being drunk or rowdy in public places. A higher number of people in Foleshill would like to move in the next four or five years (40%) compared to Coventry and St Michael's (30%) (Coventry City Council, 2010).

4.2.2.1 Ward provision of Greenspace

Coventry City Council's (2008) greenspace strategy devised the recommended minimum standards for park/open space, natural greenspace, provision for children, grass pitches, other outdoors sports and allotment. It then assessed the provision for each of these standards across all wards of Coventry. It found that Foleshill and St Michaels ward were deficient across all areas of greenspace provision and that these wards were low in comparison to the city average provision (Table 4.1).

Table 4.1 Provision of greenspace in Coventry per 1000 population

Place/Ward	Population	Park/Open space (Hectare)	Natural greenspace (Hectare)	Provision for children and young people (Hectare)	Grass pitches and other outdoor sports (Hectare)	Allotment
Coventry		3.1	1.72	0.10	1.02	0.38
Foleshill	17968	0.85	0.03	0.11	0.23	0.9
St Michaels	15413	0.88	0.00	0.09	0.30	0.24

Revised from Coventry Council Greenspace Strategy 2008

5.2.3 School characteristics

The school selected from Foleshill ward is larger than average (intake of 60 students per year intake more) and continues to increase. Most children are from ethnic minority groups with common first languages including URDU, Punjabi, and Gujarati. The school has National Healthy School Status, Active Mark, Sports Mark Awards and Anti-bullying Charter Mark. In an Ofsted inspection in 2010, the school was awarded good for their overall effectiveness and for their capacity to sustain improvements (Ofsted, 2010). The children were also awarded good for adoption of health lifestyle, which included eating well and exercising regularly.

The school selected from St Michael's ward is larger than average and culturally diverse, with 40% speaking English as an additional language and 40% eligible for free school meals. The school has Healthy School Status, Basic Skills Award and Accreditation as a Foundation Level International School. The school achieved satisfactory for overall effectiveness, sustained improvement and good for adoption of healthy lifestyles (Ofsted, 2011).

4.3 Participants

For Study one, children (8 - 11 years) were recruited from two primary schools in Coventry, UK. Year Three and Year Four children were selected since age is a major determinant of PA (Caspersen, Pereire & Curran, 2000). Boys and girls from all ethnic groups were included in the studies. A sub-purposeful sample of children and their parents was then used for the qualitative component of the research (study two and three). For study four, the children that took part in study 1 were recruited, to which they were in Year four and five. An additional year group (Year six) was recruited at this stage, to act as the control group. There were no formal exclusion criteria so that the study could be as inclusive as possible, but the following variable was considered for statistical analysis:

a. The presence of a physical impairment likely to affect physical performance however, none of the study sample had a physical impairment.

4.4 Ethnic information

Ethnic information was gained from school records in accordance with the Department for Education and Skills guidance (DFES, 2002). A SA classification included children from Indian, Pakistani and Bangladeshi ethnic backgrounds. A White European classification included children from any White and European background. Black was defined as any child from any Black African or Black Caribbean background. Any other mixed backgrounds were classified as other ethnic background.

4.5 Research ethics and consent

The study was approved by Coventry University Research Ethics Committee, written consent and assent were obtained from parents/guardians and children. Children and parents were both informed that participation in the study was voluntary and that they had the right to withdraw from the study at any time.

4.5.1 Data storage/handling

Parents/ children were informed that any information relating to them will be anonymous and a study number will be allocated to match each child on testing dates. The lead researcher was the only person with access to the data collected. Procedures for handling, storage and destruction matched the Caldicott principles and data protection act 1998.

4.5.1.1 Debrief

Participants were debriefed via an oral session which provided a broad discussion of the overall results. A written debrief was also provided to each school.

4.6 Data collection

All Chapter study one assessments (height, weight, body fat, PA and interviews) took place during the winter period (January – February 2012) when hours of sunlight were lower. A number of UK studies have shown that seasonality affects PA (Fisher, 2005; Riddoch 2007; Rich, Griffiths & Dezateux, 2012). The PEACH project (Cooper et al., 2010) reports that GPS measured PA outdoors is lowest in the winter period in primary school children, highlighting the seasonal sensitivity of GPS measured PA outdoors. Thus study one focused on winter assessments of PA to account for these differences. Qualitative data (study one and two) were collected in the spring period following the winter assessment of PA. For the final intervention study, baseline data was collected in March 2013, the intervention ran from 15th April until 31st May 2013. Post intervention measures were collected 15th to 19th July 2013, post 6-weeks intervention.

4.7 Measurement procedures: Quantitative procedures

4.7.1 Anthropometric measurement and assessment of body fat

In study one to four, anthropometric measures were taken included height, mass and body fat (more information below). Assessments were taken on an individual basis so that other children would not overhear or see sensitive information regarding individual children's height, weight or body fat.

Stature was measured using a stadiometer (Leicester portable height measure, UK). All scores were measured to the nearest 1mm in bare feet, with the child standing in an upright position, feet together and ears and eyes at a horizontal level. Body mass and body fat were measured in light indoor clothing, without shoes or socks on and were measured to the nearest 0.1kg using BIA (Tanita inc. Tokyo Japan). Height and mass scores were entered into an Excel add in software programme (LMS growth, Harlow Healthcare). The programme provides BMI-for-age value along with BMI standard deviation scores (Z scores) and percentiles based on British reference curves (1990) for children and young people (Cole et al., 1995; Cole and Pan, 1999). A systematic review concluded that BMI-for-age is a well-established method in children to identify excessive fatness (Reilly 2006b). Overweight was defined as a BMI-for-age >85th percentile and<95th percentile, and obesity as a BMI-for-age >95th percentile, in accordance with epidemiological monitoring (Cole et al., 1995). Further information regarding the benefits and limitations in the measurement of BMI are addressed in Section 2.3.1.

Two measures were used to assess body fat: foot to foot BIA and WC. More than one measure of fatness was used to provide a more comprehensive understanding of body fat in SA children, as phenotype differences show that SA's have increased fatness at low BMI.

For BIA, the height and age of the child were input into the leg-to-leg BIA (305 Tanita inc. Tokyo, Japan). The children were instructed to stand in a still bare foot position, with one foot on each of the impedance sections on the analyser. The analyser automatically estimated body fat percentage with weight and is a valid and reliable estimate in children (Jaritti, 2000; Goss et al., 2003; Sung et al., 2001; Tyrell et al., 2001). Furthemore, it is a quick, non-invasive, safe and portable measure (Kushner et al., 1990; Segal et al., 1988; Utter et al., 1999) of body fat which has shown to provide reliable results compared to the gold standard DEXA in adults (Jebb et al., 2000) and children (Sung et al., 2001). Further information regarding the benefits and limitations using leg-to-leg BIA to measure body fat in children is discussed in Section 2.3.2. All measurements were conducted in the morning at least two hours following breakfast and with an empty bladder in light sports clothing, in accordance with the leg-to-leg protocol (Sung, Lau et al., 2001). The stature and age of the child were input into the leg-to-leg BIA.

WC was measured using a non-stretchable measuring tape midway between 10th rib and the superior iliac crest. WC data were converted to standard deviation scores using an Excel add on computer programme from LMS Growth, based on reference curves for children and young people (Cole et al., 1995; Cole and Pan 1999). A review into the prognostic value of WC in assessing obesity and being able to estimate intra-abdominal fat have been highlighted in Reilly et al's (2006) review. Further information of the usefulness of WC in estimating body fat can be found in Section 2.3.4.

4.7.2 Physical activity estimation

Within these studies, PA was assessed using two methods. When the aim of the study was to examine how children use their environments for PA, then GPS and HR monitoring was used (study one). When the focus was on using activity as a self-monitoring open loop feedback tool to increase overall PA patterns, then pedometers were used (study four). A brief explanation of these methods can be found below.

Information about how children utilise their surrounding environments for PA was collected using a GPS monitor with an integrated HR monitor. The GPS receiver (the watch) calculates location by measuring the distance between the watch and three or more GPS satellites. The GPS watch constantly receives and analyses the satellite signals enabling the monitor to calculate position, speed, distance and elevation (Maddison & Mhurchu, 2009).

The HR component to the monitor provides a continuous recording of physiological response to exercise that are both reflective of duration and intensity of PA. The monitor sends the information to the GPS watch that stores the information, which can be downloaded at a later date. The information can be used in many different ways including time spent at HR intensities (i.e. 50% or 75% of individuals resting HR, Table 2.8), time spent above a specific HR (i.e. 139 bpm for all) and sustained periods of 5 minutes or 10 minutes at or above a set HR (Armstrong et al., 1990). Simons and Morton (1988) have suggested that a HR greater than 140bpm in children is representative of MVPA. However, resting HR does vary among children and can be indicative of fitness physiologic parameters. Thus, considering resting HR provides the greatest accuracy in the measurement of PA at an individual level. Study one used time spent in HR intensities as described in Section 2.2.2.3. A number of studies reporting HR information singularly (no GPS monitor) have also used this measure (Armstrong et al., 1990; Gilbey & Gilbey, 1995; Gilliam et al., 1981; Janz et al., 1992; Sallo & Silla, 1997),

The use of Garmin Forerunner 305 with accelerometers has been used to assess free living PA in studies assessing MVPA bouts of PA (Maddison et al., 2009) and walking patterns (Mackett et al., 2007). A study using GPS with HR monitoring was also able to discriminate between children's activities within locations using HR (Duncan et al., 2008), clarifying it's feasibility. Portable GPS monitors are reliable within a 3 m radius and their average bias was within the limits of agreement (Rodriquez et al., 2005, Table 2.9)). Monitoring devices are able to provide more precise, valid and reliable estimates of amount and intensity of PA (Corder, Brage & Ekelund, 2007; Metclaf et al., 2002; Rowlands, 2007; Trost et al., 2007). The GPS component makes it possible to understand the location of PA which traditional measures do not.

PA was determined using pedometers in study four, as they provided daily feedback direct to the pupils on their daily PA patterns. Luban's et al's (2011) systematic review concluded that pedometers provide an easily understandable tool for children to understand feedback about their PA patterns. Moreover, they describe that this is the most useful tool for self-monitoring and goal setting, providing an appropriate objective measure for primary school children (Lubans et al., 2011).

Each child was fitted with a NEW lifestyle (NL200) pedometer, attached to clothing and positioned on the hip (Figure 4.1). The 20 step test was conducted to ensure the pedometer was working and positioned correctly (New Lifestyles.Inc, 2002). For baseline and post intervention, the control and intervention group wore the pedometer for 7 days (wake until bedtime), recording total amount of steps at 9am and 3pm and resetting the pedometers after every recording. During the intervention, the intervention groups wore the pedometer everyday for 6 weeks. The pedometers were used during the intervention to motivate the children to achieve daily target steps. As outlined in Section 2.2.2.1, electronic pedometer are a reliable and valid measure for assessing PA in children (Beets et al., 2005; Crouter et al., 2005; Haskell et al., 1993; Klesges & Klesges, 1993 ; Nakae et al., 2008) The new NL-200 specifically has been shown to be the most accurate pedometer across different speeds (Duncan et al., 2007).

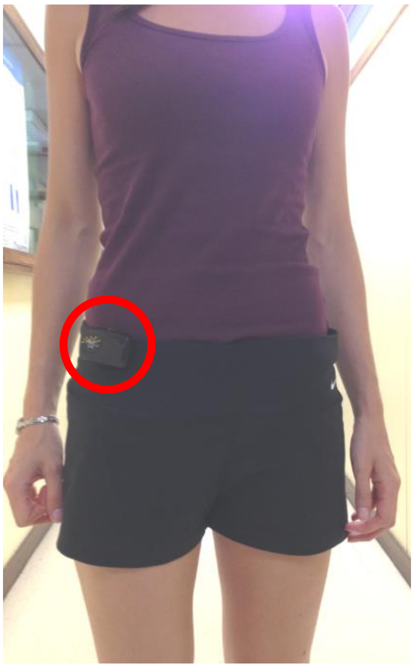


Figure 4.1 *Pedometer placement at the hip*

4.7.2.1 Validation in classification of environment type

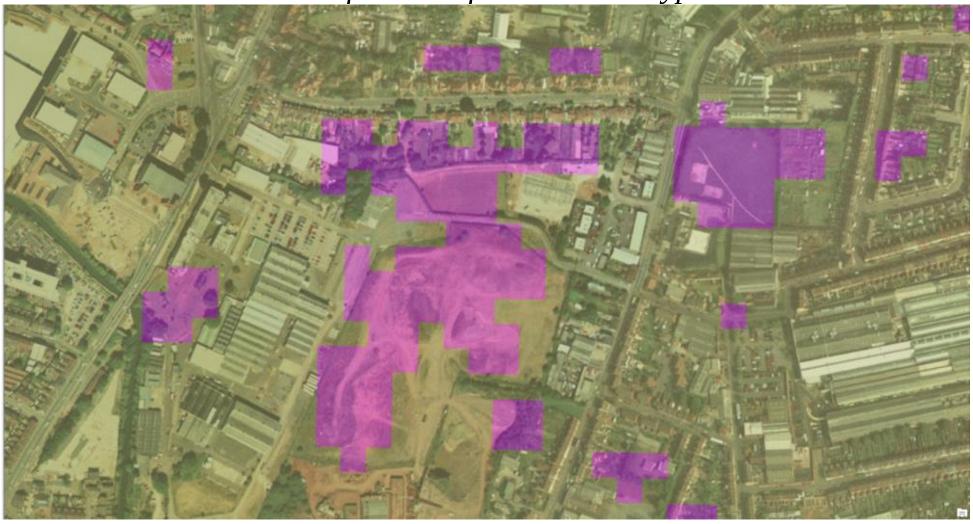


Figure 4.2: *Classification of greenspace defined using the NDVI index, greenspace defined by purple areas.*

Green-ness was firstly considered using the normalised difference vegetation index (NDVI). The measure is derived from specially processed remotely sensed images to isolate photosynthesising (green) vegetation present (Jenson, 1983). Landscape data from earth explorer (1999 – 2003) with a resolution of 30m were used to calculate NDVI in ArcGIS10 (ESRI, CA, USA). As can be seen from Figure 4.2, the resolution of the data (30m) means that in many cases, houses and greenspaces canbe misclassified and that back gardens may not be represented as greenspaces. This is due to the age of the image and basemap, and descrepancies in the data. For example, later images are polluted by lines, which are artefacts of data processes. For this reason the NDVI was deemed inaccurate to assess greenspace and so other alternative methods were sought and validated.

Time spent in indoors and outdoors environments (i.e. greenspace or non- greenspace) were determined using the theme and descriptor group, term and make coding in the Ordinance Survey data coding (Digimap, June 2013), which are further detailed in Table 4.2. These themes were reclassified as indoors, non-greenspace or greenspace in ArcGIS

10 (ESRI, CA, USA) (Figure 4.3) and data points within each location (i.e. indoors, non-greenspace or greenspace) were exported and calculated in excel.

Table 4.2 Classsification of environment type based on ordinance survey theme, descriptor and make coding.

Indoors - buildings	outdoors		exclude
	Non-greenspace	greenspace	
Structure – structure - manmade	Roads, tracks, paths – road/track – manmade	Land – GS – natural	Water – inland water – natural
Building – building - manmade	Roads,tracks,paths – path – manmade	Land – natural environment – nonconferous – natural	
	Roads,tracks,paths – roadside manmade	Land – GS – path – manmade	
	Roads,tracks,paths – roadside – natural	Land – GS- step – manmade	
	Road, tracks, paths – road/track	Land –GS – multi surface – multiple	
	Traffic calming – manmade		

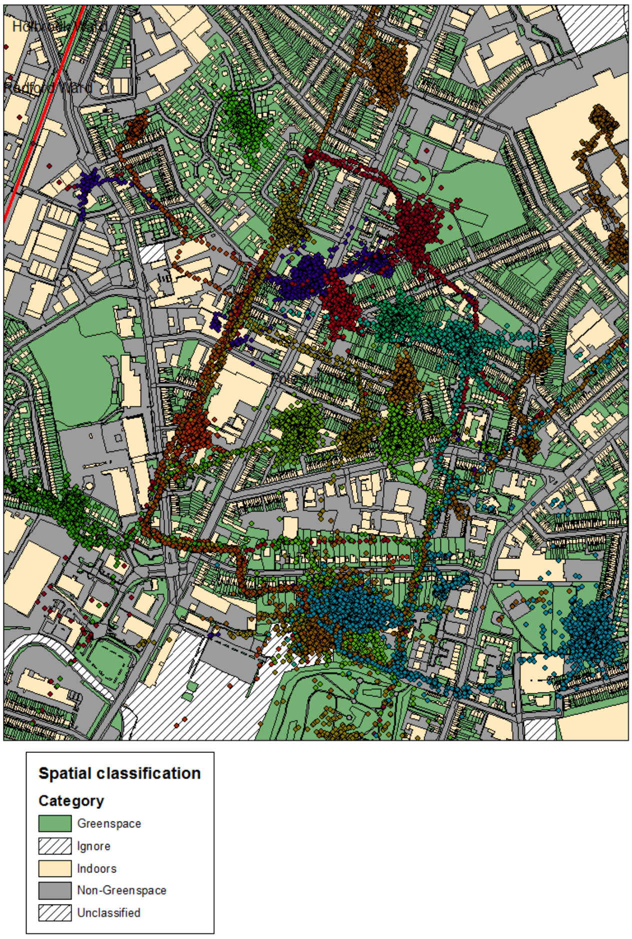


Figure 4.3 *Classification of environments based on ordinance survey data.*

Table 4.3 Classification of environment type based on manual calculations

Indoors - buildings	outdoors		exclude
	Non-greenspace	greenspace	
Houses School building Commercial buildings (shops) Religious buildings	Pavements Roads Paths Paved playground areas (at school and within local parks)	Natural land (parks) Natural land (gardens) Natural fields (school)	Streams Rivers

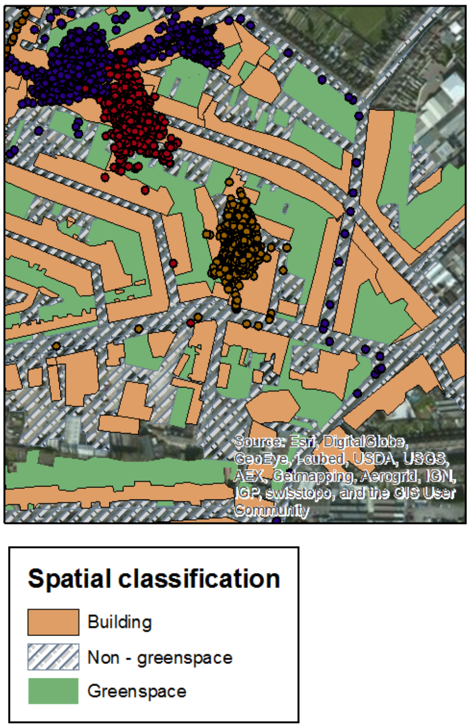


Figure 4.4: *Classification of environments from manual drawings*

In the ordinance survey analysis, multiple surfaces representing the front and back garden surrounding the house were defined as garden areas. However, front gardens within the Foleshill and St Michaels ward area were paved areas. Additionally, some gardens were natural land, some paved and some mixed. This mix of land use enables no demineralisation between building types as they represented as blocks, thus manual calculations were obtained. Polygons were hand drawn around each item feature following training from a cartographer and classified as indoor, greenspace or non-greenspace using ArcGIS 10 (ESRI, CA, USA) (Figure 5.4) and as detailed in Table 5.3. This was considered and determined based on observations in person and against the baseman in ArcGIS and in Garmin connect (Garmin Ltd, USA). Each data point within each location (i.e. indoors, non-greenspace or greenspace) were exported and calculated in excel to determine the time spent in each environment. The calculations from the ordinance survey and manual calculations were determined on 10 subjects for one weekday recording lasting 10 hours. The repeatability was assessed between time spent in each environment determined by ordinance survey and manually. The Cronbach α and intra-class correlations values indicate consistency within and across analysis for indoors ($\alpha = 0.96$, ICC = 0.96), non-greenspace ($\alpha = 0.85$, ICC = 0.79) and for green ($\alpha = 0.64$, ICC = 0.63). Repeated measure t test revealed no significant difference between indoors, green and non-green calculations made from the different methods ($P = >0.05$).

4.7.3 Statistical analysis of quantitative data

All descriptive variables performed using the Statistical Package for Social Sciences (SPSS) version 12 (SPSS INC. CHICAGO, IL). Shapiro-Wilk test of normality was conducted prior to the data analysis to confirm that data met the pre-requisitions for parametric statistical analysis. A number of specific statistical tests were then used which are detailed in each study Chapter.

4.8 Measurement procedures: Qualitative procedures

The second component to the study involves a qualitative element in order to provide more detailed information from a smaller sample, which is informationally representative (Cottrell & Mckenzie, 2011). The qualitative element provides non numerical data to understand assumptions of PA behaviour in physical environments. It is subjective but rich, providing meaning and understanding of real experiences and behavioural patterns. Qualitative information is able to support and explicate the meaning of why in supplement of quantitative data it will provide a bigger picture of how the built environment might affect activity behaviours (Gratton & Jones, 2010). However, it must be understood than objective and subjective data are not also supportive of each other. For instance, on an objective level children might be more active in parks, however on a subjective level children might perceive the parks as unsafe and spend more time in other activity environments. This will be considered during the analysis.

4.8.1 Interviews

Interview techniques were utilised for both children (study two and four) and adults (study three). Interviews are a useful way to gain in depth information about behaviours for children from similar environments but different ethnic backgrounds and gender. They enable culture and social environments to be explored as well as physical environments that drive behaviour. A sem- structured interview guide was used for both children and adult questioning, which is described below. Having a semi structured interview guide is useful because it utilises open questions, which can generate rich responses compared to interviews or questionnaires (Wilkinson, 2004). The topics/questions are only used as a guide and so the interviewer can be flexible in the order of the questions and thus this allows the interviewee the freedom to talk about topics and issues in a way that might be more relevant to their talking and thinking patterns. It provides freedom and flexibility, allow respondents to build upon the responses of other group members and the relatively free flow of talk can provides an pportunity for hearing the language and experiences of the respondents' (Wilkinson, 2004). This might be more appropriate for those who originate from different cultures where English might not be a first language and also in children. However, it requires the interviewer to be aware of what might have already been discussed (Flick, 2002). Semi structured interviews do provide a degree of standardisation in which comparison can be made between groups. This is important in enabling the children and adults from different ethnic backgrounds to feel comfortable.

Focus group interviews are beneficial because they are a flexible, useful way of capturing children's experiences. They also give children the flexibility to put them into their own words, which enables the researchers to see things from a children and parents' perspective. Group discussions are useful for children because they allow them to hear from other children, to reflect on these experiences or thoughts and refine their own, which can deepen insight. This provides support for remembering events that go beyond that of an individual interview (Flick, 2002) and thus is an appropriate way to overcome any problems children may have in remembering. Using heterogeneous and homogenous groups is said to generate discussion, reveal meaning, generate diversity and differences (Flick, 2002). Heterogeneous focus groups provide opportunities to explicit differences, which may be useful when making comparisons between ethnic and gender groups (Ritchie & Lewis, 2005). It is anticipated that the presence of classroom peers opinions will also aid discussion and provide a relaxed atmosphere.

Focus groups are efficient, cost effective and stimulate answers by the interaction of a group over a shorter time period, which produces data (Flick, 2002; Hesse - Biber & Leavy, 2010). The data generated can be extremely useful for intervention planning. It also enables greater understanding of PA behaviours and how they people perceive the physical environment might influence their behaviours. The children in this study were pre-pubertal and were likely to be influenced by parental constraints and/or behaviours. Therefore, parental interviews were conducted to provide understanding of children's PA behaviours.

4.8.2 Analysis of qualitative data

All interviews were recorder using a digital dictaphone (Olympus VN-750, Tokyo). The Dictaphone had a battery life of 36 hours and thus the tape didn't need to be swapped which didn't affect the flow of the interview. The researcher practiced mock interviews and had prior experience of interviewing, which reduced anxiety and minimised non-verbal behaviour leakage (King & Horrocks, 2009). The researcher facilitated the interviews by being empathetic, a good listener, persuasive and also mediating between participants in order to encourage reserved members to be involved and provide their view as suggested by Flick (2002). All interviews were transcribed verbatin using Microsoft word and were second checked against the recording to provide the most accurate transcription (Flick, 2002). The transcripts were analysed for reoccurring themes by the researcher. These were second checked by an experienced researcher (supervisor MD) to minimise error and reduce bias. Thematic analysis is a widely used way to identify, analyse and explore patterns within qualitative data. The following steps were used as guided by Braun and Clarke (2006):

1. Familiarisation of the data by repeatedly reading the transcripts, searching for meanings or patterns. At this point notes will be taking and ideas for codes. Transcription will also provide a basis of becoming familiar with the data.

2. Generation of initial codes: start to create codes to the data whereby the data begins to be organised into meaningful groups based on data driven. This will be done manually instead of a software programme.

3. Searching for themes: this section focuses on producing themes instead of codes. This is where codes begin to be grouped together under different themes known as an overarching theme. Mind maps will be utilised to organise codes into themes which will then be shown in a table for ease in interpretation. Sub themes may also be needed.

4. Reviewing themes is the fourth stage. This section refers to refining themes created in stage three. The first component of review is concerned with the codes and the second with the themes identified. It is crucial to determine at this stage whether the themes

accurately provide an account of the data set which is meaningful as a whole. The data is set is thus re read.

5. Defining and naming themes. This is where it will be decided what each of the themes is about. A detailed analysis will then be written for each theme to define what it tells about the data.

The interviews were continued until point of redundancy (Schensul & LeCompte, 2010).

4.9 Validation of quantitative and qualitative methods.

When using mixed methods (quantitative and qualitative techniques) the results are providing two different perspectives on the environment and behaviours. However, when this information is combined despite addressing in theory the same issues the difference perspectives might not replicate each other, but might provide an extended understanding of why these might differ. Triangulation is a method that can be used to check inferences drawn from different methods or sources. Triangulation does not provide absolute validation because it is hard to assess this when there is no single reality in qualitative data. Despite this it can add breadth and depth to analysis from multiple perspectives (Ritchie, 2005). The sources of information derived from study one to three were taken collectively in order to understand how objective assessment impacts environmental influence on PA. The qualitative responses in study two and study three were used to gain rich information about the context and to understand perceptions affecting the objectively assessed PA behaviour (study one). These findings were taken collectively to provide a focused intervention in study four.

5.0 STUDY ONE: PHYSICAL ACTIVITY PATTERNS OF ETHNIC CHILDREN FROM LOW SOCIO-ECONOMIC ENVIRONMENTS IN COVENTRY, UK.

5.1 Abstract

Introduction: Many children fail to meet physical activity (PA) guidelines for health benefits. PA behaviours are complex and depend on numerous interrelated factors. The study aims to develop current understanding of how children from low socio-economic environments within the UK, use their surrounding built environments for PA by using advanced technology.
Method: The environment was assessed in 96 school children (7 – 9 years) using GPS monitoring (Garmin Forerunner, 305). In a subsample of 46 children, the environment and PA was assessed using an integrated GPS and HR monitor. The percentage of time spent indoor, outdoor, in green and non-greenspace environments along with time spent in MVPA in indoor and outdoor environments were assessed. A 2-by-2 repeated measures ANCOVA, controlling for BMI, body fat, assessed environmental differences.
Results: The findings show that 42% of children from deprived wards of Coventry fail to meet PA guidelines, of which 43% was accumulated during school. Children engaged in more MVPA in outdoor than indoor environments ($P = <0.01$) and a greater amount of time was spent in non-greenspace environments ($P = <0.01$). Increased time outdoors was negatively associated with body fat.
Conclusion: To conclude, outdoor environments may ne important for health enhancing PA and associated with reduced fatness in deprived ethnic children.

5.2 Introduction

Large numbers of children are obese and continue to have obesity related complications, causing a global health burden (WHO, 2010). The benefits of engaging in PA for weight management (Reichert, et al., 2009), physiological and psychological health is acknowledged (Janssen & LeBlanc, 2010; WHO, 2010). Children who engage in more PA have less fatness and improved cardiovascular risk profiles (Andersen Riddoch, Kriemler & Hills, 2011, as described in Section 2.1). However, many children fail to meet the recommended 60 minutes of health enhancing PA per day, and even fewer when ethnicity (e.g. SA) is considered (Eyre & Duncan, 2013a; Eyre, et al., 2013b; Owens et al., 2009).

The determinants of PA behaviour are complex and depend upon a number of factors including SES and environmental influences. As discussed in Section 3.1, the physical environment refers to all features that children encounter in their neighbourhood (Sallis & Glanz, 2006) and these features are associated with inactive and/or unhealthy behaviours (Mot et al., 2011; Swinburn et al., 2011; Zhu & Lee, 2009). Understanding how aspects of the environment shape PA and obesity is important because children spend a large proportion of their time in these environments, playing, living and being educated.

A systematic review by Dunton et al., (2009) reports a lack of strong empirical evidence for most environmental factors. This is because of the lack of consistency in results and variances in findings, which were dependent upon population, age and SES. For example, the neighbourhood where an individual resides is affected by SES (Fernandes & Sturm, 2010; Kimbro, Brooks-Gunn & McLanahans, 2011) but the findings are equivocal. In some studies, low SES areas are associated with greater public open spaces, increased amenities (i.e. cycle paths and trees) (Crawford et al., 2008), and increased walkability, thus increasing PA (De Meester et al., 2012, 2013; Kimbro et al., 2011; Zhu & Lee, 2008). In others, low SES is associated with reduced PA (Bolte, Tamburlini & Kohlhuber, 2010; Griew, Page, et al., 2010; Pabayo et al.,2011; Panter et al., 2010; Spengler et al., 2011), the causes of which may in part relate to poorer access and provision of playground facilities (as described in Section 3.1).

Ethnicity is also a key socio-demographic variable that needs considering. Ethnicity appears to be associated with deprivation but the direction of these effects are also conflicting (Conrad et al., 2013; Franzini et al., 2010). In non-White neighbourhoods, Franzini et al., (2010) reported increased poverty, increased access to facilities for PA but low parental perceptions of these environments (i.e. less safe, comfortable and pleasurable for outdoor PA). However, Conrad et al. (2013) suggests that children in low SES areas spend more time outdoors.

The lack of consistency in the role of the environment on PA patterns across studies may be due to methodological weaknesses and failure to account for the combined influences relating to the population and SES (Dunton et al., 2009). Scarce previous research has explored SES and ethnic differences in the PA of youth by objectively tracking young people's movement patterns. Using GPS monitoring enables insight into how youth from differing ethnic backgrounds may utilise their surrounding built environment for PA.

Furthermore, the wealth of information comes from non-UK studies and so the direct application in terms of built environments, SES and ethnic groups in the UK is limited. In order to undertake such a study within the UK, geographical areas are needed that have high levels of deprivation and a high ethnic mix. In the UK, people from SA backgrounds have been described as living in the most socio-economically disadvantaged areas (Jayaweera et al., 2007; Williams et al., 2009). Specifically, Coventry is ranked 52nd out of 326 local authority districts (1 being most deprived). In comparison to England as whole, the ethnic population of Coventry is increased (17% Black and 6% Asian vs 26% and 12% Asian for England and Coventry respectively), with large ethnic populations residing in the most deprived areas (Coventry City Council, 2010). In the two most deprived wards in Coventry (i.e. Foleshill and St Michael's), Asian and Black people make up 44 - 61% of the total population. In addition, studies objectively measuring PA in Coventry have found that 67% of all children meet the current PA guidelines, but this adherence is lowered in SA children (35%) (Eyre et al., 2013b). Therefore, the primary aim of this study was to develop current understanding of how children from a low SES area within the UK use their surrounding built environments for PA by using advanced technology (GPS). The secondary aim was to consider how ethnicity may influence the physical activity behaviour of these children.This study thus attempts to address the following research questions; (1) How do children from deprived backgrounds use their surrounding environments for MVPA? (2) Do SA and White children use their surrounding environment similarly for MVPA? (3) Is time spent in specific environments associated with BF?

5.3 Method

An observational design was employed to collect data on 96 primary school children's (7-9 years, White = 24, SA (Indian, Pakistani, Bangladeshi) = 60, other = 14) PA patterns during winter (23rd Jan 2012- 13th Feb 2012). Height, mass, WC and BF were measured, BMI calculated as described in Section 5.8.

5.3.2 Measurement of the physical environment and PA

The measurement of location was determined using a GPS device. This was synchronised and wirelessly connected with a HR monitor (HR) to measure PA (Garmin Forerunner 305, Garmin Ltd, USA), sampled at 10second epochs. GPS monitoring is a reliable measure of PA (Maddison et al., 2010) with its feasibility in both British (Collins, Al-Nakeeb, Nevill & Lyons, 2012) and international children reported (Duncan, Badland & Schofield, 2009; Fjortoft, Kristoffersen & Sageie, 2009; Fjortoft, Lofman & Thoren, 2010).

5.3.2.1 Procedure

The GPS devices were fitted to a wrist of all consented children at school on the initial wear day by a trained researcher who instructed the children on how to operate the monitor. The HR monitor was also fitted around the chest at the sternum and tightened accordingly (Figure 5.1), in a subsample of children (n= 46) due to feasibility. All participants wore the monitor for four consecutive days including two weekend days (Friday, Saturday, Sunday, and Monday) from 9:00am to 9:00pm. Any participants that did not record four days monitoring data were omitted. A four day monitoring period was chosen because the reliability of four days activity to be representative of a full week's physical activity (r = 0.80, r-0.71 to 0.78) is reported in prior research (Riddoch, 2004; Janz et al., 1995), as discussed in Section 2.2.3. Data were included in the analysis if there was 180 minutes of data per day, this is consistent with previous GPS monitoring in British children (Collins et al., 2012). At this stage, 23 children failed to record 180minutes GPS data. This left a final sample of 73 children (76% response rate) of which nine were from other backgrounds and so data will be presented on 64 children from White or SA backgrounds. From the children excluded from the final analysis, 25% were overweight or obese. This is consistent with overweight and obesity data from the National Child Measurement programme for England and Coventry (NHS, 2010) and thus fatness is not deemed a bias in this PA study relating to lack of compliance.

All the GPS units were given a cold start (initialised) in a stationary outdoors environment as recommended by Duncan and Mummery (2007). When the monitor is first initialised it acquires a satellite signal, during this the atomic clock with the satellite signal is synchronised with the GPS clock (Madison & Mhurchu, 2009). This was done during the fitting and took no longer than one minute (Maddison et al., 2010). Participants were instructed to remove the monitor for water based activity and during sleeping. The battery on the GPS monitor operates a short life of 12-hours and consequently the monitors needed to recharge at home during sleeping periods. Children and parents were shown how to charge the monitors and reminder instructions were sent home. All monitors were returned to school and collected from school on Tuesday morning. Information of how the monitor operates to record location and PA can be found in Chapter 5.1.8.2.1.1 along with the advantages and disadvantages of the method in section 2.1.2.7.2.

5.3.2.2 GPS analysis

The data were downloaded from the monitor to Garmin training centre and Garmin connect (Garmin Ltd, USA) where they were converted to the KML format. The KML file containing the data were manually cleaned for erroneous data points, mapped and analysed in ArcGIS 10 (ESRI, CA, USA) for time spent in different environments. These environments were classified into street, greenspace, house, school (school field, school playground, school indoors), garden and indoor building (any other indoor building) (Figure 6.2). Calculations were made for time spent in indoor environments, which were classified as house, other building or school building. Outdoor environments were classified together as greenspace and non-greenspace. Greenspace was defined as park, public gardens, children play areas, outdoors sports facilities (playing pitches, sports grounds), woodlands, nature reserves, allotments, and linear greenspace in accordance with Coventry City Council, (2010) and is congruent with other studies (Jones et al., 2009; Wheeler et al., 2010). Non-greenspace was defined as buildings, built land (car park, hard surface play areas), road and pavements as stated in Coombes, van Sluijs and Jones (2013). The final calculations made were; average daily minutes in each environment for weekday, weekend and all days, percentage of the total time spent (i.e. total minutes in school/ total recorded time for all environments) in each environment for weekday, weekend and all days, as used in the PEACH project (Wheeler et al., 2010).

Non-greenspace was defined as buildings, built land (car park, hard surface play areas), road and pavements. This is consistent with prior definitions of such environments

(Coombes, van Sluijs & Jones, 2013). Average daily minutes in each environment and the percentage of the total time spent (i.e. total minutes in school/ total recorded time for all environments) in each environment were calculated. These calculations were made for weekdays, weekends and all days and are consistent with the calculations used in the PEACH project (Wheeler et al., 2010).

Figure 5.1 *Monitor placements for integrated GPS and HR monitor*

5.3.2.3 HR and GPS analysis

HR and location (Garmin connect and Google earth) for time and day (Garmin training) were manually cleaned and calculated in a subsample of children. These data were then used to calculate time spent in environments such as indoor, outdoor as well as percentage of the time spent in these environments that represented moderate and vigorous PA (MVPA). The intensity of PA was assessed as 50% of HRR (moderate) and 75% (vigorous) (Ridgers & Stratton, 2005, Table 2.8). Resting HR reserve was assessed as the average five lowest HRs during the sampling period in accordance with Ridgers and Stratton (2005). This method considers individual variation in resting HR and intensity thresholds between children instead of using generic PA cut points such as <120bpm (inactive), 120–139bpm (low to moderate), 140–159bpm (moderate to vigorous) and >160bpm (vigorous) which have been used in previous studies (Collins et al., 2012; Fjortoft, et al., 2010). The percentage of MVPA time (time in MVPA/ total time recorded)*100) was then calculated for daily (average of all days), week (average of weekdays) and weekend (average of weekend). Total daily minutes in MVPA were also assessed to determine whether children were meeting current PA guidelines for health (60minutes of MVPA daily) (WHO, 2010).

5.3.3 Statistical analysis

All analyses were conducted using SPSS version 20. The alpha level was set at p= <0.05. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to assess normality. All data were normally distributed (p >0.05). Independent t-tests assessed ethnic and gender differences in anthropometric variables (BMI, BMI z-scores, BMI centile and body fat). Following this, Pearsons product moment correlation's assessed the associations between environmental conditions and fatness (BMI, body fat %). A 2 (i.e. indoor weekday vs. indoor weekend) by 2 (i.e. male and female) repeated measures ANCOVA, controlling for independent covariates (BMI, body fat % separately) was used to assess any effects of day and sex on time spent in different environments. A 2 (i.e. White vs. South Asian) by 2 (i.e. male and female) ANCOVA, controlling for independent covariates (BMI, body fat, WC separately) assessed ethnic differences in time spent in different environments. On the subsample who also had their HR recorded (n = 46, SA = 25 and White = 21) a paired t-test was used to assess differences in time spent in MVPA between environmental conditions (i.e. indoors vs. outdoors). Independent t-tests were used to assess ethnic differences in MVPA between environmental conditions. 95% confidence intervals (CIs) and effect sizes using cohens d were also calculated for ethnic and gender differences for descriptive variables and time spent in environments, and for estimated time spent in moderate to vigorous physical activity in different environments.

5.4 Results

The means and SD's are displayed in Tables 5.1 & 5.2. The final sample included 63% normal weight children , 30% of overweight/obese children and 7% underweight (BMI = 17 ± 3 kg/m^2, Body fat % = 23 ± 9 %) with an average GPS recording time of 388 ± 179 minutes. No significant ethnic or gender differences were found for anthropometric variables (Table 5.1).

Table 5.1 Descriptive variables by sex and ethnicity

	All n = 64	Males n = 30	Females n = 34	*P* (95% CI of gender difference)	*d*	South Asian n = 46	White n = 18	*P* (95% CI of the ethnic difference)	*d*
Height (cm)	130 ± 7	130 ± 8	131 ± 7	0.60 (-3, 4)	0.13	130 ± 7	133 ± 8	0.21 (-7, 2)	0.41
Weight (kg)	31 ± 9	31 ± 10	30 ± 7	0.53 (-3, 6)	0.001	29 ± 8	33 ± 11	0.40 (-7, 3)	0.45
BMI (kg/m2)	17 ± 3	18 ± 4	17 ± 3	0.65 (-1, 2)	0.29	17 ± 3	19 ± 4	0.62 (-3, 2)	0.61
BMI centile	60 ± 31	61 ± 33	59 ± 30	0.68 (-12, 18)	0.06	57 ± 31	70 ± 31	0.55 (-24, 13)	0.42
Body Fat (%)	23 ± 9	22 ± 10	22 ± 9	0.73 (-6, 4)	0.001	22 ± 9	23 ± 9	0.73 (-11, 1)	0.11
Waist Circumference (cm)	57 ± 25	57 ± 29	57 ± 21	0.23 (-3, 12)	0.001	57 ± 24	57 ± 21	0.67 (-14, 1)	0.00
Waist circumference centile	57 ± 43	46 ± 46	65 ± 37	0.70 (-24, 16)	0.46	57 ± 42	52 ± 45	0.35 (-32, 12)	0.12

Mean ± SD

Table 5.2. The percentage of time spent in environments (n = 64)

	Indoor	Outdoor	***d* for indoor to outdoor difference**	**95% CI of difference between indoor and outdoor**	Greenspace	Non-greenspace	***d* for greenspace to non-greenspace difference**	**95% CI of difference between greenspace and non-greenspace**
	Percentage of time spent				**Percentage of time spent**			
All days	41 ± 25	59 ± 25*	-0.72	-28 to -8	18 ± 12	41 ± 19#	-1.21	-29 to -17
Weekdays	32 ± 22	68 ± 22*	-1.64	-45 to -27	20 ± 12	48 ± 19#	-1.47	-34 to -22
Weekend	49 ± 29	51 ± 29	-0.07	-14 to -10	18 ± 20	33 ± 19#	-0.79	-23 to -7

Mean ± SD adjusted for body fat.

* >indoors (*P*<0.01), #<greenspace (*P*<0.01)

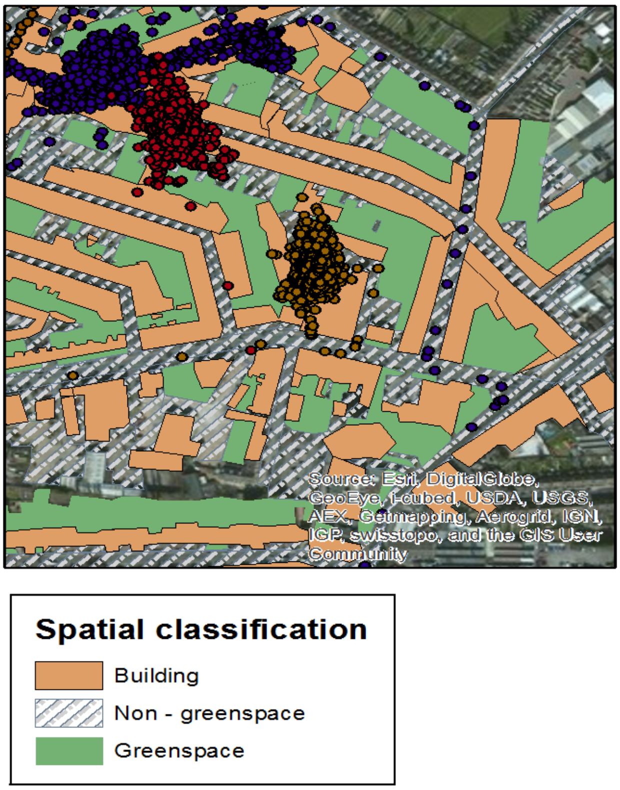


***Figure* 5.2** *classification of environments*

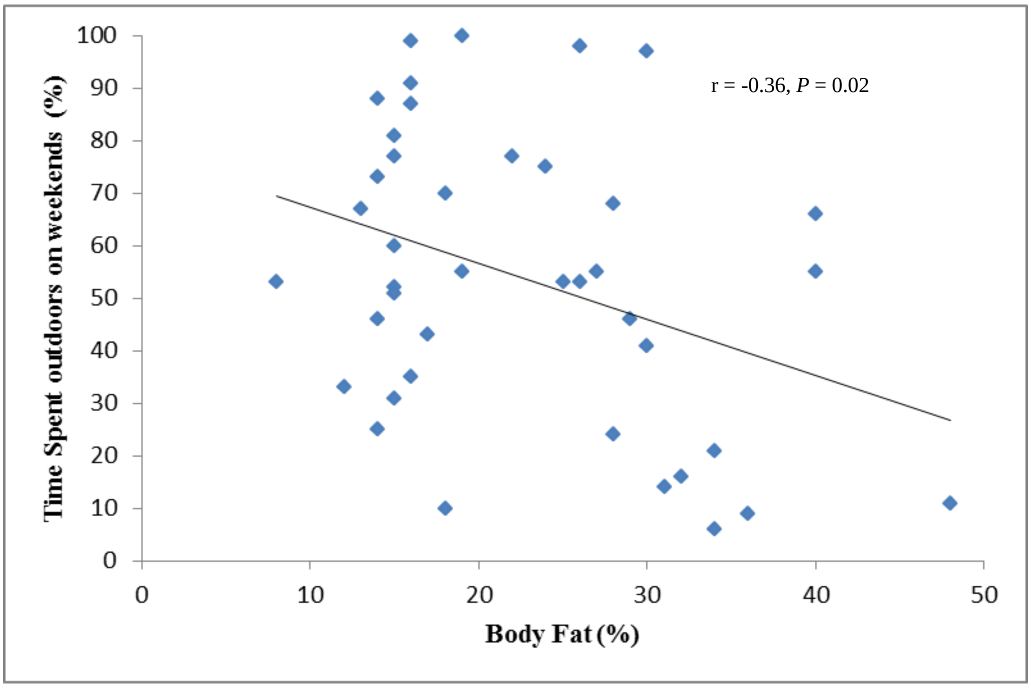
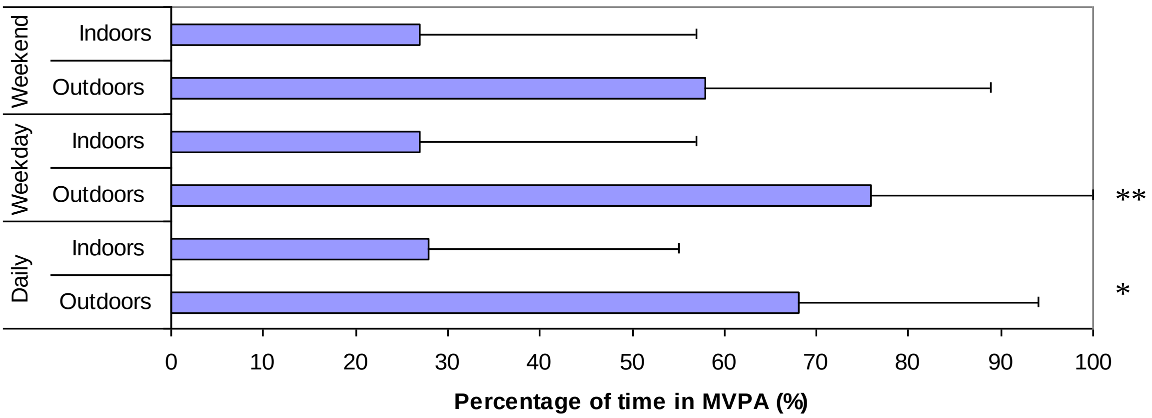


***Figure* 5.3** *Relationship between time spent outdoors (average of weekend days) with body fat (%).*



** *P* = >0.01, * *P* = 0.01

Figure 5.4 *Percentage of time in MVPA for daily, week and weekend activity.*

5.4.1 GPS environmental data

5.4.1.1 Environment and fatness

The results showed a significant positive relationship between the percentage of total time spent in indoor environments on weekends with body fat % (r = 0.39, *P* = 0.02) and BMI Z-score (r = 0.28, *P* = <0.05). Spending a greater percentage of total time in outdoor environments was negatively associated with body fat (r = -0.36, *P* = 0.02, Figure 5.3). The percentage of time spent in non-greenspace was negatively associated with BMI (r = -0.26, *P* = <0.05).

5.4.1.2 Day (weekday vs. weekend) and sex effects on time spent in the environment

Results from repeated measures ANCOVA indicated a significant day by sex effect for percentage of time in outdoor environments (*P* = 0.02). Females spent less time engaged in outdoor environments on weekdays than weekends (32 ± 4% vs. 54 ± 3%, 95% CI, -23, -21%, *d* = 6.22, controlled for BMI). When other anthropometric variables were controlled, similar findings were observed (body fat *p* <0.01, WC *P* = 0.01). Percentage of time spent in non-greenspace was also significantly lower on weekdays (15 ± 7% vs. 31 ± 6%, 95% CI, -18, -14, *d* = 2.45, *P* = 0.01, controlled for BMI). In addition, males spent more time outdoors on weekdays than weekends (41 ± 5% vs. 33 ± 44%, 95% CI, -

1, 17, d = 0.26, P <0.01). When other anthropometric variables were controlled, similar findings were observed (body fat P <0.01, WC P = 0.01). No day by sex effects were observed for percentage of time indoors (controlled for BMI P = 0.17, body fat P = 0.22, WC P = 0.14) or percentage of time in greenspace (controlled for BMI P = 0.08, body fat P = 0.15, WC P = 0.05)

5.4.1.3 Indoor vs. outdoor environments

No sex differences were observed between engagement in time indoor or outdoor environments for all days, weekday or weekend day (P >0.05). Children spent a significantly greater percentage of time in outdoor environments than indoor for all days (mean difference = 18%, P >0.01) and weekdays (mean difference = 36%, P >0.01), controlling for body fat % (Table 5.2). These differences were not found when BMI was considered or for weekend days (P >0.05).

5.4.1.4 Greenspace vs. non-greenspace

No significant sex differences were observed for greenspace compared to outdoors for all days, weekdays or weekend days. Children spent a greater percentage of time in non-greenspace compared to greenspace for all days (mean difference = 23%, P >0.01), weekdays (mean difference = 28%, P = 0.01) and weekend days (mean difference =15%, P >0.01), adjusted for body fat (Table 5.2).

5.4.2 GPS environment and activity intensity data

HR data were also collected on a subsample, 42% of children met the current guideline of 60 minutes of MVPA. Of this time in MVPA, 43% was achieved at school, 23% from playing outside (street/garden), 20% at home and 14% from active travel (walking one journey).

5.4.2.1 Percentage of time in MVPA in outdoor and indoor environments

Results indicated no significant differences in time spent in MVPA outside on weekdays or weekend days, or total MVPA for weekdays compared with weekend (p >0.05). However,time spent in MVPA indoors was greater on weekdays than weekends (41 ± 30% vs. 17 ± 20%, 95% CI, 18, 39%, d = 0.94, P = 0.01, Figure 5.4).

5.4.2.2 Percentage of time spent in MVPA in outdoor vs. indoor environments

Children spent more daily (average week and weekend) time in MVPA in outdoor than indoor environments (59 ± 45 vs. 27 ± 27%, 95% CI, 15, 49%, d = 0.86, P = <0.01). Time spent in MVPA in outdoor environments was greater than indoor environments for both week (76 ± 24% vs. 31 ± 29 %, 95% CI, 29, 60%, d = 1.69, P = <0.01) and weekend days (49 ± 35% vs. 23 ± 30%, 95% CI, 10, 42%, d = 0.80, P = 0.01), Figure 5.4).

5.4.2.2 Time spent in MVPA and fatness

There was no significant relationship found between BMI, BMI Z-score, body fat and time spent in MVPA for outside, inside, on week, weekend or all days (P >0.05).

5.4.3 Ethnic differences

The results showed no significant ethnic differences in time spent indoors (week), outdoor (weekday and weekend), greenspace (weekday and weekend) or in outdoors other (weekday and weekend), p = >0.05. However, SA children spent significantly more time indoors on weekends when compared to White children (52 ± 5% vs. 34 ± 7%, 95% CI for difference in time spent indoors in White vs. SA, 2, 34%, d = 2.96, P = 0.03). For MVPA, no significant ethnic differences were found for time spent in MVPA (weekdays or weekends) or MVPA outside (p >0.05). Yet, SA children achieved significantly less MVPA indoors than White children (17 ± 6% vs. 33 ± 46%, 95% CI for difference in MVPA in White vs. SA difference, -1, -32%, d = 0.49, P = 0.04).

5.5 Discussion

The major novel finding of the study is that adherence to the 60 minutes of daily PA guideline is very low in low SES groups (42%). Further research needs to compare these findings against high SES children to ascertain whether such low levels of PA are only seen in children from deprived wards. To answer the research question of how do children from deprived backgrounds use their surrounding environments for MVPA, the findings show that children spend little time engaged in greenspace for activity. These findings support the theoretical models presented in Figure 3.2 and 3.3 whereby macro-environmental factors relating to SES, result in less time outdoors and thus lower PA. Children thus spent greater time in non-greenspace environments closer to home than local greenspace environments. In response to the second question (Do SA and White children use their surrounding environment similarly for MVPA?), SA children spent more time indoors but less of this time in MVPA than White children. The mechanisms behind this may relate to physical and social environmentsl factors and socio-economic challenges within deprived areas such as limited provision and accessibility of greenspace in the area as well as high crime rates resulting in low perception of safety. However, this will require further investigating. Finally, to answer the final question (Is time spent in specific environments associated with BF?), increasing time spent in outdoor environments was associated with health enhancing PA and reduced body fat.

5.5.1 Environment and body fat

The results show that spending more time in indoor environments was associated with greater fatness. In addition, spending more time outdoors and specifically in non-greenspace environments was associated with lower fatness. However, the associations were weak and the cross sectional nature of the study limits the ability to infer cause, thus it is not known whether there was reverse causality. When MVPA time in environmental conditions was considered, no relationship was evident with measures of fatness. The lack of relationship between MVPA in different environments and fatness could be due to a number of reasons. Firstly, fatness differences exist between White and SA children (Deurenberg, Chew & Deurenberg, 2002; Nightingale et al., 2011; Saxena et al., 2004) and the existing criteria for determining fatness is validated in White populations, providing mean bias in ethnic populations (Haroun et al., 2010). The lack of ethnic specific cut points thus might make this challenging (Jebb et al., 2000; Frisard et al., 2005; Sun et al., 2003). The majority of the study sample was SA which may limit associations. In addition, factors leading to obesity and 'obesogenic environments' are complex, which might not have been captured during this analysis. Finally, the measurement of activity came from HR which is the response to activity; energy expenditure might be more important. Body fatness was estimated using BMI, WC and body fat (%), which may also limit associations. The problems in the association between PA and body fat have been previously described in Section 2.1.2. In future studies using both GPS, HR monitoring and accelerometry, could provide detailed information regarding PAl behaviour and the physical environment.

5.5.2 Environmental differences

The findings show that females spent more time in outdoor environments on weekends than weekdays, which was attributed to increased time in non-greenspace environments. For males, no differences were found in time spent in outdoor environments (weekdays vs weekend) even though males spent less time in non-greenspace on weekend days than weekdays. Given that the children have the same exposure to non-greenspace at school; the sex differences observed appears to relate to engagement with the environment outside of school hours. The social, cultural and environmental influences might explain some of these differences, but further research is needed to explore this. The notion that young children are not autonomous in their decision making and so parental constraints limit their activity behaviour are supported by prior research (Brockman, Jago & Fox, 2011; Veitch et al., 2010). However, these constraints might be experienced differently amongst sexes. The PEACH project found males had greater independent mobility than females and that increased independent mobility was associated with increased play, PA and active travel in children (Page, et al., 2010). Another large study using GPS monitoring and accelerometer was able to explore this is more depth and found that males were more likely to roam outside of their neighbourhoods where as females used the garden and street spaces for PA (Jones et al., 2009b). During winter months, the hours of sunlight are reduced which may limit time available for PA in females for whom parents might exert more constraints due to safety concerns. This is supported by Pabayo et al., (2011) who found increased MVPA with greater deprivation in males when measured objectively but that greater deprivation in females was associated with lower MVPA.

In addition, cultural factors may inhibit time spent in environments and also affect parental constraints. A large proportion of the sample was made up of SA children and parental restrictions on activities might be experienced differently for SA females and males. Moreover, socio-economic and environmental issues must be considered. For both males and females a large proportion of their outdoors PA is made up of non-greenspace, which suggests that children spent most of their time playing in the street. This agrees with prior research on this topic (Wheeler et al., 2010), which shows that non-greenspace is facilitative of PA. These findings highlight the importance of understanding non-greenspace for PA in deprived neighbourhoods in the UK. It is not known whether living in a deprived area might affect parents' safety concerns and result in the children playing closer to home (i.e. street) instead of in greenspace, these issues are explored further in study two and three. The consensus data for these two Coventry wards suggest that 33% and 41% of the community perceive their neighbourhood as unsafe at night (Coventry City Council, 2010). Secondly, the greenspace provision in these wards is described as deficient across all areas (i.e. park, greenspace, outdoor sport, pitches, provision for young children and allotments) (Coventry City Council, 2008). In previous research (identified in Table 3.1), greenspace was identified as facilitative to PA. The availability of recreational space or public open spaces (e.g. park, playgrounds, playing fields or courts) and proximity to these sites were associated with increased activity (Chomitz et al., 2011; Grow et al., 2008; Loureiro et al., 2010; Nielsen et al., 2010; Timperio et al., 2008; Vietch et al., 2010). In addition, Foleshill and St Michaels wards used in this study have the highest population density (56.8 per hectare and 51.8 per hectare vs mean 39.8 per hectare), resulting in high numbers of flats in blocks, flats/apartments, shared dwellings and the lowest percentage of owned houses (Coventry City Council, 2011).

Therefore, it is clear that both provision of greenspace is low and safety concern high within the environments examined in the present study. These are likely to be a main cause of increased engagement in non-green environments (which from observation were close to home) in the autumn for PA. It is also apparent that outdoors PA and school is important for health enhancing PA but that environmental and SES factors are key determinants of behaviour. Future research needs to assess the mechanisms and perceptions of the environment relating to PA behaviour. Understanding how patterns of behaviour are affected by hours of sunlight (i.e. changes in greenery with seasons) also needs further exploration.

The results of the current study indicate that less than half of the children from low SES and ethnic backgrounds meet the current PA guidelines. Low levels of adherence to PA in SA children are already described in the CHASE study and other research (Eyre & Duncan, 2013a; Eyre et al., 2012b; Owens et al., 2009). However, in this current study the adherence is lower, this could be due to the specific socio-economic groups assessed i.e. the two most deprived wards and monitoring by HR not accelerometry. Secondly, of this time spent in MVPA, PA in school contributed to nearly half of this (43%), which was higher than the mean reported from previous literature in Table 2.1. This highlights the importance of the school environment for increasing PA in low SES environments. A further 14% was achieved from active travel (14% walking one journey), this was lower than the mean of 21% found in previous literature reported in Table 2.1, and could reflect a range of factors (e.g. distance, connectivity). A further 23% was achieved by playing outside (i.e street/garden) or 20% in the home environment, these components have not been extensively researched previously. However, previous literature has highlighted the significant positive impact that school (Ridgers et al., 2011; Fairclough et al., 2012, Stratton & Mullen, 2005), spending time in outdoors environments (Cleland et al., 2008; Dunton et al., 2011; Jones et al., 2009a; McCurdy et al., 2010) and active travel (Lubans et al., 2011; Lee et al., 2008) has on daily MVPA levels. Therefore, it is clear that PA policies focused on school and active travel are important for increasing PA in children from deprived and ethnic environments.

The present findings also suggest that these children were most active, spending more time in health enhancing PA in outdoor environments (non-greenspace environments) irrespective of week or weekend days. Previous research is supportive of these findings (Cleland et al., 2008; Dunton et al., 2011; McCurdy et al., 2010), with some research yielding a positive relationship between MVPA and time spent in outdoors environments (Cooper et al., 2010; Jones et al., 2009b). The PEACH project identified that 1/3 of weekday and 40-57% of weekend MVPA occurs in greenspace, with increasing time outdoors associated with higher PA (Laschowitz, et al., 2012; Wheeler et al., 2010). Furthermore, they identified that only 15% of after-school time was spent outdoors, with the majority of this time being spent in non- green environments (Wheeler et al., 2010), which is supportive of the findings from this thesis.

For indoor time, time spent in MVPA was increased during weekdays, which may be attributable to PE lessons conducted in the school hall during autumn and media engagement indoors at home on weekends, moderated by weather constraints (Eyre et al., 2013b). This highlights again, the importance of the school environments through PE lessons on health enhancing PA. In addition, the children in this study spent a significantly greater percentage of time on weekdays in outdoor environments. This is surprising and is likely to reflect an under representation of indoor time spent at school due to spatial error (i.e. error in retrieving signal leading to wrong location, or missing signal) (Elgethun et al., 2003), unworn monitors when inactive at home and is supportive of the lower contribution of school recording time. Secondly, ethnic differences were found, with SA children spending more time indoors on weekends than White, but when indoors, SA children engaged in less MVPA than White children. The mechanisms for these differences are unknown and will be explored further in study two and three. In the BEACHES study religious practice was identified as a barrier to PA (Pallan et al., 2010). During religious practice (approximately 2 hours per day) children will spend time indoors inactive, perhaps explaining the increased time indoors for SA children and reduced MVPA indoors. This is the first study to explore ethnic differences using GPS and suggests that PA is low as previously described (Eyre et al., 2013a; Owens et al., 2009).

Previous studies have found that children are more active on weekdays (Duncan, Schofield & Duncan, 2006; Duncan et al., 2007; McGall et al., 2011; Oliver et al., 2007; Owens et al., 2009; Riddoch et al., 2007). Research suggests that highly active children spend more time in PA before school, during class, lunch and after school (Rowlands et al., 2008). However, it is not apparent what the school to after school contribution plays on these patterns. Other research suggests that greater PA engagement occurs during school time (Fairclough et al., 2012; Ridgers et al., 2011) because school provides specific PA opportunities within the school day (i.e. PE, recess), contributing to overall PA (Stratton & Mullen, 2005). However, other research suggests that children are most active after-school and that it is the differences in after-school activity, which accounts for differences in overweight/obese vs. normal children and inactive vs. active children (Deforche et al., 2009; Riddoch et al., 2007; Olds et al., 2011). Eyre et al. (2013b) is the only study to consider within day patterns of PA in SA children. The study concluded that SA children are less active because they engage in less activity and expend less energy after school than White children. This might relate to the increased time after school spent indoors but further research needs to understand the mechanisms underlying these behaviours before focusing future interventions.

5.5.3 Limitations of study

This study shows the feasibility of GPS and HR monitoring in young children from low SES and ethnic groups to explore differences in their engagement with environmental features. GIS data used was recent (2013) and thus minimises issues with the data being outdated due to areas changing with time. This study also used a protocol requiring participants to wear the HR and GPS monitors throughout four whole days unlike other work where smaller windows of wear time have been presented (Collins et al., 2012). Adherence to the monitoring period is also good, indicated by high response rate and an average monitoring compliance time of 6.5 hours (ranging to 9.5 hours). For a weekday, on average 63% of this time was worn for free living and 37% at school, thus confirming that weekday contributions were in both school and out of school environments. However, it is acknowledged that there could be some inflation in the findings between outdoors vs. indoors due to increased spatial error indoors (Elgethun et al., 2003), as summarised in Table 2.9. The current sample size, although small, is consistent with other published studies utilising GPS to assess young people's PA (Collins et al., 2012; Duncan et al., 2009; Fjortoft et al., 2009, 2010; Maddison et al., 2010). It is acknowledged that in future studies, a larger sample size would enable more sophisticated statistical analyses in future research. This would also enable subgroups analysis of SA children in order to account for heterogeneity in the ethnic sample and to establish if the limited ethnic findings relate to grouped effect. However, this would require multi-centre studies to obtain large samples and is beyond the scope of this thesis.

5.6 Conclusion

Outdoor non-greenspace environments are important for health enhancing PA in children from low SES and ethnic groups, but complex and interrelated factors, environmental and SES challenges within the neighbourhood, limit engagement in PA. Interventions aimed at increasing PA in these environments may need to consider a holistic social, environment and cultural approach to challenging both the physical environment and perceptions associated with the environment for ethnic groups. A school based approach to increasing PA in people from ethnic, low SES and living within challenging environments may be beneficial for policy makers.

6.0 STUDY TWO: ENVIRONMENTAL INFLUENCES ON PHYSICAL ACTIVITY IN ETHNIC CHILDREN FROM LOW SOCIO-ECONOMIC BACKGROUNDS: FOCUS GROUPS WITH CHILDREN

6.1 Abstract

Introduction: South Asian children are less physically active and have increased metabolic risk profiles. Physical inactivity is a modifiable risk factor for metabolic disease. Evidence suggests that environmental factors and SES influence PA behaviour. The purpose of this study was to understand barriers and facilitators of PA in deprived environments in children from ethnic backgrounds.

Method: Meetings were held with five focus groups with children aged 7 - 9 years (n = 33, Male= 16, Female = 17, SA = 17, White = 8 and Black = 8) from two schools in deprived wards of Coventry, England. Thematic analysis was used to identify key themes and subthemes across all transcripts.

Results: The school, equipment and outdoor activity were identified as faciltators of PA. The home environment, poor weather, parental constraints, concerns for safety were identified as barriers to PA. Ethnic differences between SA and white children were found for sources of beliefs and knowledge and religious practice. This was identified as a constraint because it reduced the time available for PA in SA children.

Conclusion: The findings suggest the positive influence of school on SA children's positive PA attitude, knowledge and behaviour. Before improving how children engage with their environments (i.e. reducing indoor inactivity time and increasing outdoor PA), further research is needed to confirm parental perceptions that may provide constraints to their child's PA

6.2 Introduction

A number of factors determine PA behaviours, these include physiological, psychological, individual, social, demographic and environmental (Giles-Corti, Wood, Pikora et al., 2011). Research in the last decade has focused on the role of environmental influences on PA. A wealth of studies have concluded that environmental factors affect PA behaviour (Lachowycz & Jones, 2011).

SA populations are likely to cluster in deprived inner city areas in the UK based on the employment opportunities available or because they have entered into the council housing system (Jayaweera et al., 2007; McGarrigle & Kearns, 2009; Singh & Tatla, 2006; Williams et al., 2009). Subsequently, this deprived environment is likely to significantly impact on their PA opportunities and behaviour, since living in deprived neighbourhoods is associated with reduced PA (Bolte et al., 2010; Spengler et al., 2011).

Outside of this thesis, a paucity of research examining the combined infuenece of ethnicity, SES, PA and the environment, exists. It is clear that SES affects PA behaviour and engagement and so this is important for research into SA's PA because they are most likely to live in deprived areas. Study one shows that SA children spend more time indoors and are less active than White children indoors. Also, , it is apparent that increased time in outdoors environments is associated with increased time in MVPA and reduced body fat. However, the approaches used in the majority of prior studies and study one have been based on quantitative assessment of PA in particular locations or using GPS technology to map PA patterns (McCormack, et al., 2004). While this is useful, it is also important to understand the lived experiences of people's interaction with the environment in relation to PA and to understand socio-economic and environmental experiences. Qualitative research in White, SA and Black adults suggest some physical (e.g. lack of single sex facilities) and social barriers (i.e. family obligations over personal preference) limit PA in SA adults (Rai & Finch, 1997). To the authors knowledge, Lake and Townshend (2012) is the only paper on PA to consider interactions with the environment in young adults (16 - 20 years) using qualitative methods. They suggest that qualitative approaches provide useful information towards understanding the impact of the built environment on PA. To date, no studies have explored qualitative experiences of PA in the built environment in a paediatric population. This would prove useful to understand behavioural patterns for why many children do not meet PA guidelines, why this adherence is lower in specific ethnic groups and to inform policy and future intervention planning aimed at increasing PA. The aim of the study is to explore environmental influences on PA from a qualitative perspective in children with a specific focus on ethnic differences in low SES areas. The study attempts to answers the following questions: (1) Do environmental factors facilitate or provide barriers to children's PA? If so, what are they? (2) Are environmental barriers and facilitators for PA the same for White and SA children?

6.3 Method

6.3.1 Participants

Following informed consent, children aged 7 - 8 years (N= 33 children, Male= 16, Female = 17, SA = 17, White = 8 and Black = 8). Every 6th child from study one that met the sampling quota (Table 6.1) was then invited to take part in the study. This was to ensure that a purposeful sample was chosen to provide the greatest insight into SA's experiences around PA, but to minimise bias in the selection of these from the criteria set (Merriam, 2009). The study period took place between March 2012 - April 2012.

Homogenous focus group interviews (Table 6.1, focus group one and two) took place with SA children enabling them to share their unique cultural experience, because people are more likely to feel comfortable speaking with those that they have things in common with (King & Horrock, 2010). For focus groups three to five (Table 6.1), ethnicity and gender were both heterogeneous, which enabled ethnic variations to be explored. It was hoped that using both of these methods would provide a wide range of variation in factors as well exploring more in-depth information with a SA sub-group.

Focus groups consisted of four to eight children (slightly larger in heterogeneous groups to allow for both ethnic and gender experiences). These fit within the requirements of focus group research which suggests a group should include from four to eight participants (King & Horrocks, 2010). Focus groups were continued until the point of redundancy, in which no new themes emerged. Four main topic areas were used for questioning; (1) knowledge and beliefs about PA, (2) key sources of knowledge and beliefs about PA, (3) PA patterns, (4) barriers and facilitators to PA (see Appendix I for questions). These were topic areas used by Rai and Finch (1997) to question SA, Black and White adult's attitudes towards PA. Questions were open ended questions to gain in depth responses, as previously discussed in Section 5.8.2.

The interviews were conducted in a familiar setting to the children ('rainbow room') during school-time as this was beneficial in providing a degree of comfort for the data collection method (King & Horrocks, 2010). The interviews took 40 - 60 minutes per group; this was the equivalent to a school lesson and was kept short in order to prevent the children becoming bored and losing concentration..

Table 6.1 Sampling quota for focus group interviews

School 1: most deprived ward	School 2: second most deprived ward
GROUP 1 3 boys 3 girls All SA aged 8 years (Year 4) **GROUP 2** 2 boys 2 girls All SA aged 7 years (Year 3)	**GROUP 3** 4 boys 4 girls Mixed ethnic groups aged 8 years (Year 4) **Group 4** 4 boys 4 girls Mixed ethnic groups aged 8 years (Year 4) **Group 5** 3 Boys 4 girls Mixed ethnic group aged 7-8 years (Year 3)

6.3.2 Analysis of qualitative data (refer to earlier methods)

Focus groups were digitally recorded (Olympus VN-750, Tokyo) anonymised and transcribed. The transcripts were verified by a facilitator. Data from the focus group interviews was analysed using thematic analysis following guidelines recently proposed by Braun and Clarke (2006) and, in this way, sought to describe patterns within the sample. Thematic analysis is a widely used mechanism to identify, analyse and explore patterns within qualitative data (Braun & Clarke, 2006). Further information on qualitative analysis is already described in Section 4.8. There were no disagreements between the three separate analyses.

6.4 Results

The quotes are referenced as the school (school 1 = S1 or school 2 = S2) followed by focus group number (G1, G2 or G3) and a summary of findings can be found in Appendix II. There were no apparent gender differences in reponses to the four topics.

6.4.1 Knowledge and beliefs about PA

There appeared to be no ethnic differences or gender differences in knowledge and beliefs about what PA was and the benefits of PA.

6.4.1.1 What is PA?

Regardless of ethnic background or gender, the children had a good knowledge of PA reporting that *'you are moving your body and your heart starts beating'* (S1, G3, Appendix II) and *'it is where you use like energy'* (S1, G2, Appendix II). The themes related to movement, exercise, the use of energy and specific activities. The children reported specific activities which most commonly related to structured activities (i.e. sports activities or their PE lesson). Play was briefly mentioned in this description of PA.

6.4.1.2 What are the benefits of PA?

A number of benefits from PA were described which can be broadly themed under psychological and physiological benefits (Appendix II). A range of psychological benefits were also reported such as 'being happy', 'enjoyable' 'relaxed' 'excited' 'feeling healthy' and intrinsic rewards from achievement'. One child reported *'I do exercise because it makes me feel healthy and when it was our sports day I was exercising every day and i had a race and I was first and I had a gold medal.. Miss it makes me feel like the champion…When I was in the race I came second and I won a silver medal and my heart was beating really fast'* (S2, G2, Appendix II). Feeling 'happy' was something consistently reported which related closely with skill mastery or competency for example *'exercise makes me happy because when I exercise I get more good like basketball'* (S2, G1, Appendix II). Exercise being enjoyable was reported and this was described in relation to activities that they did *('it is fun and we have really fun activities to do*' (S1, G1, Appendix II) *'all of the games and the extensions that we do... like the warm ups and the little things'* (S1, G1, Appendix II). In addition, learning skills and becoming competent at skills made the children happy and provided intrinsic rewards' *think you should exercise because if you don't do more exercise then like somebody kick this ball in the air you won't kick it up very far because you don't do much exercise'*(S2,G1, Appendix II).

For benefits of PA, answers that related to muscle or bone growth and strength were Commonly reported '*you should do exercise because it makes your bones strong and It's good for you and will make you stronger'* (S2, G1, Appendix II). Children also considered the role of PA on bone growth and strength in adults *'I think PA is good because like [child's name] said when you are older you tend to have more , you can move your back a bit more than just sitting down on the couch feeling old '*(S2, G2, Appendix II).

Health and fitness benefits of PA were also most commonly reported particularly in relation to PA making you fit '*I think PA is good for you because you get fit and if you* *want to get fitter then you have to exercise more to so you can get more fitter'* (S2, G2, Appendix II). Individual children made more specific quotes which related to diseases '*it stops you getting cancer... diseases and diabetes'* (S2, G2, Appendix II), dental health *'because if I am not healthy then it will make my teeth fall out'* (S1, G2, Appendix II). The need of PA for weight management was commonly reported also *'if you didn't do exercise then you would end up being fat'* (S2, G1, Appendix II).Finally children reported the physiological responses that they feel when engaging in PA. These responses related to feelings of strangeness *'every time I finish my exercise it feels like something strange inside me…good* (feeling)' (S2, G3, Appendix II) and the heart ('*after I have finished my exercise I feel like I have just run away from a monster....because I can feel my heart beating really fast* '(S2, G3, Appendix II).

6.4.3 Key sources and beliefs about PA

In regard to key sources of beliefs about PA, there appeared to be an ethnic difference. Children from SA backgrounds reported that the school and specifically the PE teacher played a major role in educating about the benefits of keeping healthy, organising activities and introducing children to a range of activities *'yeah he runs these clubs' '[teachers name] does all these activities'* (S1, G1, Appendix II). For other ethnic groups, family (i.e. granddad, dad, mum) was a key influence for demonstrating, encouraging and taking them to an activity environment *'my dad because we go to the park'* (S2, G2, Appendix II) and finally by educating them *'my mum because she is a member so she can tell me what is good and bad'* (S2, G2, Appendix II). None of the children from SA backgrounds reported parental influence on their activity engagement or beliefs about PA. Other ethnic groups, reported also that their only influence was themselves '*I did It myself…I just do it by myself then I don't have to get moaned at by my mum when I do it wrong*' (S2, G2, Appendix II). The media also influences all children's behaviour and beliefs, which include the TV *('...I saw this exercise programme it was called keeping your arms, your bum, your hips healthy…it showed you how you keep your bum and your legs fit. It was to keep the muscles on your bum'* (S2, G3, Appendix II)), books *('erm I have a book and it is called 'keeping fit and healthy* '(S2, G3, Appendix II)) and websites (…*and sometimes I go on a website called Olympic exercise* (S2, G3, Appendix II)).

Ethnic differences were also found for role models. SA children's role models were their class teachers and most commonly the PE teacher describing ' *[PE teachers name] …make sure that you are good…make sure that we enjoy them …at lunch we play a skipping game and [teachers name] helps me to skip, he holds the rope'* (S1,G1, Appendix II). Children from other ethnic groups reported role models as sporting stars from football and athletics stars were named for example, '*Wayne Rooney, he plays football, so I play football just like him* (Appendix II) and *'miss my role model is Usain Bolt …because he is like me ,running faster'* (S2, G2 Appendix II,).

6.4.2 Factors affecting PA engagement

An outline of the barriers and facilitators to PA can be found in Table 6.2 divided into two broad areas of social and physical environmental factors, as previously defined in Figure 3.1.

6.4.2.1 PA and the environment: outdoors vs indoors PA

There were no ethnic differences in preference for PA. The majority of children reported that they preferred playing outside, which included the park/playground, greenspace/garden or the street/car park. This was because playing outside gave them more space and fresh air. One child reported *'I prefer outside because you get more air, you get more space and you spread out more to do activities'* (S2, G2, Table 6.2). Playing outside also enabled the children to keep cool *'I prefer inside actually because* *when I am outside I get really hot but when I am outside I feel cool'* (S1, G2, and Table 6.2).

A few children reported a preference for activities indoors. These included sports/recreational facilities, home or school. Weather was the most common reason why, one child reported *'when it is windy... I can't go in the car park because I might hurt myself'* (S1, G1, Table 6.2). Children also reported parents' concerns regarding the weather, one example '*She said that I will get ill and then you will miss too many days off school and you wouldn't get a good school report'* (S1, G1, Table 6.2). Space was also reported, *'I like to do it in my house because we have a big massive space and it is where my mum, dad and me do gym and sometimes I like to put the music on and do my gym'* (S2, G3, Table 6.2). PA at school was related to feelings of safety, *'Because if you get hurt then someone will help you'* (S2, G1, Table 6.2).

6.4.2.2 Environmental facilitators

When the children were asked when they were more active the most common answer related to the school environment, which mostly related to the playground. A child reported '*because in school we can go in the adventure playground and there is more things to play with'* (S2, G1, Table 6.2). Children also reported PE time stating *'in PE because we do lots of sports, we do it for a long time. It makes you active.* (S1, G1, Table 6.2). Other children reported at 'home', or 'all the time'. Again, no ethnic differences were observed here.

There also appeared to be no ethnic differences in environmental facilitators. It was clear that having lots of moveable equipment in the garden was a facilitator of PA (*'I play in my garden and outside, I have lots of stuff in the garden that I can play with* '(S1, G2, Table 6.2)). Proximity was also a facilitator to PA for example *'I have a big garden and a* *big park next to my house…there is a big park there and I play with my bike there once a week'* (S1, G1, Table 6.2).

Table 6.2 Barriers and facilitators to PA in children

BARRIERS	FACILTATORS
PHYSICAL ENVIRONMENT	
Weather *'When it is windy…..like really windy I can't go in the car park because I might hurt myself'* (S1, G1). *'The rain stops me from playing outside….. Because it is too wet'* (S2, G3). **media** *'What stops me from doing my exercise is my game because I always watch the TV and play on my laptop'* (S2, G1). **Safety of local activity spaces** *'I've got one by me but people leave injections on the stairs so I just stay outside the house'* (S2, G2) **Inappropriate equipment** ('*when I go on the monkey bars my feet touch the floor so I can't really go on anything…… it is too small for me'* (S1, G1)	**Outside environments (grass, playground, back garden)** *'I prefer outside because you get more air, you get more space and you spread out more to do activities'* (S2, G2). *'I prefer outside because when I am inside I get really hot but when I am outside I feel cool'* (S1, G2). **Space** *'I like to do it in my house because we have a big massive space and it is where my mum, dad and me do gym and sometimes I like to put the music on and do my gym'* (S2, G3). **School environment** *'because in school we can do, we can go in the adventure playground and there is more things to play with'* (S2, G1) *'In PE because we do lots of sports, we do it for a long time. It makes you active. And I do sometimes play football at home* (S1, G1). *'Because if you get hurt then someone will help you'* (S2, G1)). **Equipment** *'I play in my garden and outside, I have lots of stuff in the garden that I can play with* '(S1, G2). **Proximity** *'Next to my house…there is a big park there and I play with my bike there once a week'* (S1, G1).
SOCIAL ENVIRONMENT	

Parental constraints '*She said that I will get ill and then you will miss too many days off school and you wouldn't get a good school report'* (S1, G1). *'my mum said If you want to stay outside play for a few minutes but I can't go back inside…only for a drink…then my mum will say you have to stay inside'* (S1, G1). **Lack of skill** *'football …because people always tackled me and they always tripped me over'* (S2, G1) **Religious practice** *'I go mosque so I have no time really'* (S1, G1) and *'I have to go mosque and I will get told off so I have to mosque, which stops me from doing my swimming'* (S2, G2). **Social** 'I have no one to play with' (S1, G2) **Aesthetics of local activity spaces** *'There is a park, like I told you before when I went it were proper trampy but now it is a bit better'* (S1, G1). **Junk Food** *When I was doing my exercise…my mum came back from shopping... and put some junk food on the table and then I had it'* (S2, G2).	**Parental non-constraints** *'I'm allowed out in the rain'* (S2, G1)
TRAVEL TO SCHOOL	
Time *'If you go in the car then you are early and you won't be late'* (S1, G2), **Weather** *'If the sun is shining then I will walk but if it raining then my mum will give me a lift to school'* (S2, G2)	**Proximity** *'I walk because I live really close'* (S1, G2),

7.4.2.3 Environmental barriers

Religious practice was the only barrier reported in SA children. Having to attend mosque was a barrier because it limited the time available for other activities (*'I go mosque so I have no time really'* (S1, G1, Table 6.2) and *'I have to go mosque and I will get told off so I have to mosque which stops me from doing my swimming'* (S2, G2, Table 6.2)).

Environmental barriers relating to the home environment were similar in all ethnic groups (i.e. parental constraints, media, junk food and lack of people to play with). Media influences (i.e. TV, PlayStation, and laptop) were identified as barriers, *'What stops me from doing my exercise is my game because I always watch the TV and play on my laptop'* (S2, G1, and Table 6.2). Not having anyone to play with, siblings and parental restraints were also identified *' my mum said If you want to stay outside, stay outside and play for a few minutes but I can't go back inside…only for a drink…then my mum will say you have to stay inside'* (S1, G1, Table 6.2). All children, regardless of ethnic background, shared common experiences of junk food (fat snacks i.e. chocolate, crisps, ice cream) at home, which was a distraction from PA. Children recalled how their parents offering them junk food whilst doing PA '*When I was doing my exercise…my mum came back from shopping... and put some junk food on the table and then I had it'* (S2, G2, Table 6.2).

The weather and parental constraints regarding weather conditions were also seen as a barrier. It was clear that for some children they were allowed to play out regardless of the conditions *'I'm allowed out in the rain'* (S2, G1, Table 6.2), for other children the rain, sun and cold stopped them from doing PA, for example *'the rain stops me from playing outside… Because it is too wet'* (S2, G3, Table 6.2). In addition, the bad weather causing indoor play at school was also seen as a barrier to PA because *'when we have indoor play there is nowhere to exercise'* (S2, G2, Table 6.2)

Barriers also related to the parks in the local environment. Children reported that they have parks near them but shared concerns about the parks aesthetics, safety and age appropriateness of the equipment. Children reported *'I've got one by me but people leave injections on the stairs so I just stay outside the house'* (S2, G2, Table 6.2) and aesthetics *'there is a park, like I told you before when I went it was proper trampy but now it is a bit better'* (S1, G1, Table 6.2). Parental constraints were also a factor, they enabled or prevented the children from doing activities such as playing out because of their safety concerns (*'sometimes my mum doesn't let me out, we use to play with these children but their house got robbed so we couldn't play out anymore but in our second house we get to play out because there is a bit of a street and car parks and stuff'* (S1, G2, Table 6.1)).

6.4.3 Travel to school

No ethnic differences were found for travel behaviour. Children reported that they run, walk, took the car or rode to school. The mode of choice was determined by the physical environment such as proximity, time and the weather such as *'I walk because I live really close'* (S1, G2, Table 6.2), *'If you go in the car then you are early and you won't be late'* (S1, G2, Table 6.2), *'If the sun is shining then I will walk but if it raining then my mum will give me a lift to school'* (S2, G2, Table 6.2), *'I get a taxi when it is really cold or I will walk in sometimes. My coat does have a hood but it doesn't stay up so that is why I get a taxi'* (S2, G2, Table 6.2).

6.4.4 Other barriers to PA

Homework, siblings and other children's poor behaviour were also identified. References were made to past negative experiences that affected current activity engagement. One child reported that there was a lack of variety *'I stopped swimming because you just have to swim every time and not do different things, I just do basketball…in basketball…I could not get back and the ball went in ... makes me want to do more'* (S2, G1, Table 6.2). Lack of skill's or competence was a barrier to activity (*'football ...because people always tackled me and they always tripped me over'* (S2, G1, Table 6.2)). Parents' constraints were also drawn upon, for one child they became too good so the parents wanted them to try other activities. For another child, the mother's lack of ability to swim and needing the child's assistance hindered their own ability to swim.

6.5 Discussion

The purpose of this study was to qualitatively explore environmental influences on PA from a child's perspective with a specific focus on ethnic differences in low SES areas. In response to the research question (1), a number of physical (e.g. school, outdoor environments, weather) and social factors (e.g. teachers, parental constraints, safety concerns) facilitate and provide barriers for PA. For question (2), the results highlight that there are some ethnic differences for environmental influences on PA, but that SES may be more important. In the few ethnic differences that were found, religion (i.e. attending mosque) was a barrier for PA in SA children. This comment is specific to the Islamic community, so shows some heterogeneity in SA children's experience of barriers to PA. In the present study 'mosque' was identified as a time constraint because children reported that parents prioritise mosque over PA. The BEACHeS study has also suggested that children in Islamic communities spend a significant amount of time at their place of worship (mosque). They report that children attend mosque daily, after school and weekends, which limits time available for PA, food preparation and travel time to school or home (Pallan et al., 2012). It is clear from this study and BEACHeS (Pallan et al., 2012) that for intervention planning, research needs to understand religious practices more effectively. Providing more after-school clubs is unlikely to increase PA because of daily religious practices as mosque attendance has been reported to clash with activities after school intervention times, resulting in non-attendance (Rudolf et al., 2006). Clearly the role of religious practices (i.e. time and location) needs to be considered when designing ethnic focused interventions.

The children's understanding of PA relate to structured activities such as sports activities or PE lessons, which arguably can be described as exercise. This is surprising because the nature of children's activity patterns is described as intermittent and transitory bursts of activity followed by periods of rest (Baquet et al., 2007), more specific to play activities. Yet, play was briefly mentioned. Walking to school is also a common activity for children but was not mentioned by children in the current sample. These findings are consistent with recent research, when children took photos of their PA engagement; photo's included illustrations of free play, fitness and organised activities (Beets et al., 2011).

Ethnic differences were also apparent for sources of knowledge and beliefs about PA. School and specifically the PE teacher were the main and only influence on knowledge and beliefs for SA children. The school teachers, especially the PE teacher, were also named as their only role model for PA, playing a vital part in providing a role model for the children to aspire to. All children despite their ethnic background also feel that they are most active when they are at school, affirming it's importance as an environmental correlate of children's PA behaviour (Table 3.1 & study one) and supporting the contextual model by Pallan et al., (2012) in Figure 3.3. The schools used in this study both had a PE co-ordinator, scheduled PE lessons (2 hours, per week), a playground with markings, an adventure play area, grassed area PE hall and opportunities for after-school clubs. The first school also had a mooga (outside court), gym equipment outdoors, and the provision of removable play equipment at lunchtime. The importance of PE co-ordinators, PE lessons, after-school PA clubs, classroom breaks, modified playground and facilities in the school environment on PA has previously been found in Table 3.1.

For other ethnic groups, school and parents were the main influences on knowledge and beliefs about PA, thus identifying the importance of a positive social environment on PA engagement as previously outlined in Figure 3.2. Role models were described as sporting stars, highlighting the role of the media. Parental influences, role modelling and the importance of school for encouraging healthy behaviours and habits has been described previously (Finn et al., 2002; Kamtsios & Digelidis, 2008) but this study is the first to explore and report ethnic differences.

The findings that the PE teacher was an important influence on PA in SA children but not for other ethnic groups might relate in part to differences in terms of PE delivery between schools. In school one, all the children interviewed were SA and PE was taught by a school-based teacher employed specifically to teach PE. In school two, PE was delivered by an outside organisation that only came in to teach PE. The effect of this on the results from this present study is unknown. However, the thematic analysis did indicate that specialised PE teachers play a crucial role on PA behaviours and attitudes especially in SA communities where this person appears to be the main source of knowledge, beliefs and engagement. The importance of school PE on attitudes and beliefs as well as current and future PA is well documented (Ferguson et al., 2009) and as such, the results of the present study are supportive of this prior work.

Despite having different sources of information for knowledge and beliefs between SA and other ethnic groups, it was apparent that all influences played a vital role in providing a source for knowledge and beliefs about PA. They provided a range of opportunities and encouragement for children to be active. As a result of this input, the children demonstrated a good understanding of what PA is and showed knowledge of the importance of PA on physiological, psychological and skill development. In addition, they were able to identify some understanding of how the benefits of PA translate to adult health. These results are therefore consistent with Fishbein and Ajzen’s (1975) Theory of Planned Behaviour, which highlights the importance of the influence of believing that PA will have positive benefits in determining PA behaviour.

Furthermore, irrespective of different sources of information, the children's understanding of PA did not differ by ethnic background. The children's understanding of PA related to structured activities such as sports activities or PE lessons, which are arguably described as exercise. This is surprising because children's activity patterns are described as intermittent and transitory (Baquet et al., 2007), which are more akin to play activities. However, play was only briefly mentioned. Walking to school is also a common activity for children but was not mentioned by the children in this current sample. These findings are consistent with recent research (Beets et al., 2011).

SA and other ethnic groups reported similarly that they were most active when they were at school, affirming its importance as an environmental correlate of children's PA behaviour. Likewise, they felt that the home environments were a barrier for PA because they provided increased availability of junk food and media entertainment opportunities. All children reported how their parents would offer junk food to them at times when they were engaged in home PA. This was also contextualised by Pallan et al., (2012) (Figure 3.3) and is supportive of the contextual model by Grow and Salens (2010) (Figure 3.2).

In addition, TV, Play station and computers were reported as a barrier for PA. This is consistent with meta-analytical data which confirmed that TV viewing and video-computer use is positively associated with body fat and negatively associated with PA (Marshall et al., 2004). It has also been suggested that lower income households have greater access to media devices that provided increased opportunity for sedentary behaviour and less for PA (Tandon et al., 2012). The current sample was drawn from the two most deprived wards in the city of Coventry and so the role of media devices and access to them may be particular to low SES groups. This comment is however speculative and future research should endeavour to explore this issue further. Interventions in the home environment where parental restrictions are made on media entertainment and junk food might therefore provide more opportunities to be active. Prior work by Beets et al., (2011) has supported the importance of improving the home environment to decrease physical inactivity. However, before this can be undertaken, the reasoning behind an unsupportive home environment needs to be explored from a parental perspective. This will be further explored in study three.

There were three main themes (i.e. facilities, safety and parental constraints), which related to PA and the environment in this study. Arguably these appeared to be pre-affected more by SES than ethnicity. These included equipment or space, safety, and parental constraints. Equipment was identified as an important facilitator or barrier to activities both inside and outside. This is not necessarily a novel finding as prior research has highlighted the importance of school facilities and unfixed equipment on increasing PA during school break times (Ridgers et al., 2012) and the availability of recreational space or public open spaces such as parks, playgrounds, playing fields or courts is associated with PA (Chomitz et al., 2011; Duncan et al., 2012; Loureiro et al., 2010; Nielsen et al., 2010; Veitch et al., 2010, Table 3.1). In this current study, the children preferred to play outside and it was a time when they perceived themselves to be most active. Researchers have confirmed that children are most active in outdoors environments (Cleland et al., 2008; Dunton et al., 2011; Jones et al., 2009). This was further confirmed in study one~~.~~ A review also concluded that the health benefits of PA are greater outdoors (McCurdy et al., 2010). However, there is no prior research highlighting why outdoor space is perceived to be better. Although speculative, the findings from this study suggest this is because they have more ‘space’ and ‘fresh air’, potentially resulting in running around more and increasing their HR greater,.

Safety was noted as a common barrier to PA outdoors relating to feelings of getting lost, feelings of crime in the neighbourhood and sharing experiences of drugs and violence within park settings. Perceptions are likely to be influenced by SES and findings support SES, physical environment factors of the local environment and perceptions related to these as highlighted in

Grow and Saelens, (2010) contextual model in Figure 3.2. Additionally, low SES environments were previously identified as less safe and unpleasable for PA in Table 3.1). Children's concerns regarding their safety in relation to crime and danger is already known (Loureiro et al., 2010) and neighbourhood satisfaction is described as a moderator of PA (Carson et al., 2010). It is likely that children's fears of danger and safety are influenced by parents own beliefs and perceptions and it was identified that parents constrained children's behaviour of 'playing out' in relation to their own safety concerns, consistent with previous research (Veitch et al., 2010). This is important because children of concerned parents are less active (Jackson et al., 2008) and the perceived absence of having safe places to play is also associated with obesity (Robinson et al., 2012). The findings in study one identified low adherence to PA and that the contribution of PA outside of school on total PA, where parental constraints are paramount, PA levels were low. Travel behaviour was also constrained by weather in addition to proximity and time. It was clear that cars were used when children lived far away from school, if they wanted to get to school on time, or if it was raining.

Children felt that their parents also constrained their PA behaviours in relation to the weather. Children shared experiences of not being allowed out if it was too windy or wet, which would restrict play too indoor settings. This is consistent with reports linking weather conditions to PA behaviour, with PA being higher in summer months (Rich, et al, 2012). Findings presented in study one identified that children were more active in outdoors environments, with findings in this study identifying that this is due to space and fresh air. Thus, collectively, these findings suggest parents' concerns about playing outside in the weather restrict PA too indoors environments, where space limits the ability to be as active as outdoor environments. The weather also restricted school PA and resulted in 'indoor play'. The children would comment that there wasn't enough space to play indoors, which may restrict the amount of activity that children can engage in. Both study one and two-findings were collected during the winter and thus provide insight into weather barriers during this specific season identified as a period when children are less active. Consideration of specific weather conditions doesn't seem to have been explored and although complicated to assess, would warrant further exploration.

The results of the current study support the assertion that children are not autonomous in their decisions and that parental constraints limit the opportunities availability to be physically active (Panter et al., 2010). The children in the current study were also relatively young (7 - 9 years) and it is not known whether children are aware of all the features of their neighbourhood that affect their behaviour at this age. Additional interviews with parents might be able to explore these issues with more detail in relation to children's behaviour and also parent's constraints. This is further explored in study three.

Finally, the social component to PA was important for engaging in activity and also promoting PA. Children reported that they like to engage in activities with people including friends, family or teachers. These findings are consistent with findings from previous studies which have found that PA in children takes place most commonly with friends and family (Beets et al., 2011; Dunton et al., 2011) and supports the contextual models in figure 3.2 and 3.3. It can be suggested that social components to PA are an important mechanism, which should be considered in intervention planning.

There are some limitations to this study. The study examined two schools within two geographical areas which makes it difficult to generalise to other built environments. It is also difficult to separate what is socio-economic or an environmental influence within this study because children in deprived areas are likely to have different environmental influences based on SES. It would have been useful to compare different ethnic groups such as Black and other ethnic minority groups. However, large samples of these ethnic groups were not available in the electoral wards of interest. Despite this, this study is the first to consider ethnicity, socio-economic and environmental influences on PA in children. The nature of the focus group data has enabled a unique and rich depth of information to be obtained in relation to children's attitudes, beliefs and experiences.

6.6 Conclusion

The findings of this study suggest time available for PA in SA children is reduced by religious practices (i.e. attending mosque). In addition, the school and specifically the PE teacher is important, and the only influence for knowledge and beliefs about PA, providing opportunity, encouragement, role modelling and engagement in PA. Therefore, the school environment provides an important foundation for PA in primary school children from SA backgrounds. This supports the role of a positive physical and social environment for increase PA engagement as illustrated in Figure 3.2. Additionally, there was a range of other physical (e.g. facilities, home environment, and safety) and social (e.g. parental constraints, safety) environmental factors outside of school, which influenced PA engagement. These factors appear to relate to SES differences as opposed to ethnic differences and are supportive of the contextual models illustrated in Figure 3.2 and 3.3. The mechanisms underlying parental constraints and the unsupportive home environment described by children need further exploration from parents. The school environment, outdoor play and being considerate to religious practice in SA's is also important for increasing engagement in PA and should be considered when targeting interventions to increase children's PA.

7.0 STUDY THREE: LOW SES ENVIRONMENTAL DETERMINANTS OF CHILDREN'S PHYSICAL ACTIVITY IN COVENTRY, UK: FOCUS GROUPS WITH PARENTS.

7.1. Abstract

Introduction: Young children's physical activity is affected SES and the environment where they live. Children are not autonomous in their decision making and thus parental decisions may affect how children utilise their surrounding environments for PA. The purpose of this study was to examine environmental influences on PA of children from a qualitative perspective in parents from the same wards and schools as stated in study one and two.
Method: A total of 59 parents of children aged 8 - 9 years completed the ALPHA environmental questionnaire. A further 14 parents took part in focus group discussions examining environmental facilitators and barriers to their child's PA.
Results: The common emerging themes related to physical and social environment influences on the PA behaviour of children. For the physical environment, poor access, safety and quality of the neighbourhood restricted children's opportunities to play in outdoors environments within their local neighbourhood. Parents also perceived their social environment as unpleasant reporting a 'rough' neighbourhood due to anti-social (drugs, violence, prostitution, sexual behaviour and gangs) behaviour. The parents believed these environmental factors resulted in the children engaging in greater sedentary activity (i.e. watching TV) indoors. The school environment was perceived as a supportive physical environment for children's PA behaviour.
Conclusion: Parents' perceptions of an unsupportive physical and social environment restrict children's opportunities to play outside and be physically active. Schools provide a supportive environment for children from low SES to be physically active.

7.2 Introduction

Specifically in the UK, people from SA backgrounds are the most socio-economically deprived, clustering in the most deprived areas (Jayaweera et al., 2007; Williams et al., 2009). Some heterogeneity is apparent with Bangladeshi and Pakistani ethnic groups most likely to live in deprived neighbourhoods than Indian ethnic groups (Jivraj & Khan, 2011). Low SES is related to low PA (Duncan et al., 2002). SA children have lower PA patterns than White ethnic groups (Eyre et al., 2013a, 2013b; Owens et al., 2009). Yet, when SES is considered, no ethnic difference in overall MVPA were found but SA children spend more time indoors inactive (study one). Several factors have been found to relate to PA behaviours in adults. External motivators (i.e. weight loss, health, enjoyment and social activity) were the main factors causing SA adults to engage in activity (Jepson et al., 2012). For older SA adults, a recent systematic review of qualitative studies investigating PA in SA, found disempowering and empowering contexts for

PA in the following four main themes, communication, relationships, beliefs and the environment, which influenced PA levels (Horne & Tierney, 2012). There is a need to understand factors that affect PA behaviours in ethnic and deprived children in order to design interventions to increase PA levels. However, the approaches used in the majority of prior studies examining the environment have been based on quantitative assessment of PA in particular locations or using GPS technology to map PA patterns (Eyre et al., 2014; McCormack et al., 2004). While this is useful, it is also important to understand the lived experiences of people's interaction with the environment in relation to PA and to understand the impact of SES and environmental experiences on PA (Lake & Townshend, 2012).

Prior qualitative research by Eyre et al., (2013c) in multi-ethnic groups (i.e. SA, Black and White) of children (aged 7 to 9 years) from deprived wards of Coventry, found that school, outdoor PA and equipment were facilitative to PA. The study also reported that parental constraints, safety, the home environment and weather were barriers to PA. Furthermore, in a review of qualitative studies, parental support was a facilitator for providing young children with opportunities to be active (Allender et al., 2006). As children identify parental constraints as a barrier to PA and given that they are not fully autonomous in their decision making, it was considered important to understand parental attitudes towards their local environment and how these relate to PA opportunities. Therefore, the aim of this study was to explore the attitudes of the parents of the children in Eyre et al., (2013) towards their environment. Secondly, the study sought to identify how these perceptions affect decisions made about the ways in which their children utilise their surrounding area for PA in low SES neighbourhoods. Finally, the study attempts to address the research question, do parents' perceptions of the environment facilitate or provide barriers for childrens' PA? If so, what are they?

7.3 Method

7.3.1 Participants

The sampling method for obtaining the sample of children has been previously described in study one. Following acceptance by the head teacher of the school, to participate in the project, every parent from of a child in Year 4 and 5 (aged 7 - 9 years) received a participant information sheet and consent form. Opportunities were provided to ask any questions and translators were on hand if needed. Following informed consent, 59/105 (response rate 56%) parents (30 to 46 years) completed and returned the ALPHA environment questionnaire (Spittaels et al., 2009; 2010) to the school. Parents were invited to attend focus groups held at the school to discuss their local neighbourhood. Three focus group discussion were held with a total of 16 parents (Male= 1, Female = 15, SA = 8, White = 5 and Black = 3). English was an additional language for all SA participants and for one Black participant. Despite this, all participants spoke fluent English.
The study period took place between March 2012 to April 2012 .

7.3.2 Assessing Levels of Physical Activity and fitness (ALPHA) environment questionnaire

The ALPHA environment questionnaire was used to gain information from a larger sample of parents relating to the environment. The findings from questionnaire and responses to the interview transcript used in study one were then used to gain further insight into environmental issues influencing their child’s PA through focus group interviews. The advantages and disadvantages of survey methods assessing the environment are summarised in Table 3.6. The questionnaire was only used in adults due to its reported international reliability in adults (Spittaels et al., 2010). However, the reliability and validity of this questionnaire is not known in children.

The ALPHA environment questionnaire (long-form) is a 49 item questionnaire that is grouped into the following 9 themes: types of residences in your neighbourhood (theme 1), distance to local facilities (theme 2), walking and cycle infrastructure in your neighbourhood (theme 3), maintenance of infrastructure in your neighbour (theme 4), neighbourhood safety (theme 5), how pleasant is your neighbourhood (theme 6), cycling and walking network (theme 7), home environment (theme 8), work place or study environment (theme 9) (Spittaels et al., 2009; 2010). The questionnaire has been validated against PA measures (self-report/accelerometers: correlations range 0.19 – 0.38) in European adults (Spittaels et al., 2010). The reliability is also reported, with intra class correlations ranging from 0.66- 0.87 amd internal consistency reported as 0.65 – 0.82. The questionnaires took on average 6 minutes to complete (Spittaels et al., 2010).

The terminology in the questions was reworded to English words in conjunction with school leaders (about how parents would interpret the questionnaire), because the questionnaire was validated on European adults and thus ‘sidewalks’ were changed to ‘footpaths’. Questions 9a-b were removed as they are on parent’s work environment and the study is interested in what affects children’s PA, leaving 38 items.

7.3.2.1 Analysis of ALPHA environmental questionnaire

The data was cleaned and analysed according to the ALPHA environmental questionnaire manual (IPEN, 2011) as can be seen in Table 7.1. High scores indicated a supportive environment for PA, with low scores indicating an unsupportive environment PA. Items 5a, 5b, 5c, 5d, 5e, 5f, 6b, 6d, 8e are negatively formulated (i.e. higher score indicates a less supportive environment) and were recoded so higher scores would indicate a supportive environment (5a to 5f, 6b, 6d were 1 = 4, 2 = 3, 3 = 2. 4 = 1 and 8e 0 = 1 and 1 = 0). Answers reported as N/A were recoded as missing values. Calculations were formulated based on Table 7.1. A copy of the questionnaire can be found in Appendix III.

Table 7.1 Themes and environmental calculations based on the ALPHA environmental questionnaire.

THEME	ANSWER	SCORE	Calculation
Theme 1	None	1	Density score = 1a + (1b *12) + (1c *50)
	A few	2	
	Some	3	
	Most	4	
	All	5	
Theme 2	1-5 min	1	Distance Score = 2a + 2b +2c +2d +2f + 2g + 2h
	6-10 min	2	
	11-20 min	3	
	21-30 min	4	
	30+ min	5	
Theme 3, 4, 5, 6a, 7	Strongly disagree	1	**Theme 3:** Sidewalks = 3a + 3b, Bike Lanes = 3c + 3d, availability = 3a + 3b, 3c, 3d.
	Somewhat disagree	2	**Theme 4** - maintenance: 4a + 4b + 4c
	Somewhat agree	3	**Theme 5** – safety = 5a + 5b + 5c + 5d + 5e + 5f, crime = 5a + 5e + 5f, Traffic = 5b + 5c + 5d.
	Strongly agree	4	**Theme 7** - network = 7a + 7b + 7c + 7d, connectivity = 7a + 7c + 7d.
	NA	5	
Theme 6b, 6c, 6d	None	1	Pleasure = 6a + 6b + 6c + 6d
	A few	2	Aesthetics = 6b + 6c + 6d.
	Some	3	
	Plenty	4	
Theme 8	Yes	1	Theme = 8a + 8b + 8c + 8d + 8e + 8f.
	No	0	

Adapted based on the ALPHA environmental questionnaire Manual (IPEN, 2012).

7.3.2.2 Statistical analysis of the questionnaire

The mean and SD were calculated for each theme according to Table 8.1 and for individual sub questions (e.g. 3a, 3b) in excel. A Pearson's chi square was used to analyse if there were differences in responses (3a - 8e) to the categorical data (agree/disagree) to the ALPHA environmental questionnaire.

7.3.3 Interviews

Semi-structured homogenous (children from the same school as study one and two) focus group interviews took place with parents of children from the same school as study one and two. Focus groups consisted of four to eight parents, consistent with (King & Horrocks, 2010). Focus groups were continued until the point of redundancy (Schensul & LeCompte, 2010). Further information of focus group interviews is previously discussed in Section 4.8. The four topic areas used in study two, were employed for questioning. A 5th topic area environmental influences was used, whereby questions were taken from the ALPHA environment questionnaire to gain insight into environmental barriers (see Appendix III). The interviews were conducted at school providing a familiar and convenient setting for the parents during school-time and took 40 - 60 minutes per group.

7.3.3.1 Analysis of qualitative data

Analysis was performed for the data in this study in the same way as that described in study two. By employing the same method of analysis, the aim was to draw better draw contrasts and comparisons between the themes identified by the children and by their parents. This approach defines thematic analysis as a method in its own right rather than locating the analysis within any of the major analytic traditions (e.g., grounded theory) to enable the lived experience of participants to be better expressed (Braun & Clarke, 2006). Considering thematic analysis as a method in its own right also minimises any effect of potential bias or assumptions made by the researcher within the process of data collection and analysis. A comprehensive overview of this method is provided by Braun and Clarke (2006). The ALPHA environment questionnaire responses were used to triangulate focus groups findings. The guidelines of Lincoln and Guba (1985) were followed to ensure trustworthiness by using an audit trail, audit method and analyst triangulation.

7.4 Results

7.4.1 ALPHA environment questionnaire

Mean sum of scores and SD's for the ALPHA environment questionnaire are presented for each theme in Table 7.2. From calculating the total sum of scores across all themes, the mean and SD was 51.95 ± 10.47 out of a possible 82 (theme 3-8) score for a supportive environment for PA.

Table 7.2 Descriptive variables for environmental themes and sub items from the ALPHA environmental questionnaire.

THEME/QUESTION	MEAN	AVERAGE SCORES
Theme 2: Distance to local facilities		15.86 ± 4.54
Local shop	1.48 ± 0.80	
Supermarket	2.76 ± 1.10	
Local services	2.25 ± 0.97	
Restaurant, café, bar or pub	2.64 ± 1.17	
Fast food restaurant, take away	2.11 ± 0.95	
Bus stop	1.66 ± 1.06	
Sport or leisure facility	2.64 ± 1.13	
Park or other open space	1.97 ± 1.11	
Theme 3: Walking and cycling infrastructure		5.81 ± 2.17
Footpaths in the neighbourhood	3.39 ± 1.12	
Special lanes/routes for cycling	2.42 ± 1.50	
Theme 4: Maintenance of walking and cycling infrastructure		7.47 ± 3.31
Footpaths maintained	2.58 ± 1.5	
Cycle paths maintained	2.02 ± 1.4	
Play areas/ parks maintained	2.88 ± 1.47	
Theme 5: Neighbourhood safety		15.63 ± 5.6

Crime		8.44 ± 2.90
Traffic		7.12 ± 3.73
Safe to leave bike locked outside	2.42 ± 1.51	
Safe to cross busy roads	2.27 ± 1.50	
Walking is safe due to traffic	2.73 ± 1.50	
Cycling is safe due to traffic	2.12 ± 1.50	
Safe at day due to crime	3.08 ± 1.34	
Safe at night due to crime	2.37 ± 1.51	
Theme 6: Pleasant		10.68 ± 3.16
Aesthetic		7.93 ± 2.43
Pleasant to walk cycle	2.88 ± 1.49	
No litter and graffiti in neighbourhood	2.17 ± 1.5	
Trees on streets	2.42 ± 1.51	
No badly maintained or empty buildings	3.14 ± 1.3	
Theme 7: Walking/cycling network		
network		10.31 ± 3.16
connect		7.37 ± 3.23
Many shortcuts	2.07 ± 1.47	
Cycling is easier than driving	2.58 ± 1.49	
Many road junctions	2.47 ± 1.51	
Many different routes to walk/cycle	2.27 ± 1.50	
Theme 8: home		3.20 ± 1.14
Have a bike for personal use	0.57 ± 0.50	
Have a garden	0.96 ± 0.19	
Have sports equipment	0.80 ± 0.40	
Have exercise equipment	0.43 ± 0.50	
Have use of a car	0.55 ± 0.50	

Key: Blue = supportive finding for PA, Red = unsupportive finding for PA

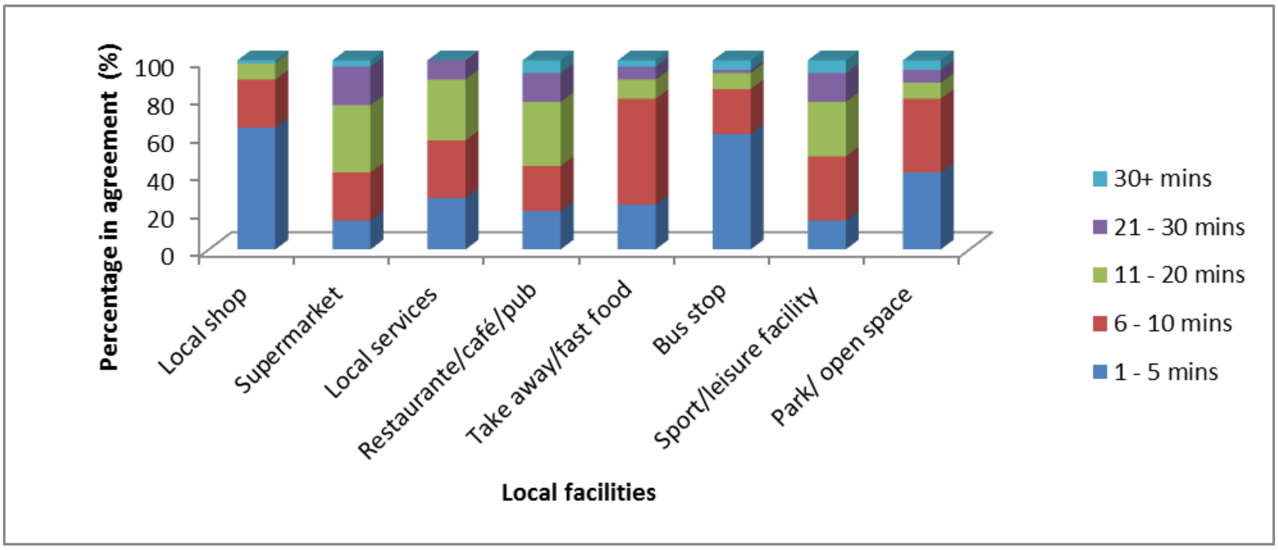
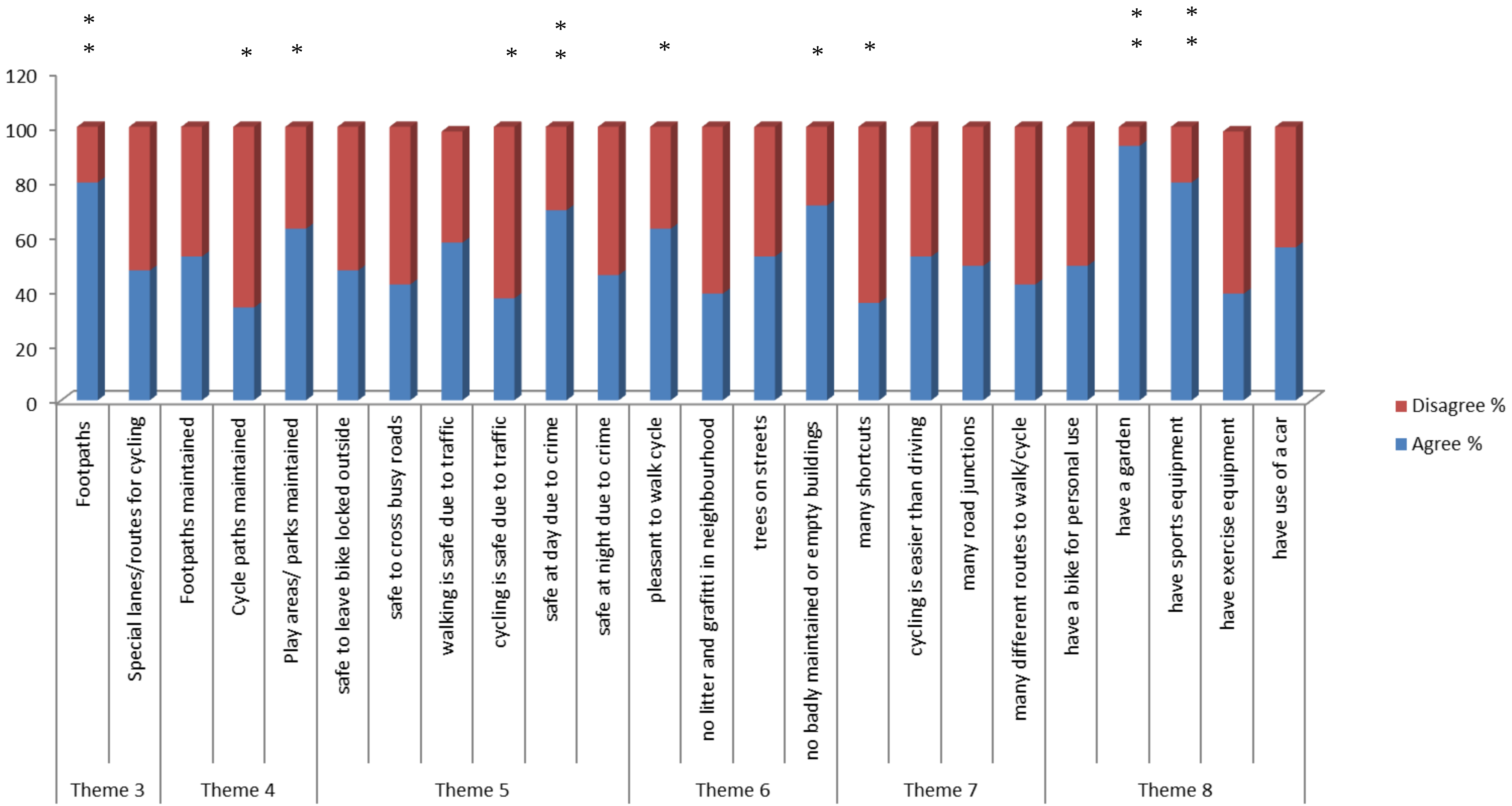


Figure 7.1 *Percentage in agreement with distance to local facilities*



*P<0.05, **P<0.01

Figure 7.2 *The percentage of parents that agree/disagree with the environmental barriers/facilitators*

7.4.1 Knowledge and beliefs about PA

The knowledge and beliefs about PA expressed by parents were positive. Parents viewed PA as *'being active'* or *'doing exercise'* (Appendix IV) and it generally meant their children 'playing'. Parents believed that their children should be active for a few hours a day. The benefits of PA/exercise were not extensively reported, with parents referring to the benefits being *'good for you'* or *'healthy'.* The main sources of beliefs were from their partner, internet, leaflets or knowledge gained from school. It was apparent their children had a need to play and that they want their children to be able to play safely *'They want to play; they want you to know some exercise… you want to be on your own and the child is playing safely '*(Appendix IV).

7.4.2 Distance to facilities

In terms of the ALPHA environment questionnaire, the parents report that their deprived environments are made up of a few semi- detached or terraced houses, but mostly made up of apartment buildings and blocks of flats. On the whole, most local facilities were within 30 minutes walking distance for all parents, with the majority of people reporting facilities within 6 - 10 minutes walking distance (Figure 7.1). For individual facilities, local shops, and a bus stop were within 1 - 5 minutes walking distance. Takeaways/fast food and recreational facilities (e.g. park) were within 6 – 10 minutes. Supermarkets, local services, restaurants were within 6 - 20 minutes (Table 7.2). From focus group discussions parents also reported local shops, takeaways, fruit stalls, parks and pubs within the local neighbourhood. There was a general lack of local youth clubs and sports clubs reported and parents identified a need for such facilities within the local neighbourhood (Appendix IV). Focus group two reported *' There is nowhere for them to* *go...If you go from the top of Foleshill road right through into town and you show me somewhere where there is a community centre for kids for them to play'* (Appendix IV).

7.4.3 Neighbourhood safety

The mean score from the ALPHA environment questionnaire for neighbourhood safety was 15.63 (out of a possible 24), with a mean of 8.44 for crime (out of a possible 12) and 7.12 for traffic (out of possible 12) (Table 7.2). When the sub items were considered, no significant differences were found between whether it was safe to leave a bike locked outside, safe to cross a busy street, walking safe due to traffic or safe at night due to crime ($P < 0.05$, Figure 7.2). However, parents felt that it was safe in the day (agree 69%, $X^2 = 8.9$, $P = 0.01$, Figure 7.2), but disagreed that it was safe to cycle due to traffic (63%, $X^2 = 3.8$, $P = 0.04$, Figure 7.2).

However, a substantial part of the focus group interviews centre on neighbourhood safety. It was apparent that the parents viewed their local neighbourhood as unsafe for many reasons. It was these perceptions which they considered as a main barrier for not allowing their child to play outside. The parents described their neighbourhood as 'rough' due to crimes including prostitution, anti-social behaviour relating to gangs, fights, attacks, drug dealing, racism and alcohol. One group reported *'The cans, they drink in groups, they are just very scary. So you can't take your child there when they are like standing there...and it's like more adults than children in the park. Like older teenagers. They in their hoodies and you can't see their face* (Appendix IV)*'*. Additionally, there were fears about dogs that were not kept on leads. Specifically, they discussed how the parks were unsafe because they are used as adult hangouts where they engage in crime related behaviours (drugs, alcohol, and sexual behaviour). Parents also talked about how anti-social behaviour affected them allowing their children to play in their own garden, sharing incidents of people throwing things into their gardens, or jumping into them

(Appendix IV). There was a general feeling that it was safe for parents to walk the streets during the day but that it was less safe at night. This related to increased crime at night, reduced lighting and a lack of warden presence (Appendix IV). It was unsafe for children to roam the neighbourhood unsupervised. They also shared concerns about the traffic, where cars were speeding, failed to follow driving rules (*'we have speed bumps in our road and they're still doing it'* (Appendix IV)) and car accidents occurred *('we've had a few accidents on my road'* (Appendix IV)). Lollipop ladies were present but it was felt that cars won't stop for the lollipop lady. In addition, their was a general feeling of non-law abiding citizens on the roads where cars drive in cycle lanes and drive the wrong way down one way streets (*'it doesn't matter if there's a cycling lane or a bus lane people still drive in them'*), (Appendix IV).

The role of social media affecting perceptions was apparent, whereby it enabled drug, dog and child abductions incidents to be shared, heightening fears. A parent shared her fears stating *'I am just scared of letting my daughter out to play…you don't know who is about. They could put them in a car, take them off or anything…so may accidents have happened…it is so easy to pick them up and take them of'* (Appendix IV). Parents felt that the neighbourhood could be made safe by increased security/safety surveillance (i.e. use of policing, cameras, wardens and increased lighting) and role modelling from local services (i.e. army, police, fire services) that could show children a route off the streets.

7.4.3 Pleasant and aesthetic environment

The mean score for how pleasant the environment was 10.68 ± 3.16 (out of a possible 16), and aesthetic was 7.93 (out of 12) (Table 7.2). When the sub items were considered, parents agreed that it was pleasant to walk around the neighbourhood (63%, X^2= 3.8, P = 0.04, Figure 7.2), and that there were not many badly maintained or empty buildings

(71%, X^2=10.6, P = 0.01, Figure 7.2). No significant differences were found in responses between those who agreed and those who disagreed that there were many trees on the streets or that there was litter and graffiti in the neighbourhood (P <0.05, Figure 7.2). Yet, in the focus group discussions parents shared complaints about dog mess, rats, rubbish on the streets, graffiti and people urinating on their properties (Appendix IV). On their walk to school they shared *' on our route of taking our children to school we would find used contraception on the floor… and empty syringes'* (Appendix IV). Drug needles were also reported along local canal sides. In local parks, parents described how the equipment was broken by older children, drug needles, and broken bottles were present, which made them unsafe/unusable places for children to play. It was described that *'there is a park on Stoney Stanton road…. I pass it... and he [referring to his son] will say can we go in there and I have to say sorry kid not that one. I won't take him into that park because I know the state of it…broken bottles and needles. It is just not very well maintained'* (Appendix IV). Furthermore, concerns about bin day and how bins were not returned to their places following the emptying were raised. It was felt that cleaning the streets and having dog mess bins would improve the neighbourhood.

7.4.3 Cycle and walking networks, infrastructure and maintenance.

Parents were in agreement that that there were many footpaths in the neighbourhood making it is easy to get around (80%), (X^2= 20.8, P = 0.01, Figure 7.2). However, they felt there weren't many short cuts or different routes for walking (X^2= 4.9, P = 0.04, Figure 7.2). No agreement was reached for whether there were cycle lanes or routes in their neighbourhood, (P = 0.69, Figure 7.2), whether cycle paths were maintained (P = 0.01, Figure 7.2), many road junctions and cycling being quicker than driving around the neighbourhood (P <0.05, Figure 7.2). No consistency was reached in perceptions of footpaths being maintained (P = 0.69, Figure 7.2).

From focus group discussions it was clear that in some places there were traffic lights which made the streets well connected. For other parents, zebra crossings were only present outside of the school. There was feeling that the lack of safe cycle lanes made cyclist ride on the pavement thus affecting walking on pavements. It was felt that more cycle lanes, speeds bumps and education on the rules of the road would improve the walking/cycling network. A parent shared *'if parks were safe we could actually go ourselves and do some activity, you know walking or even stroll'* (Appendix IV).

7.4.3 Home environment

The mean total response for the home environment was 3 (out of a possible 5). Parents agreed that they had access to a garden (93%, X^2= 44.1, P<0.001 and small sports equipment (garden sports equipment 80%, X^2= 20.8, P = 0.0001, Figure 7.2). Despite this positive physical environment/equipment, the focus group discussions revealed that parents feared for their children's' when playing in the garden because of people throwing things into the garden and general anti-social behaviour (Appendix IV).

From focus group discussions parents reported a pattern of sedentary behaviour for children in their home environment for both week and weekend days. Parents reported *'It is the weekend; they are always inside the house. Yeah, there's nothing that goes on in the weekend they are always inside the house. We don't trust the area.... To let your children go out and play'* (Appendix IV). On school days parents reported that their children *'come home from school, put the dinner on, lock the door at 6, she gets changed into her Pj's and does her homework or whatever she has got to do. She sits there and watches Cbeebies or whatever is on tele* '(Appendix IV). For parents from Muslim backgrounds it was acknowledged that schools days were further limited by religious practice. It was reported that *'kids have to go mosque so by the time they have gone to mosque come home, done their homework it is bedtime......so no time to do any other activities apart from at the weekends'* (Appendix IV)

Focus group 3 *reported. They are always inside the house. We don't trust the area.... To let your children go out and play* (Appendix IV). Some parents reported how the home environment didn't have sufficient space to engage in activities indoors. Some children did attend activities at clubs or local recreational facilities, but there was a feeling of few opportunities within the local neighbourhood (e.g. opportunities/accessibility for clubs).

7.4.4 School environment

All parents highlighted the importance of their child's school on their child's PA patterns. Parents reported *'the school plays an important role in their activity...they mainly [get PA] through school ...Because they are here most of the time...They have loads in this school and I think this school is brilliant for that ... but every other school hasn't got that'* (Appendix IV). The school was also described as a place of many opportunities (i.e. good facilities at the school and sports clubs), parents reported *'the swings, climbing frame, they have loads in this school…gym trainer, mooga…and running around the playground'* (Appendix IV).The opportunities at school were also described as a building block for future PA for some children (*'my son use to play football at school and he has continued because the PA was so good here'* (Appendix IV)). However, parents expressed a view that school provision only encompassed the hour after school, following this there were no other opportunities available within their neighbourhood outside of these hours. One parent said *'... We have lots of sport activities here; football, netball. My daughter's in football and netball, but that's just 3 to 4 o'clock. It's for one hour* *though'* (Appendix IV). Parents wanted their children to be physically active on weekends but reported the lack of opportunities available.

7.4.5 Other factors

Parental constraints driven by their perceptions of the surrounding environment, limited how children utilised their surrounding environment for PA. This was not specific for boys or girls, with parents objecting that they were not over protective of girls. A parent stated *'I wouldn't let my kids run around my street... I mean they say we are more protective with our daughters but even my son I would not let him out. So it is our sons as well now'* (Appendix IV). There appeared to be some age differences with primary aged children not allowed out, but more independent mobility for older teenagers (15 years of age). It was described that '*kids are limited because they are younger so they need supervision and can't do things on their own'* (Appendix IV). This was because younger children needed more supervision and a responsible adult. Other barriers related to lack of time, energy and money for parents (Appendix IV).

7.5 Discussion

This study sought to build upon the environmental barriers and facilitators to children PA as explored in study two by examining parental perceptions on determinants of children's PA patterns. This is the first to consider the lived experience of parents living in deprived environments and how this affects their child's PA. The findings are supportive of the physical and social environmental determinants of outdoor PA and overall PA patterns of children. In response to the research question (Do parents' perceptions of the environment facilitate or provide barriers for childrens' PA? If so, what are they?), tt was apparent that unsupportive physical and social environmental factors within the neighbourhood caused fear for parents and thus inhibited the children's ability to play outside, play in local parks, in their garden and thus resulted in spending their time indoors watching TV when not at school. The importance of the school environment was also highlighted, specifically relating to the physical environment and safety.

7.5.1 Knowledge and belief about PA and sources of these beliefs

From parental discussions, children's PA was described as mainly play and no structured activities. This is consistent with previous research that identified the nature of children's activity patterns as intermittent and transitory bursts of activity followed by periods of rest (Baquet et al., 2007). This was different to the findings in study two, where children described PA as structured activities (e.g. sports activities or PE lessons). Parent's knowledge of the benefits of PA was vaguely related to it being 'good for you' and 'healthy' and may relate to the sources of information being their husband, internet/leaflets or past knowledge from school. The media, family and friends have been described as main sources of beliefs in previous studies in ethnic adults (Rai & Finch, 1997).

Surprisingly, the children (study two) appeared to have a better knowledge and understanding of the benefits of PA (e.g. physiological, psychological and skill development) and the importance of engaging in PA for current and lifelong health than their parents. Given that the school and specifically the PE teacher was the only source of beliefs and role model for PA in SA children, it seems that the school played a vital role in education about the benefits of PA. Given that the parents had limited knowledge about the benefits of PA, it seems viable to suggest that this is why the children failed to report parents influence on their knowledge and beliefs in study one. Parental support, parental influences, role modelling and the importance of school for encouraging healthy behaviours and habits has been described in previous research (Finn, Johannsen &

Specker, 2002; Gustafson & Rhodes, 2006; Kamtsios & Digelidis, 2008) but this study is the first to explore ethnic parental influences qualitatively. These results are also consistent with Fishbein and Ajzen's (1975) Theory of Planned Behaviour, which highlights the importance of the influence of believing that PA will have positive benefits in determining PA behaviour. Both parents and children believed PA would have a beneficial effect.

8.5.2 Physical and social environmental determinants of PA

7.5.2.1 Neighbourhood factors

For residential type, parents described an area that was made up of some semi-detached or terraced houses, but that mainly consisted of flats or apartments. The consensus data for Coventry supports these views, large numbers of lower income workers have been found to live in urban terraces in often diverse areas (21,736 houses (16.1% of population in Coventry)), there were large numbers of families in low rise social housing with high levels of benefits needed (13, 232 houses (9.8% of population in Coventry), and large numbers of owner occupiers in older style housing on ex industrial areas (22,435 houses (16.6% of population in Coventry). This made up a total of 43% of all households across Coventry (Coventry City Council, 2012). Foleshill and St Michaels ward have been classified as having some of the highest population density scores across Coventry (54.4 and 55.8 per hectare respectively (Coventry City Council, 2010), resulting in high numbers of flats in blocks, flats/apartments, shared dwellings and the lowest percentage of owned houses (Coventry City Council, 2011). The density of neighbourhoods has been previously identified as facilitative to PA (Table 3.1).

7.5.2.1.1 Neighbourhood safety

For children, parental constraints and safety were the main barrier to PA outside (study two). It was apparent that there were local parks in the local neighbourhood within 10 minutes walking distance (Figure 7.2). However, an unsupporting physical and social environment affected the ability to play in these environments due to safety concerns. In previous research the availability and proximity of recreational space or public open spaces such as parks, playgrounds, playing fields or courts is associated with PA (Duncan et al., 2012; Chomitz et al., 2011; Loureiro et al., 2010; Nielsen et al., 2010; Tappe at al., 2013; Veitch et al., 2010, Table 3.1). However, this study suggests it is much more complicated than just availability and that in fact despite the availability these parents reported they won't let their children play in these parks. Both children alike reported drug needles in local parks. For children, there was a fear of getting lost due to unfamiliarity with the neighbourhood without supervision). Children's concerns regarding their safety in relation to crime and danger is reported in other studies (Loureiro et al., 2010).

However, parental perceptions provided greater insight into the constraints around their children's PA and allowing them to engage in outdoors environments for PA. It was identified that parents constrained children's behaviour of 'playing out' in relation to their own safety concerns, which is consistent with previous research (Veitch et al., 2010) Parents felt their neighbourhood was 'rough' due to a range of social and physical factors (young people or adults hanging around on streets/local parks or engaging in anti-social behaviour (fighting, drugs, alcohol, prostitution, throwing things, trespassing) and roaming dogs) and shared concerns over traffic, which prevented them allowing their children to play in local parks, streets or even in their own garden. These fears were heightened at night and by social media reporting about child abduction and drug incidents. For deprived areas, the social stigmatization (Lorenc et al., 2013), safety concerns at nights, increased reported and recorded crime (Foleshill and St Michaels is higher than the average for Coventry (121.5 per 1000 compared to 91.5)) and reported anti-social behaviour offences (257.9 offences per 1000 compared to 90.7 for Coventry) has previously been described (Coventry City Council, 2010). Dealing or using drugs, drink and people hanging about are also reported as the top three reported problems in Foleshill and St Michaels (Coventry City Council, 2010).

In addition, the physical environment reduction in street lighting and lack of warden presence during the night made the environment unsafe. It was felt that there was poor commitment to social norms within the neighbourhood with drivers failing to follow driving rules (e.g. driving wrong way down one way streets) and failing to abide to speed rules. The parents' suggestions for reducing their fears related to changes in the physical environment (i.e. policing, cameras, wardens and increased lighting) which would make them feel safer. In terms of traffic, presence of speeds bumps and education on the rules of the road would improve the walking/cycling network.

Previous qualitative findings from a systematic review have reported the role of the physical environment (i.e. physical security, street lighting, lack of commitment to social norms) and social environment (e.g. young people hanging around) which determine fear and limit engagement in social, cultural activities and outdoor play as a consequence of fear (Lorenc et al., 2013). Additionally, Lorenc et al's (2013) systematic review proposed that a feeling of familiarity with the neighbourhood can reduce fears and engagement with the local environment for PA. From the focus group discussions in this study, none of the parents reported familiarity with the environment, a feeling of integration or 'everyone knowing each other'. In fact, they reported a feeling of being watched and described Coventry as a melting pot full of a multi-ethnic and cultural representation. Of the population in Foleshill, 61% are from Black or ethnic minority backgrounds and 44% from St Michael's (Coventry City Council, 2010). The parents' familiarity thus may have heightened safety concerns and limited PA.

Parental safety concerns relating to the physical and social environment, especially during dark nights might thus explain several factors. Firstly, the low numbers of children meeting PA guidelines. Secondly, the low contribution of after-school PA to total MVPA. Finally, the low PA levels found on weekends (study one) obtained during winter months. Given these concerns it seems imperative to maximise opportunities during the school day especially during winter months, where opportunities outside of school may be limited. These findings relating to safety are supportive of Grow and Saelens (2010) contextual model and the findings that children of concerned parents are less active (Jackson et al., 2008) and less independent mobility (Santos et al., 2013).

<u>7.5.2.1.2 Perceptions about the aesthetics of the surrounding environment</u>

The walkability of the neighbourhood was reported due to many footpaths, crossings and local facilities near. However, this was not felt for cycling in, instead the need for cycle lanes were identified. It was clear that fears of crime related behaviours made the neighbour unpleasant for children to be physically active in. Common complaints made included the environment unpleasant were dog fouling, rubbish (causing rats), graffiti, people urinating, used 'used contraception' and 'empty syringes' from drugs, broken equipment in parks, and broken bottles or equipment, which made environments unsafe/unusable places for children to play. Rubbish and dog fouling were identified as the top problem in Foleshill and St Michaels wards from the consensus data (Coventry City Council, 2010). Neighbourhood aesthetics, cycle and walk facilities have been associated with higher reported child activity in the neighbourhood (Tappe et al., 2013). Given that the parents had a low perception of the neighbourhood aesthetics, this might explain some of the low PA patterns found. It was felt that cleaning the streets and having bins for dog mess would improve the neighbourhood.

7.5.2.2 Home environment

It was apparent that social and physical environmental resulted in a low perception of the environment and fears of child safety if children played outdoors. This resulted in the children on the whole, spending time indoors on weekdays mainly watching TV and playing with toys on weekends. Children in study two also reported the media entertainment opportunities (i.e. computers, computer games and TV) as barriers to their PA. Despite having a garden, parents expressed fears of people throwing things into the garden and general anti-social behaviour, which restricted their child's activity to indoors. The limited space in their home environment meant that there wasn't enough space indoors to do PA, and parents felt it was hard to entertain their children in home environments with limited space, thus resulting in increased media entertainment opportunities. Space identified as facilitative to PA from interviews with children (Table 7.2). These findings are supportive of previous research in lower income households, where greater access to media devices were provided, increased opportunity for sedentary behaviour and less for PA (Tandon et al., 2012). This also provides context to the findings in study one where SA children were found to spend increased time indoors and of this time they were less active. Prior work by Beets et al., (2011) has supported the importance of improving the home environment to decrease physical inactivity.

7.5.2.3 School environment

All parents highlighted the importance of their child's school on their child's PA patterns. It was a place of many opportnities (i.e. facilities at the school and sports clubs) and a building block for future PA for some children. Parents felt their children were most active at school. This is supportive of the findings in study one where school contributed almost half of total MVPA and in study two where children identified the importance of the school environment on their PA. It was the opportunities and facilities that were described as facilitative to PA for parents. These were similarly felt by children; however the children also described the supportive and safe environment that school offered for their PA. For SA children in study two, it was apparent that the specialised PE teacher played a crucial role on PA behaviours and attitudes, providing the main source of knowledge, beliefs, engagement and support. Parents also described their school as a foundation of knowledge for the benefits about PA. School thus plays an important role in developing the knowledge and understanding of PA in both parents and children. The importance of school PE on attitudes and beliefs as well as current and future PA is well documented (Ferguson et al., 2009) as such; the results of the present study are supportive of this prior work. The importance of school as an environmental determinant of children's PA behaviour from qualitative studies is reported (Kirby et al., 2013) and supports the contextual model by Pallan et al., (2012) in Figure 3.3. These findings highlight that school might be a useful mechanisms to which shared normative values can be developed for both parents and children, due to the way they interact with this school environment. Thus, school may provide a useful target for maximising PA (Martin et al., 2012).

However, parents shared concerns for what was available outside of school, suggesting that after-school clubs at school are just for an hour and there were limited opportunities out of school. Parents wanted to their children do things on weekends or during school holidays. Given the heightened safety concerns resulting in children being restrictive to their home environment, these findings highlight that providing safer and supervised opportunities through school and in the local community would provide increase PA for children.

7.5.2.4 Weather/seasonality

The children shared experiences of parental constraints around the weather, whereby if it was too windy or wet they were not allowed out to play (study two). Additionally, bad weather resulted in wet play at school (indoors). The parents however shared issues with seasonality and that in winter months the dark nights came earlier and thus the associated safety concerns. They reported that no-one would do an outdoors intervention in the autumn/winter but would in spring/summer. This is consistent with reports linking weather conditions to PA Behaviour, with PA being higher in summer months (Rich et al., 2012). The weather also restricted school PA and resulted in ‘indoor play’. The children would comment that there wasn’t enough space to play indoors. This may restrict the amount of activity that children can engage in.

7.5.2.5 Social environment

Children reported the importance of the school environment on their PA patterns; they enjoyed engaging in activities with peers, family members and teachers. These findings are consistent with findings from previous studies which have found that PA in children takes place most commonly with friends and family (Beets et al., 2011; Dunton et al., 2011; Veitch et al., 2013) and supports the contextual models in figure 3.2 and 3.3 .However, the importance of their children playing with others was not reported in parents. There was a perception that they didn’t want their children mixing with the children hanging around on the streets. None of the parents reported engaging in regular activity or exercise and thus parental modelling was low. Understandably, the parents were too tired to be active with their children after school/work and taking them to clubs was costly. Specifically, parents discussed limited budget and spare cash for activities.

One parent shared how they had just £7 left after their bills had been paid. This highlights the important role of the social opportunities at school to be active. It can be suggested that social components to PA are an important mechanism, which should be considered in intervention planning.

7.5.2.6. Religious practice

Similar to the focus group discussions with children (study two) parents identified 'Mosque' as a barrier to PA in SA children. Attending mosque is a religious practice which is specific to Pakistani (i.e. Muslim) ethnic groups and is viewed as high priority over PA. The parents identified that children spend approximately 2 hours per evening and weekends at mosque, which limits the time available for other activities, especially in the winter. Many school clubs are run immediately after school for an hour, which may minimise opportunities for Pakistani children to be involved in the clubs because they conflict interests with religious practice. These findings are supportive of prior research, which has highlighted the importance of religious practice in SA children and adults (Pallan, Parry & Adab, 2012; Eyre et al., 2013c; Rai & Finch, 1997). For Muslim children in PE, conflicts relating to PE kit, showers, Ramadan and provision of extra curriculum activities have been proposed as barriers to engaging in PA (Carroll & Hollinshead, 2013). These factors were however not identified in this current study, despite this though they identify the need to understand religious practices when designing ethnic minority focused interventions to increase PA in ethnic minorities.

7.5.2.7 Autonomy: age and gender

The results of the study one and two and this current study support the assertion that young children are not autonomous in their decisions and that parental constraints limit the availability to be physically active (Panter et al., 2010). Parents reported how younger children need supervision outdoors and that they would only let them to play in areas where there was a responsible adult. They also reported that these rules were the same for boys and girls, but that older children (i.e. teenagers) were given more independent mobility than younger children. This is contradictory to the findings previously reported; suggesting boys have greater independent mobility (Jones et al., 2009b). There was a feeling of them not being allowed to walk to school on their own even if in local proximity to the school and that the children had to be taken everywhere with parental supervision because of the unsafe neighbourhood.

7.5.3 Limitations

Although, the most practical, the convenient sampling method used in this study may limit the findings of this study to the larger community. Specifically, this sampling method resulting in the opinions being mainly mothers dominated, these may differ from those of their fathers. The social role of the mother and father on the children's PA is likely to be different. However, in the schools present it was only mothers who were responsible for bringing the children to and from school, thus the findings are representative of the mother's role in the community. Additionally, despite internationally validity, the lack of triangulation between some of the items in the questionnaire with the interviews would suggest that the multi-ethnic populations may have misunderstood the questions. This misunderstanding was overcome by the interviews.

7.6 Conclusion

The findings of this study support the contextual model by Grow and Saelens (2010) identified in Figure 3.2, that an unsupportive social and physical environment limits PA opportunities outside. The findings show little ethnic differences but highlight the role of SES and parental perceptions in determining PA behaviour in children. It was apparent that despite having access to local facilities to be active, these environments were perceived as unsafe and unpleasant places to play even with parental supervision. The role of the physical environment at school for providing PA for children was an important facilitator of children's PA. Policies need to focus on building supportive social and physical environments for children to play safely in deprived environments.

8.0 STUDY FOUR: EXAMINING THE EFFECTIVENESS OF A SCHOOL BASED INTEGRATED CURRICULUM TO IMPROVE PA IN SA CHILDREN FROM A LOW SES AREA

8.1 Abstract

Introduction: Children from SA backgrounds are less active than children from other ethnic groups. The school environment offers an opportunity to integrating PA within a school curriculum to promote PA throughout the school day at the same time as enhancing cross-curricular educational opportunities (Duncan et al., 2012; Oliver et al., 2006). To date, no research has modified the social and physical environment to integrate PA through school in SA children. The purpose of this study was to ascertain whether an integrated school based curriculum and pedometer intervention could increase PA in children from deprived ethnic backgrounds.

Method: Following ethical approval and informed consent, 134 children (63 boys, 71 girls), control (n = 40 with mean age ± SD= 11.12 ± 0.32 years) and intervention (n= 94 with mean age ± SD= 9.48 ± 0.62 years)) from a primary school in central England, completed a 6 week integrated PA intervention based on a simulated walk 252 miles (from their school to Weston Super Mare). Habitual PA was determined at baseline and post 6 weeks intervention for the control and intervention group, and determined weekly during the intervention for intervention group.

Results: The results indicated that average daily steps were significantly higher in the intervention group at 6 weeks post compared to baseline and the control group (mean change ± SD of change = 8694 ± 7428 steps/day vs. -1121 ± 5592 steps/day, 95% CI of difference, 6726, 7428 steps/day, $P = 0.001$, $d = 1.76$). No significant change from pre to post 6 weeks was found for the control group (mean change = -1121 ± 5592 steps/day, 95% CI of difference = -1301, 3004 steps/day, $P= 0.42$). In addition, significant decreases in body fat % (mean change ± SD of change = -4.46 ± 4.77% vs. -1.09 ± 2.77%, 95% CI of difference, -1.26, -0.34% , $P = 0.001$, $d = 1.22$) WC (mean change ± SD of change = -1.73 ± 4.48cm vs. -0.21 ± 3.49cm vs. respectively, 95% CI of difference, -3.40, 0.36cm, $P = 0.001$, $d= 0.44$) were observed in the intervention group post 6 weeks compared to the control group.

Conclusion: School-based integrated curriculum and pedometer interventions provide a feasible and effective mechanism for increasing habitual PA in primary school children from deprived and ethnic backgrounds.

8.2 Introduction

A paucity of studies exist that have considered the determinants of PA behaviour in SA children or employed an intervention to increase PA levels in SA children. BEACHeS was the first to consider the determinants of PA behaviour in deprived SA children. Pallan et al. (2012) identified the child, family, culture, school, local environment and macro environment as key factors. Pallan et al. (2013) also highlighted a two component intervention, which includes increasing children's PA through school and increasing skills of families through activity based learning. In this thesis, the findings from study one, highlighted that children were more active outdoors, in non-greenspace (i.e. playground and street), but that SA children spent more time indoors inactive. Qualitative findings from parents and children (study two and three), identified the importance of the physical and social environment at school on children's PA patterns. Specifically, the children discussed their teachers as role models, sole source of information about PA and keeping healthy and their primary motivator for PA by organising, introducing and encouraging their PA (study two, Eyre et al., 2013c). Finally, an unsupportive perceived physical and social neighbourhood environment limited PA opportunities outside of the school day. Given the impact of the school and the proposed importance of school interventions to increase PA in SA children (Pallan et al., 2013). In addition to the inability to change the physical and social environment outside of school, it seemed feasible that an intervention to increase PA should focus on the school environment. The collective findings from study one, two and three, suggests; opportunities for PA should be maximised throughout the school day, that interventions should be considerate to religious practice, PA indoors needs to be increased where safety concerns are high, and outdoors when safety is achieved, as well as providing a supportive social environment.

Given that education is a priority over PA within SA communities (Eyre et al., 2013c; Rai & Finch, 1997), and that children spend a large percentage of their day in school being educated, school based interventions seemed a viable mechanism to maximise impact on PA behaviours in SA children. Integrating PA within a school curriculum is a promising approach which enables the promotion of PA throughout the school day at the same time as enhancing cross-curricular educational opportunities (Duncan et al., 2012; Oliver et al., 2006). Prior work suggests that the use of pedometers in interventions provides an effective open-loop feedback mechanism, which is both motivational and educational, resulting in increased habitual PA (Duncan et al., 2012; Oliver et al., 2006). The most effective pedometer based intervention to enhance children's PA used an integrated curriculum model (Lubans et al., 2009). Subsequent data has supported this assertion (Duncan et al., 2012) showing that children were more physically active during and after curriculum integration. The aim of this study is thus to ascertain whether manipulating the physical and social environment through school can increase PA behaviours in SA children from deprived backgrounds. This to attempt to answer the research question, can PA be increased in SA children by changing the physical and social environment? The intervention is based on the conceptual model by Grow and Saelens, (2010) (Figure 3.2) and the findings gathered from study one, two and three.

8.3 Method

8.3.1 Participants

The design of this study is described in detail in Chapter 4.0. A total of 134/135 SA (Indian, Pakistan and Bangladesh) children (40 control, 94 intervention, 63 boys, 71 girls) participated. The control group were from Year 6 (mean age ± SD= 11.12 ± 0.32 years) and the intervention group were from Year 4 and 5 (mean age ± SD = 9.48 ± 0.62 years). Both groups were not significantly different at baseline for pedometer steps/day or fatness (P <0.05), so age was therefore controlled for in subsequent statistical analysis. The intervention group were shown a video (made by EE and included EE and staff from Coventry University), at the beginning of the intervention. The video provided detailed information about the pedometer challenge, what activities they could do after school, about how to record their steps and feedback about their current activity levels.

8.3.1 Procedures

Height, mass, BMI, WC and body fat assessments were conducted on all children in accordance with the procedures outlined in Section 4.7.

8.3.2 Intervening with the conceptual model

The intervention focused on changing the physical environment by providing equipment (i.e. a pedometer and skipping rope) and after-school activity clubs. The social environment was changed to provide a supportive environment at school such as teachers role modelling and by integrating role modelling into after-school clubs (e.g. Olympic circuit - jump like Gregg Rutherford). This was to create a social environment where PA is important and to utilise the physical environment to increased PA. Opportunities for independent and peer working (e.g. individual trophies for effort and trophy for class with most weekly steps, education about ‘being healthy’ at school) was also provided. This was because social and physical barriers were identified by both children and parents in study two and three. Additionally, the school was identified as the main and only source of PA.

8.3.2.1 Curriculum integration

The full schematic for the intervention design can be found in Table 8.1. The intervention group undertook a 6-week, school-based pedometer intervention using an integrated curriculum model (Duncan et al., 2012; Oliver et al., 2006). There were two stages to this intervention; the first stage was designed to increase PA through increasing opportunities to be active throughout the school day using a pedometer challenge that was linked to curriculum. To increase adherence to the pedometer challenge, each child was taught to skip (15 minute lesson) and provided with a personal skipping rope. This was included to encourage free play at school and outside of school. Additionally, locomotive activities and playground games sessions were held with a shorter duration (45 minutes), once a week, for 4 weeks after-school, allowing the children time to attend mosque and activity sessions. Secondly, an environment was created to promote that exercise was beneficial. The curriculum was modified whereby topics in Science (i.e. 'keeping healthy' (Year 5) and 'journeys' (Year 4)), were developed and delivered to varied education/ability needs. Science was therefore used as the main subject and provided cross curriculum links to other subjects. A themed health week was held, where all subject lessons related to the theme (Table 8.1). At the end of this intervention (week 6), the curriculum reverted back to its regular provision.

Table 8.1 Schematic of intervention

Main PA task: Virtual walk to Weston Super Mare (6-weeks)
Target : total miles 252 (756,000 steps), 42 miles per week (15,000 steps a day, (3000 bonus steps provided for walking to/from school or attending afterschool activity sessions).

Curriculum links: Science (exercise and the body's response (e.g. lungs, heart), Maths (weekly steps, comparing less/more active days), geography (map tracking progress on route), PE (engaging in habitual PA)

MECHANISM FOR EDUCATION, PA AND HEALTH BEHAVIOUR CHANGE.

Curriculum delivery	Quantity	Summary of tasks	Cross curriculum links
PE (delivered by teachers)	1 hour per week, 6 weeks	Athletics Games Dance Gymnastics	Science: keeping healthy, the heart, lungs, movement. Maths: pedometer steps and activity
Science: keeping healthy and journeys - delivered by teachers - delivered by EE with teachers	 1 hour per week, 6 weeks 1 hour per week, 6 weeks	Healthy balanced diet Exercise and the body (heart, lungs) Journey of blood around the body Healthy and unhealthy drugs Smoking and the body	Literacy: create posters , menus, timetables for activity classes ICT: video on how heart works, create videos to promote PA Art and design: design healthy drug, design health centre Maths: plot graph of changes of the heart before, during and after exercise. Compare boys and girls. PE: create games, activity sessions and lead them. Music: create song, or rap for healthy video.

Health week (week 6): Integrated health theme into every curriculum lesson over a whole week. - Delivered by teachers - Skipping lesson by EE	9-3.30, 5 days, 15 minutes per class	Create video summarises what they know on keeping healthy and advises others to keep healthy.	ICT, English, maths, science, PE
Activities to increase daily PA			
Afterschool activity sessions	45minutes, 1 per week, 4 weeks	**General plan** Warm up (5 minutes) Plyometric and skill drill circuits (15 minutes) Playground games (15 minutes)i.e. what's time Mr wolf, dodge ball, Cool down (5 minutes) Change time (5 minutes) Each week had a specific focus for example: week 6 Olympic games focused on problem based learning to develop techniques Station 1: sprint like Usain bolt (sprint race) Station 2: Jessica Ennis's Heptathlon (obstacle course) Station 3: Score like Messi (football shoot out) Station 4: Bowl like Hasim Amla Station: Dribble and shoot like Jo Leedham Station 6: Jump like Gregg Rutherford	PE
Activities with dinner ladies	1 hour per week, 1 session, 6 weeks	Circuit training	

8.3.2.2 The pedometer challenge

The pedometer was used as an open loop feedback tool to provide motivation to increase PA steps. The information regarding the pedometer challenge was delivered as part of a video, which was specifically made for the children. The pedometer challenge required the children to walk virtually from school to Weston Super Mare (total miles 252

(756,000 steps), 42 miles per week). This location was chosen as it was a place that the children had visited on a school trip, so it was real to them. Based on the Tudor-Locke et al's (2004) conversion of 15,000 steps/day as representative of healthy weight and meeting PA guidelines (WHO, 2010), the children were challenged to achieve total daily steps of 18,000, inclusive of bonus steps. Children who walked to or from school, or attended after-school activity sessions were given 3000 bonus steps, which were not included in the final analysis. A conversion rate of 3000 steps to 1 mile was used based from pilot work on children's stride length. Each child was provided with a global position-derived satellite map of their route, which was broken down into weekly challenges to meet the 6-week target. Each week (i.e. Monday) the total weekly steps were calculated and feedback was given to each child about their progress.

8.3.3 Quantitative data collection

All children wore one unsealed hip mounted piezo-electric pedometer (New Lifestyles, NL2000, Montana, USA) at baseline and post-6 weeks. Steps were also obtained on a weekly basis for a total of 6-weeks during the intervention, for the intervention group only. All activity monitoring was obtained for 7 days on each measurement period and removed only for water based activities. The New Lifestyles pedometer was employed as it shows high reliability and validity in assessing ambulatory PA in children from different weight status groups (Crouter et al., 2005; Tudor-Locke et al., 2002). The children, under teacher's supervision recorded their steps at 9am and 3pm on weekdays and 9am weekends, at all measurement points. Children recorded non-wear time; pedometers removed for >1 hour were treated as missing data, consistent with previous pedometer research (Duncan et al, 2007; Johnson et al, 2010; McNamara et al, 2010).

8.3.4 Quantitative Data analysis

From the 134 that consented, three moved school by the end of the testing period. A further 29 participants were absent on baseline (control n=7, intervention n= 5) or post 6-weeks testing days (control n= 3, intervention n= 14), and were excluded from analysis. A strict inclusion criterion was applied to the remaining data, days in which the step counts were <1000 steps/day was excluded as incomplete data for that day, consistent with research (Rowe et al., 2004). Following this, children who failed to provide four complete days and <10 hours of PA data (Janz et al 1995; Trost et al., 2000) at all measurement time points were excluded (intervention n= 16) in order to account for day to day variations in activity patterns. Thus, a total of 49 children were excluded (control = 5 boys, 5 girls, intervention = 21 girls, 18 boys), leaving a final sample of 85 children with a compliance rate of 63%, which is consistent with other studies (46-99%; Clemes & Biddle, 2013). Mean pedometer steps for week, weekend, school (9am - 3pm) and afterschool (3pm - 9am) were calculated for baseline, intervention and post 6-weeks.

8.3.4 Qualitative procedure

At 6-weeks post intervention (July 2013), the children took part in homogenous focus group interviews based on their baseline PA level. These groups were defined as high activity based on upper quartiles (>10, 036 baseline steps/day), medium activity based on >5518 and <10, 036 steps/day, and low activity based on lower quartiles (<5518 steps/day) of PA, and the children were grouped accordingly. Six children per group were invited based on the quota of every 4th name in alphabetical order and boy, girl (low, medium and high PA), resulting in a total of 18 children (boy = 9, girl = 9). The main topics for questioning were: the video (did they understand it), walking to Weston Super Mare, science lessons, after-school activity sessions and sustaining PA (See Appendix V for questions). The analysis is previously reported in Section 4.8.

8.3.6 Statistical analysis

All statistics were conducted using SPSS version 20 and the alpha level was set at $p<0.05$). The following analyses were conducted to assess PA variables, 1. An independent t-test assessed whether PA (steps/day) between the control and intervention group were equal at baseline. 2. A 2 (control vs. intervention) by 2 (boy vs. girl) by 2 (pre and post- PA/ BMI/WC/body fat) repeated measures analysis of variance (ANCOVA) assessed PA (steps/day) and body fat (%) changes. In the present study BMI was used as a covariate in the analysis as it has been associated with PA in children, independent of the other variables assessed in this study. The use of ANCOVA also enables any differences in PA, pre to post intervention and between groups to be analysed, controlling for any impact of weight status whilst at the same time enabling the association between the dependant variable and the covariate to be determined (Field, 2010). The effect size was used to calculate differences using cohens *d*. According to Cohen (1988) a small effect size ranges from $d= 0.3$, $d= 0.5$ is a medium effect and $d= 0.8$ and above represents a large effect. 95% confidence intervals were calculated for mean difference. Eight factor analyses (baseline, Week 1, 2, 3, 4, 5, 6 and post 6-weeks) examined week by week differences in PA during the intervention.

8.4 Results

8.4.1 Baseline characteristics

Anthropometric data for the children (n = 85) indicated a mean BMI of 19.00 ± 7.42kg/m^{2}, BMI z-score of 0.43 ± 1.29, 24.7% of which were classified as overweight/obese (Cole et al., 1999). At baseline there were no significant PA (10479 ± 6665 vs. 7845 ± 2942 steps/day, 95% CI of difference, -4710, -558 steps/day, $P >0.05$, $d = -0.40$) differences found between the control and intervention group. No differences in BMI (BMI z- scores = 0.47 ± 1.42 vs. 0.33 ± 1.22, 95% CI of difference, -0.72, 0.44, *P*

>0.05, d = -0.10) or body fat (21.72 ± 9.42% vs. 22.35 ± 8.60%, 95% CI of difference, -3.39, 4.65%, d = 0.07, P >0.05) were found between the control and intervention group. Significant gender differences were found in which boys were more active and evidenced higher BMI values.

8.4.2 Intervention results

8.4.2.1 Week by week variations in PA

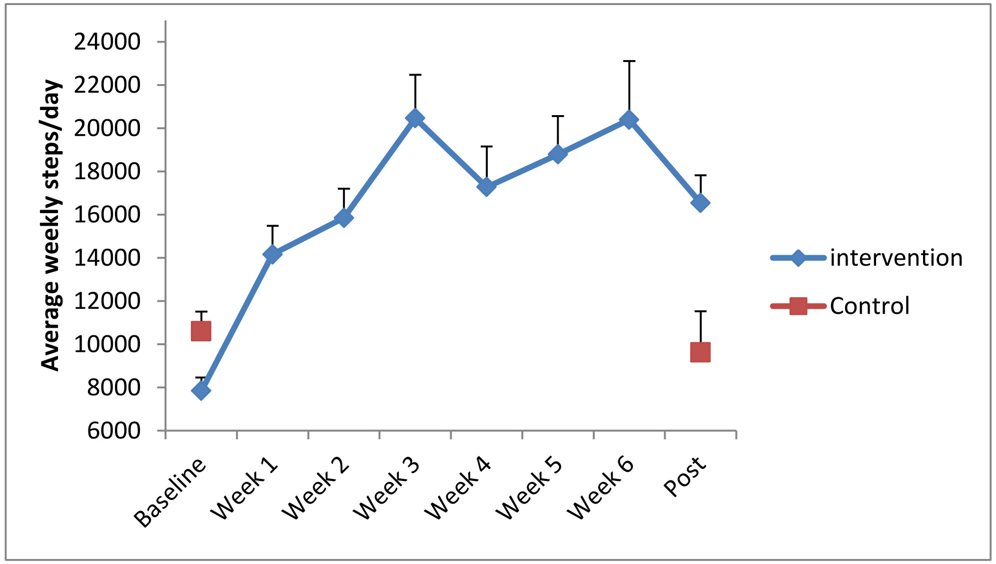
The week by week variations in PA are plotted in Figure 8.1. The largest magnitude of increase in PA was seen at week 1 (an 80.5% increase in steps from baseline, +6318 steps/day), from week 1 to week 2, PA continued to increase by 11.9% (+1691 steps/day), and 22.5% more (+4611 steps day) for week 3, to which the peak in PA was observed. At week 4, there was a 15.6% reduction in PA (-3185 steps/day), this increased at week 5 by 8.8% (+1514 steps/day), and further by 8.5% (+1604 steps/day) by week 6. From week 6 to post 6-weeks PA decreased by 18.9% (-3859 steps/day), however PA 6-weeks post was still higher than baseline (+8694 steps/day) and weeks 1 and 2, suggesting a plateau in PA around an average of 17641 steps/day.

Table 8.2 Descriptive variables from baseline to post 6 weeks intervention for control and intervention group.

	Control (n = 30) Age = 11.12 ±0.32 years			Intervention (n = 55) Age = 9.48 ± 0.67					
	Baseline	Post 6 weeks	Mean change from Baseline to post 6 weeks	Baseline	Post 6 weeks	Mean change from Baseline to post 6 weeks	*P* for group difference	95% CI of difference in mean change between control and intervention	Effect size (*d*)
PA (steps/day)									
Daily PA*	10479 ± 6665	9358 ± 4770	-1121 ± 5592	7845 ± 2942	16539 ± 4929	8694 ± 7428	0.001	6726, 12904	1.76
Week PA*	11543 ± 7825	7506 ± 3419	-4037 ± 7284	8609 ± 3429	17402 ± 10748	8793 ± 8881	0.001	9057, 16602	1.76
Weekend PA*	5270 ± 4615	16331 ± 12063	11061 ± 10045	3935 ± 3740	13273 ± 7613	9338 ± 4096	0.68	-4790, 1344	-0.17
School PA*	5923 ± 3259	5013 ± 3041	-910 ± 3256	4716 ± 4527	8903 ± 3059	4186 ± 2986	0.01	3704, 6488	1.57
Afterschool PA*	9027 ± 6498	6259 ± 3962	-2768 ± 6395	8397 ± 3189	10773 ± 7070	2376 ± 2339	0.01	3236, 7051	0.8
Body Fat									
BMI (kg/m^2)	20.18 ± 6.85	18.24 ± 4.62	-1.94 ± 0.93	17.77 ± 6.25	17.56 ± 4.23	-0.21 ± 0.88	0.11	1.38, 2.44	1.86
BMI Z-scores	0.47 ± 1.42	0.03 ± 1.50	-0.02 ± 0.49	0.33 ± 1.22	0.18 ± 1.37	-0.18 ± 0.39	0.16	-0.82, 0.08	0.33
WC (cm)	63.61 ± 11.34	63.40 ± 10.19	-0.21 ± 3.49	63.19 ± 13.94	61.46 ± 12.53	-1.73 ± 4.48	0.001	-3.40, 0.36	0.44
WC SDS	0.86 ± 1.57	0.75 ± 1.53	-0.11 ± 0.71	0.82 ± 1.44	0.03 ± 1.40	-0.79 ± 0.99	0.001	-1.21, -0.29	0.96
Body Fat (%)	21.72 ± 9.42	20.63 ± 9.31	-1.09 ± 2.77	22.35 ± 8.60	17.89 ± 8.53	-4.46 ± 4.77	0.01	-1.26, -0.34	1.22

Mean ± SD, * Adjust for baseline BMI Z-score

Abbreviations: BMI- body mass index**, CI –** confidence interval, **PA –** physical activity, **WC** – waist circumference



Mean daily steps ± SD

Figure 8.1 *PA steps from baseline to post 6 weeks*

8.4.2.2 Changes in PA post intervention

The results evidence a significant increase from baseline to post PA for the intervention group compared to control (*P* = 0.00) (Table 8.2). Specifically, increases for the intervention group were observed for daily PA , weekday PA, weekend PA, school and afterschool PA 6-weeks post intervention for the intervention group, adjusted for BMI Z-scores (Table 8.2). Noticeably, steps/day were lower at 6 weeks post intervention than at the end of the intervention, but still higher than at baseline. Contrastingly, the control group's PA decreased for daily, weekday, school and afterschool, but weekend PA increased. An increase in the proportion of children meeting the pedometer cut-offs for health was also observed (from 11.7% to 44.7%). Significant differences (*P* <0.01) were found regardless of whether BMI Z-scores, body fat, WC or WC Z-scores were controlled for.

8.4.2.3 Changes in body fat post intervention

For fatness, the findings evidenced no significant change in BMI (*P* = 0.17) or BMI z-scores, (*P* = 0.36) between control and intervention group from baseline to intervention. However, the intervention group evidenced significantly lower WC (-2 cm, *P* <0.01) and body fat (-4%, *P* <0.01) scores post 6-weeks intervention compared to the control group (Table 8.2).

8.4.2.4 Gender differences

The descriptive variables for gender can be found in (Appendix VI). No main effect of gender or interaction effects with group (control and intervention) or measurement time (baseline and post 6 weeks) were found (*P* <0.05). The response to the intervention was similar for boys and girls (*P* = 0.77, 95% CI of difference for boys, 7459, 16497 steps/day and 95% CI of difference for girls, 5124,10099 steps/day, Appendices VI and VII).

8.4.3 Qualitative intervention evaluation

8.4.3.1 The video introducing the project

Regardless of their activity group (i.e. low activity group, medium activity group and high activity group) and gender, the children reported that the video was motivating and funny (Appendix VIII). All children reported that the video was good. For the low and medium active group, similarities in the humour of the video (i.e. people dressed up and dancing) were reported. Low and high active reported that the video made them excited about doing exercise. Secondly, the educational element of the video was reported, by the low and medium active groups, with the children reporting the statistics for not being healthy. For the high active group, they commented upon positive role modelling in the video, reporting the influence of David Beckham and how they viewed a range of activities and it made them want to show other people that they could exercise as well (Appendix VIII). Regardless of their group or gender, the children were able to recite the main message of the video, which was the task of *'to do enough steps to walk to Weston Super Mare and back...18,000 a day...6 weeks'* (Appendix VIII) For the medium active group, they also commented on the invitation to come to after-school clubs to be more active also.

The children in the medium active and high active group also offered suggestions on how the video could be improved but these differed by group. For the active group, they wanted more information in the video about fitness and healthy foods. For the medium active group, the themes came from boys only who wanted some of the information slowed down (i.e. activities in slower motion) and the music to be removed from the text part and just used over pictures because it confused them.

8.4.3.2 Virtual walking to Weston Super Mare: The pedometer challenge

All of the children in the low active group felt that the task was easy and 4/6 children in the medium active group said the same. The children felt it was easy because of the school environment (e.g. walking to school and the playground) and the home environment. For girls, their home environment meant they could '*run around and do housework'*, for boys it meant they could *'play out'* (Appendix VIII).

The children discussed behaviours that resulted in their increased daily steps, these related to being more active in general daily behaviour, more active at school and more active out of school (Appendix VIII). For general daily behaviour walking more (e.g. mainly transport) was common for low and medium active groups, but engaging in more free play activities specifically relating to skipping was most common for boys and girls, although trampolining was also common in the low active group. Sport specific activities were briefly described only for the medium active group. For school behaviour, active play during lunchtime was commonly reported across activity and gender groups, this again was related to mainly skipping.

8.4.3.3 Outside of school

Changes in behaviour were not independent to school. There were emerging themes relating to increased activity outside of school also. For low and high active group, the themes related to independent activities (e.g. engaging in more active free play and being less sedentary), and activities with friends (outdoors walking and free play). A child reported *'you couldn't do your general stuff like watching TV... you actually had to do it and play'* (Appendix VIII). All groups similarly reported the role of engaging in more family activities (e.g. activities outdoors mainly relating to the park) for enabling them to achieve their daily steps (Appendix VIII).

The free skipping ropes provided to each child and as well as teaching the children how to skip was an important factor in their increases PA (*'I used it about four times a day'*, (Appendix VIII). For the low and medium active group the mastery of the skill of skipping for boys was an important factor. The boys discussed how they didn't know how to skip but that they mastered this skill which made them skip more. A child reported '*by learning with you, we learnt forward skip, backwards skip, and cross over and then more boys skipped'* (Appendix VIII). For the medium and high active group the school environment (social skipping, equipment and mastery of new tricks) was facilitative to being able to skip more. It was also apparent that skipping was undertaken indoors and outdoors, alone and with others.

The key emerging themes relating to the pedometers were that they got *'lost'*, that they were useful. The children liked the maps, reporting that they were easy to use, that they liked having the feedback about their steps, their progress, distance and location (Appendix VIII). For future similar interventions the children would like to go to a new destination which was another country and longer, they would then like to visit the location they walked to.

The children enjoyed the curriculum integration recalling specific activities that they did during these lessons. They reported that the lessons were useful because of the increased learning, the experiments, which helped this and the children recited some of the activities they did in their lesson. One child reported *'it was very good, I learnt how much more you can breathe in you exercise and how hard your lungs work to make you exercise'* (Appendix VIII).

The uptake for the after-school activity sessions was positive with 54/134 (40%) children attending. 14/18 of the children interviewed attended the after-school sessions and reporting that they would come again. The children felt the after-school sessions were a good work out, the penalty shootout, athletics, playground games and plyometric were popular. A child reported *'the ladders. They were really good for your legs, make you fitter'* (Appendix VIII). The children reported an interest in visiting different venues such as swimming centres as learning to swim is a life skill and to use their BMX track and bikes at the school. They reported how some activities at lunchtime would offer opportunities for children who could not come after school and that they would like it to include Year 6 as well. They finally expressed how having activity sessions for an hour (i.e. 15 minutes longer) would stop them from going to the club because some of the children need to be at mosque for 4pm and if they are late they get a detention.

8.4.3.4 Motivators for keeping active

The children's main motivators were their teachers who encouraged them during PE, they did exercise with the children *'[teacher name] was doing it too as well as making us exercise we were making him exercise'* (Appendix VIII) and by goal setting. The external rewards were also a motivating factor for increasing PA for the high active group. The children reported how the rewards made them work as a team to be active and how the best effort trophies during the school club encouraged them to be get more fit.

8.4.3.5 Sustaining PA

All the children (18/18) felt that they were more active and healthy now than before and reported that they still use their skipping rope. All of the children said they would like to do the intervention again. The factors causing this change relate to a change from sedentary activities to more active activities for low active group. For the medium and active group, it was more free play, sports or activities with friends. The importance of the change in weather and being allowed out to play and for longer was mentioned by the low active group as was the role of family activities in the park. In the low active group the children reported that other children in their class were not as active now and they felt that this was because of the school environment. They wanted the teacher to come and exercise with them at least once a week *' because most of the teachers don't come out and actually do this with us anymore'* (Appendix VIII) *'Thing is we want a teacher to do it with us at least once a week or something'* (Appendix VIII). The low active group reported the impact it had on other people in their family, this wasn't reported in other activity groups (suggesting they were surrounded by a sedentary environment at home). For the high active group they talked about ways they could help others be active in their school e.g. posters or running activities.

8.5 Discussion

This study assesses two of the top three research priorities in children and adolescents (Gillis et al., 2013) and the research question, by developing an effective and sustainable intervention over 6 weeks post intervention and by changing the environment to influence children's PA and reducing sedentary behaviour. Specifically, it assessed the utility of an integrated curriculum pedometer intervention to enhance PA in SA children from the most deprived ward in Coventry, UK. The novel results provide evidence that an integrated approach can increase habitual PA and decrease fatness for up to 6-weeks post intervention in SA children. This is the first study to date, which compares the integrated model to a control group and examine changes in measures of fatness/weight status alongside PA. These findings support previous studies showing that integrating PA into the curriculum with a pedometer based feedback loop is effective (Duncan et al., 2012; Lubans et al., 2009; Oliver et al., 2006) in enhancing short term habitual PA behaviour in children.

8.5.1 Changes in PA

The findings showed an increase in post intervention steps compared to baseline, for the intervention group. There is only two studies (Duncan et al., 2012; Oliver et al., 2009) to date which have assessed the combined effects of both a pedometer and curriculum intervention (Lubans et al., 2009). Other research has focused on just curriculum interventions with discrete elements (i.e. PE or health education) (Guinhouya et al., 2009). Our findings are supportive of Duncan et al's (2012) research that a combined curriculum and pedometer intervention results in increased post intervention steps. However, this study extends beyond that of Duncan et al., (2012) by examining these effects one school half term later (6-weeks) and making comparisons with a control group, confirming intervention effects. Noticeably, the average daily steps were lower in this current study at baseline (Table 8.2), and lower than accelerometer predicted cut points from previous study, which ranged from 35 - 54% (Eyre et al., 2013; Owens et al., 2009). Despite this, they are in agreement with the literature evidencing low PA in SA children (Eyre et al., 2012a, b; Owens et al 2009). Low adherence to PA was also found in study one, with SA children spending more time indoors inactive. Yet, it was apparent that with an appropriately targeted intervention PA could be increased substantially compared to a control group and result in nearly half of the children post intervention meeting the pedometer cut points for health. This is promising given that the intervention group evidenced lower steps/day at baseline compared to the control group, evidencing the impact of this intervention. Of concern though, still half of the children failed to meet these targets.

Given these low baseline activity patterns, it could be argued that the substantial increases witnessed in this current study might be a result of the increased opportunity to improve from baseline. Oliver et al., (2009) support this notion as they found no differences in the PA when their total sample was analysed, but that children with low activity levels increased significantly. Although, both prior studies (Duncan et al., 2012; Oliver et al., 2009) used a similar integrated curriculum approach, the present study built on this by providing simple moveable PA equipment and opportunity for the children to achieve these daily targets i.e. afterschool session, skipping introduction and equipment. This may have enhanced the success of the present intervention model. This study provides evidence that such changes can be observed for an extended period beyond 6-weeks although any longer term effects are not known.

This study also required the children to wear their pedometer over weekend days thus measuring the impact of the intervention on weekend activity; this was not employed in earlier studies and is a strength of this current research. There were no significant differences found for weekend activity post intervention. Thus, further approaches which have a direct impact on weekend PA may need incorporating to augment PA increases at these times. However, an increase in weekend PA from baseline in both the control and intervention group was seen. The significant changes were due to increases in after-school activity and school day activity. This was supported by the qualitative information gathered whereby children reported engaging in more activity outside of school by getting outside more and not engaging in sedentary activities indoors. Such results are supportive of prior research that reported that outdoor PA results in increased health enhancing PA and that children who spend more time outdoors are more active (McCurdy et al., 2010). Study one also identified that the children spent increased MVPA time outdoors, but that SA children spent more time indoors inactive. Study two and three provided further context to these findings highlighting that the home environment was inductive of sedentary behaviour. The findings thus support that increased PA was obtained by increasing activity outdoors and reducing sedentary behaviours. This study was carried out during the summer term due to feasibility. A review of UK studies has shown PA in children to be greater in the winter (Fisher, 2005; Rich et al., 2012) and thus it could be argued that the season influenced the change in PA. However, the use of a control group minimises the confounding effect of seasonality on PA. Future research needs to ascertain whether the same increases in PA can be seen across seasons.

The children in the present study also reported that they were more active at school during lunchtimes mainly by engaging in skipping activities, regardless of their gender, again supporting previous research confirming the importance of school recess on children's overall PA (Stratton & Mullen, 2005). The importance of the school environment (e.g. organised break times, PE lessons, equipment and facilities) for PA is previously described in Section 3.1.1.1, and in study one to three and is supportive that modifying the school environment has beneficial effects on PA engagement in SA children. The finding that children were more active outside of school is of particular importance, as the ethnic differences between White and SA children's daily PA are posited to be as a result of SA children being less active after school (Eyre et al., 2013b). The current study provides evidence of an intervention that can increase PA in and out of the school environment, potentially decreasing the ethnic gap in PA.

There is some debate about the most influential determinant for overall PA; some argue that school is the main component (Ridgers et al., 2011; Fairclough et al., 2012), others argue that afterschool activity account for the differences between overweight/obese vs.

normal children and inactive vs. active children (Riddoch et al., 2007; Deforche et al., 2009; Olds et al., 2011). The findings from the current study are largely in agreement with Rowlands et al., (2008), that highly active children spend more time in PA before school, during class, lunch and after school, because changes were observed and reported across all components of the day.

The intervention was focused around changing the physical environment during school through moveable equipment (e.g. skipping ropes, pedometers) and changing the structure of the school day (i.e. curriculum) as well as extending the school day by providing afterschool activity sessions. This was augmented in integrating curriculum around keeping healthy, embedding the walking challenge into the school day with the pedometers, providing free play equipment (skipping rope) and after-school club once a week. The change in the physical environment also resulted in changes to the social environment. The teachers' role modelling further expanded in, which the teachers were actually skipping and exercising with their classes during school break times. The teachers' commitment increased further, whereby they were encouraging the children to set goals and work as a class to gain the most steps to win the most steps trophy per week. The influence of peers at the school who were also carrying out the skipping was apparent, as was working as a team. Although the physical environment away from school did not change (e.g. access to facilities), the children also reported increased engagement in activity outside of school. This was conductive to skipping indoors and outdoors (with free skipping rope they were given), spending time at the park with friends or family, suggesting that this was a result of the changing social environment. The only physical environment that did change was the weather, the low active group reported how the weather changing meant they were able to play outside for longer. Therefore, the findings are supportive of the conceptual model proposed Grow and

Saelens (2010, Figure 3.2) and suggests that changing the physical environment (school) and social environment can have a positive impact on children's PA patterns from deprived environments. The model however, does not mention the school environment explicitly and in addition, there was an element of independent behaviour shown by the children that made them more active (less sedentary and more active, skipping indoors). The children had an impact on family members as opposed to the other way around. Therefore, the research would suggest that the increase in PA is due to internal and external sources of motivation. Although speculative, this might suggest that the intervention resulted in a move along the continuum spectrum for children becoming more autonomous (Rutten et al., 2013) instead of relying only on their teachers for motivation as highlighted in study one. Additional research examining social deterministic changes as a consequence of this intervention would be needed to verify this suggestion.

8.5.2 Changes in body fat

The current study also provides evidence that a short term PA intervention can result in favourable changes in fatness (WC and body fat %). This is important because prior research suggests SA children suggest that they have higher levels of central fatness (Ethisham et al., 2005) and that even SA's with smaller waist circumferences have higher levels of visceral fat mass compared to White children (Banerji et al., 1999; Raji et al., 2001). Abdominal fat and body fat is associated with adverse metabolic risk factors in children from five years of age (Freedman et al., 1999; Thomas et al., 2007). Although further research is needed, this intervention may provide a method for reducing abdominal fat and thus reducing metabolic risk in SA children. However, these differences were not seen when BMI was used a measure of weight status. This may be due to the low BMI and high body fat evident in SA's (Misra & Khurana, 2011; Stanfield et al., 2012).

Duncan et al's (2012) study also reported no change in weight status, potentially due to their use of BMI as a measure of weight status. The findings thus support the measure of WC to detect small changes in SA children over time (McCarthy et al., 2003), as a result of a PA intervention.

8.5.3 Limitations

To the author's knowledge, this is the first study to apply a deprived ethnic focused intervention, combining PA into the curriculum. The strengths of the study relate to the homogenous environment and SES of the children within the study, which limits the impact of such on PA behaviour. The second is that the study applies a multi-faceted intervention focused on changing the environment in children of low PA and from hard to reach groups i.e. ethnic and deprived. The present study is not without limitations. The study included 6 classrooms (4 interventions, 2 controls). There is a possibility of nesting effects and clustering of activity/step counts due to the children being involved in the same curriculum provision. However, given the sample size of the study and the fact that this study sought to provide an ecologically valid/real world intervention to would be difficult to control for these. Although, reactivity to wearing the pedometer was not examined directly, the mean scores suggest no reactivity to the pedometer. For example, during the first week of intervention there was a rapid increase in steps/day, the steps/days following this showed increases with some subtle changes week to week. The study used a control group, which attributed the changes in PA as directly related to the intervention. However, there may be some systematic bias due not randomising the children. It would not have been possible to randomise the children and if they were randomised it could have increased diffusion bias because the control and intervention group would have interacted in the same class. Therefore, the control group was in the same school to minimise potential school differences that might affect PA and given that activity was not significantly different at baseline between the two groups, that the control groups PA was not significantly different from baseline to post 6 weeks, and that this was a natural setting for the children, it seemed valid. It was not feasible to obtain physical activity steps/day at the end of the intervention because at week 7, the school ran a second themed week of physical activity and thus this may have influenced PA measures for post if they had been collected. Additionally, further post 6 week measures for sustainability could not be recorded because the school changed from a two form entry to a three form entry. This meant major building work, changes to the playground and school took place after the 6 weeks measures, which could have influenced any measures taken post the 6 weeks follow up.

This intervention was delivered in the spring/summer term due to parents describing that no-one would want to do an intervention in the winter and the feasibility within the school curriculum. However, given that study one, two and three identified seasonal effects as a barrier to PA; it would be useful to ascertain whether such an intervention could increase PA during winter. Further research into how to modify the social barriers that children and parents face might be beneficial in increasing PA. However, given that such interventions (e.g. increased security/safety surveillance) might need input from council and policy makers, this was beyond the scope of this study. Finally, from a practical perspective, running future interventions needs to consider ways to minimise pedometer loss and to provide longer follow up.

8.6 Conclusion

This research addresses two of the top three research priorities for children set out by Gillis et al (2013). This research provides evidence and confirms the feasibility of an integrated curriculum school based approach to increase PA and reduce body fat in deprived and ethnic primary school children. However, the sustainability of such an approach on health benefits post 6-weeks needs clarification and the impact of reduced PA and fatness on metabolic risk in adulthood health.

CHAPTER 9.0 GENERAL DISCUSSION

The main aim of this thesis was to assess the association between environmental factors and PA behaviour in SA primary school children in low socio-economic. From the findings it was apparent that features of the physical and social environment influence PA behaviour. The findings also showed that by modifying the physical and social environment through school, PA can be increased in children with low PA levels. From this main aim, three objectives were developed in order to address this overarching question. These were; (1) To explore objectively measured environmental factors on SA children's PA from deprived areas, (2) to explore environmental facilitators and barriers to PA in both children and their parents, (3) to gather information from objective 1 and 2 to design and employ an intervention in an attempt to increase PA in SA children from deprived areas. Research questions were developed from these objectives. Each of these questions are presented along with their findings in the sections below.

9.1 How do children from deprived backgrounds use their surrounding environments for MVPA? (study one, question one)

The findings from study one identified that less than half of the children sampled met the current PA guidelines for health, with only 42% engaging in 60 minutes of MVPA daily (assessed using HR monitoring). This is lower than previous studies objectively assessing PA in UK children aged 9 - 10 years (64-74%) (Table 2.3) and may represent the low SES of the group studied. It was apparent that children engage in MVPA at school, by walking (i.e. active travel to school and outside of school) and outside of school by playing indoors. Specifically, school contributed to nearly half of total daily MVPA (43%, study one). During the winter, when PA might be constrained by the weather, school provided 25.8 minutes of daily MVPA, which is a higher contribution that previously described in other studies (mean = 38%, Table 3.1). In the literature review, school facilities, PE time, the PE co-ordinator, after-school PA and school breaks were identified as facilitators of PA (Table 3.1). The schools involved in this thesis had a range of school facilities (e.g. playground with marking, adventure playground, grassed area, moveable equipment), had organised PA (PE lessons), a PE co-ordinator, a school break time (15 minutes), lunch break (1 hour), and a range of after-school clubs (e.g. cricket, football, basketball etc.), which may be supportive of their increased school contribution to total MVPA. On school days, the children were also more active indoors. This might represent the contribution of PE to PA as well as their movement around the school during the school day, again identifying the importance of school. This important contribution of school to daily MVPA is described in previous UK studies (Kirby et al., 2013; Klinker et al., 2014; Ridgers et al., 2013: Long et al., 2013) but none have confirmed this in deprived SA children.

A further 14% of daily MVPA (study one) was achieved from active travel, specifically accumulated from walking to and from school. Active travel is the most commonly reported component of daily PA that has been researched worldwide, with studies reporting that it can contribute between 11% and 35.6% to daily MVPA depending on gender (Klinker et al., 2014; Southward et al., 2012). The findings from this study are at the lower end of previous findings from studies (Table 2.1). The possible reasons for this difference might relate to none of the previous studies considering deprivation or controlling for seasonality. This thesis confirms that during winter, active travel can provide 8.4 minutes of daily MVPA. A systematic review by Lubans et al's (2011) identified that active travel to school is associated with healthier body composition and cardio-respiratory fitness in children, supporting the importance of walking to school on PA and health.

When considering the types of environments in and outside of school (indoors and outdoors environments) and how this affects PA, it was apparent that children engaged in more MVPA in outdoors environments at school and outside of the school environment (Figure 6.4). Of this time in outdoors environments, children spent more time in non-greenspace environments (i.e. pavements, playgrounds). These findings are consistent with research in the UK from the PEACH project though, showing that non-greenspace in important for PA (Wheeler et al., 2010). Yet, in international studies greenspace was supportive of increased PA (Chomitz et al., 2011; Spengler et al., 2011; Timperio et al., 2008; Veitch et al., 2010). The lack of engagement in greenspace environments in the UK and in our study, might relate to the deficiency of greenspace in Coventry (Coventry City Council, 2010) and the poorer weather conditions of the winter months. Collectively, these findings confirm the importance of the physical environment at school, active travel and outdoors non-greenspace environments, being supportive of PA.

9.2 Do SA and White children use their surrounding environment similarly for MVPA? (study one, question two)

The findings from study one identified that similar levels of White and SA children from low SES achieve the PA guideline (60 mins of MVPA daily; WHO, 2010). In previous studies, ethnic differences in adherence to PA guidelines has been reported (Eyre et al., 2013b, Owens et al., 2009). These studies suggest between 35-56% of SA children met the guideline (Eyre et al., 2013b, Owens et al., 2009), which is similar to the 42% within this thesis that met the guidelines. Thus, despite no ethnic differences, similar levels of prevalence to the guidelines were found. The reasons for the lack of consensus between previous research and the findings in this thesis could relate to several factors. Firstly, the measurement type used (i.e. HR vs. accelerometer), for example, previous studies used accelerometers, whereas HR monitors were used in this study. Secondly, the SES of the sample obtained. In previous research, deprivation is associated with poor facilities, provision, increased traffic volume, pollution, inadequate housing, poor residential conditions and less opportunity for PA (Table 3.1). Additionally, SA's are most likely to live in the most deprived areas (Jayaweera et al., 2007; Williams et al., 2009). In this thesis, PA is measured between White and SA children from the same environment (i.e. low SES) and thus similar exposures to the same physical environment, which may be enabling/disenabling their PA. Yet, previous research has not obtained the children from the same low SES environments. Therefore, considering these factors, the findings might suggest that SA and White children from the same low SES environment engage in similar levels of total PA. As a result, previous research identifying lower PA levels (Eyre et al., 2013b, Owens et al., 2009) in SA children might in part be explained by their lower SES status.

When the time spent in different environments was considered, small ethnic differences were found. The findings showed that SA children spent more of the total recorded time indoors on weekend days than White children did (difference = 18%). Additionally, SA children achieved less MVPA indoors when compared to White children (difference = 16%). One of the reasons for these differences might be explained by religious practice (Pallan et al., 2012; Rai & Finch, 1997). In Muslim children, attending mosque (an indoors venue), praying and doing homework for mosque are an important part of their religion. It is suggested that 15 - 20 hours a week is devoted to these rituals. On a typical evening after school 2 or more hours can be spent at mosque and additional hours on the weekends (both Saturday and Sunday, 1+ hour (Smith, 2005). This duration was not seen for other religions (Smith, 2005). Religious practice was identified as a barrier in focus groups with children and parents (study two and three). It was suggested that religious practice limited the time available for PA, which supports these views. This might increase the time spent indoors but reduce time spent in MVPA and limit time available for other activities. Secondly, although SA children might not be engaging in MVPA in indoors environments, it doesn't mean that they are not active, they might be doing a lighter intensity of activity. Eyre, (2012, MSc unpublished data) found that SA children engaged in less MVPA but engaged in more light activity than White children.

No other ethnic differences were found for time spent active at school or types of journeys to school (i.e. active or inactive). Therefore, to answer the research question, it would appear that SA children use their indoors environments differently to White children. It would appear that they spend less time using these indoor environments for activities and more for sedentary type activities.

9.3 Is time spent in specific environments associated with BF (study one, question three?

Furthermore, the results showed that children who spent more time outdoors, engaged in more MVPA and had lower body fat (study one, Figure 6.3 and 6.4). These findings are supportive of prior research (Cleland et al., 2008; Cooper et al., 2010; Dunton et al., 2011; Jones et al., 2009b; McCurdy et al., 2010). Children reported a preference for exercising outdoors and felt they were more active outdoors because there was 'more space' and the 'fresh air' (Section 6.4). Children also identified the increased distraction of sedentary behaviours indoors such as the TV, computer and also linked junk food to these distractions (Section 6.4) Whether SA's experience this more than White children, would need further investigation. However, children didn't make an association between the environment, PA and their BF. From the intervention study, children became more active and lost weight (study 4). The children reported that they spend more time outdoors but also reported being active indoors too (Section 8.4).

Collectively, it is not possible to conclude whether the reduction in body fat seen in the intervention group was merely a cause of spending more time outdoors and less indoors or whether it was purely just a result of increased engagement in PA. Given the findings from the first study, it might seem viable that outdoors environments merely offer an opportunity to engage in more MVPA, which then affects body fatness. In the future, more advanced assessment of body fatness is needed to confirm this. In adult studies, there is some evidence from meta-analysis that outdoors natural environments might have additional benefits on psychological well-being over synthetic environments (Bowler et al., 2010). The psychological benefits of exercise outdoors in children needs further research. Further research is needed to confirm whether modifying home environments to be more active could bring about the same effect in deprived communities.

9.4 Do environmental factors facilitate or provide barriers to children's PA? If so, what are they? (study two and three, question one)

The findings from qualitative studies (study two and three) found that the physical and social environment influences total PA. These findings support the contextual model (Figure 3.2), which highlights the role of the physical and social environment on children's PA.

The physical environment at school provided a range of opportunities to be active (e.g. physical environment- clubs, equipment during recess). Through PE, the children were taught skills and they felt they were encouraged (e.g. supportive social environment). In focus group discussions (study three), the parents identified the physical environment at school being supportive to their child's PA. They felt that their children were most active at school and identified a good physical environment, describing that their children *'were lucky because the facilities were good*' (Appendix IV). School also provided a safe environment to engage in PA. A positive social environment of parents, teachers and the media was important in forming childrens' good perceptions about PA (study two), which are supportive of prior research (Finn et al., 2002; Kamtsios & Digelidis, 2008). These findings support the importance of a supporting physical and social environment for children's PA (Grow and Saelens, 2010, Figure 3.2).

Yet, several barriers relating to the parks in the local environment were identified by the children. These included; poor aesthetics, lack of age appropriate equipment and poor safety. Playing outdoors was further restricted by the weather, specifically a windy or wet day resulted in them playing indoors. Furthermore, poor weather days meant the children had to play indoors at school, which the children identified as a barrier. Parental restraints were identified by the children as preventing them from playing outdoors (study two). Additionally, the home environment provided further barriers to PA due to media influences, junk food and a social environment where there is no-one to play with. Increased opportunity for sedentary behaviours have previously been associated with low PA and associated with lower income households (Marshall et al., 2004; Tandon et al., 2012).

Additionally, study two and three identified that active travel to school was dependent on the physical environment (e.g. proximity and weather). It was apparent that inactive travel (car) was due to 'living far away from school' or perceived weather constraints (rain). Larsen et al's (2008) research in Canadian children found that some physical environments features (i.e. distance) were negatively associated with the likelihood of walking, which is supportive of the findings in this thesis examining UK children. Larsen et al., (2008) study also found that other physical environmental influences (e.g. land use and the presence of trees) and demographics (SES of neighbourhood and households) were positively associated with the likelihood of walking. Therefore, it is clear that some environmental factors such as a positive physical environment at school, social environment at school and home, locality for walking and good weather are facilitators for PA. Yet, poor weather, fears of safety, parental constraints, and a unsupportive physical environment at home (i.e. TV, PlayStation) provide barriers to engaging in PA and specifically PA outdoors.

9.5 Are environmental barriers and facilitators the same for White and SA children? (study two and three, question two)

The findings from both children and parents (Section 7.4 and 8.4), suggest that SA and White children have similar environmental barriers and facilitators. However, ethnic differences were found for the social and cultural factors. For SA children, the school was their only source of knowledge and beliefs about PA. Additionally, their PE teacher and class teachers were described as their role models for PA, identifying a positive social environment with supportive perceptions of PA. In White and Black children, parents were also described as an important influence on knowledge and beliefs about PA, and shared stories of engaging in PA with their parents. From the children interviewed, no SA children shared experiences of parental support or modelling for PA. However, following the intervention, SA children reported engaging in more family activities, some of which were in local parks (Appendix VIII). They reported that this made them achieve their daily PA targets. Furthermore, children from low activity groups reported the positive impact that their change of behaviour had on encouraging other people within their family to be active (Appendix VIII). The findings thus suggest that SA might lack positive parental influences for PA, which may be a cause of low PA. However, despite parents not being a feature of the intervention, flowing the school based intervention, parents support and engagement in PA with their children, increased SA children's PA. Children also provided a positive role model for inactive parents by encouraging them to be more active.

SA children were also less active indoors (study one). Yet, media entertainment as a barrier for PA was reported similarly between ethnic groups and by parents and children. However, a record of time spent in these sedentary behaviours was not obtained and might provide further evidence on the role of these in SA low PA patterns. Further ethnic differences were found in religious practice. Religion (i.e. attending mosque) was a barrier for PA in SA children because it limited the time available to do PA. Children from the Islamic community have to attend mosque daily on school days and weekend days (Pallan et al., 2012). This can provide a barrier in attending clubs after school and on weekends. The intervention attempted to overcome this barrier by providing an afterschool club for a reduced time (30 minutes), which allowed children to attend mosque and the school club (54/134). Thus by working around this barrier SA children's PA can be increased.

Collectively, the findings suggest that PA differences between ethnic groups may in part be explained by SES, which affects the physical and social perceptions of the environment they live in. This is because SA and White children have some similar environmental barriers and facilitators to PA as already outlined in Section 10.2. Further differences can be explained by some cultural and social differences (i.e. religious practice limiting time available for PA, increasing time indoors inactive, lack of parental modelling and influence).However, it was apparent that an intervention delivered through school and consideration of religious practice can increase PA and parental engagement in PA with children.

9.6 Do parents' perceptions of the environment facilitate or provide barriers for childrens' PA? If so, what are they? (study three, question one)

Parental perceptions were a key influence on children's PA. The findings from study three identified parental constraints on children's walking patterns, playing outdoors or in local parks. Firstly, it was apparent that due to the child's age and safety fears, that children were not allowed to roam in their neighbourhoods unsupervised by parents. Some of these fears were associated with road safety fears, in which fears about cars speeding, drivers lack of awareness for the Highway Code and lack of ability to follow rules, were reported. Such fears also prevented parents from allowing their children to roam. Previous, research has identified the importance of independent mobility on increased PA in children (Jones et al., 2009; Page et al., 2010). Secondly, despite parks being in local proximity to their house, parents perceived these as unsafe due to crime related behaviours (e.g. anti-social behaviour), which prevented the parents from allowing their children to playing in local parks. These fears were heightened during winter months by reduced hours of sunlight and by media influences. It was particularly felt that during winter months when dark nights emerge earlier, that these gangs and associated behaviour came out earlier than in summer months. These findings identify the complex interactions between the physical and social environment for PA in children. Thirdly, parents believed that their children could not play in their own gardens (study three). Parents reported that crime related behaviours (e.g. anti-social behaviour) of the citizens living in their neighbourhood, stopped their children playing in their gardens. Parents recalled experiences of objects (e.g. drug packages or stones) being thrown into their garden) and felt that emergency exits meant that people had easier access to their garden. For parents living in flats or maisonettes, which made up the majority of households in this area (Section 8.4.2), parents had limited or no access to a garden. This has not previously been assessed or found and thus provides valuable insight into parental perceptions and experiences. Given that parents also felt that local parks were unsafe for children to play, this limits the opportunities for PA outside of the school environment. It is apparent that young children are not autonomous in their decision making and these parental perceptions have a detrimental effect on children's PA patterns. Future research needs to consider improving the safety of local physical and social environments, to increase PA in children.

Finally, as a result of these fears, it was felt from the parents that this was due to a lack of space available indoors to be physical active and unsafe gardens to play in, resulting in media entertainment as a way to stop their child from getting bored. Some parents described how they would watch TV with their child, reinforcing parental role modelling of inactive behaviours. These findings were supportive of previous research in lower income households, where greater access to media devices was provided, increased opportunity for sedentary behaviour and less for PA (Tandon et al., 2012).

From qualitative analysis in the intervention (study four), it was apparent that parents were an important influence on their child's increased PA. Children reported how they took them to the park or walking with them around the park. Thus, identifying that increasing safety by supervision can increase PA patterns and engagement with outdoors environments. From focus group discussions (study three), parents described how increased security/safety surveillance (i.e. policing, cameras, wardens and increased lighting) would make them feel safer. In terms of traffic, speeds bumps and education on the rules of the road would improve the walking/cycling network. Further research needs to consider ways to increase real safety and feelings of increased safety in deprived neighbourhoods for parents, as well as providing safe places for children to play.

9.7 Can PA be increased in SA children by changing the environment? (study four, question one)

It was apparent that changing the physical and social environment through school can increase total daily PA on weekdays (+8793 ± 8881 steps/day, Table 8.2) and weekend days (+9338 ± 4096 steps/day, Table 8.2) enabling more children to meet the current PA guideline (baseline = 11.7% and post intervention = 44.7% meeting pedometer cut point's).

It was apparent that an intervention based around school by changing the physical and social environment had a positive impact on overall PA, time spent in outdoors playing and resulted in increased activity at school (+4186 steps/day, Table 8.2) . The qualitative analysis highlighted the impact of the social environment (teachers' supportive behaviour and modelling for PA) and physical environment (after-school clubs, curriculum lessons and skipping ropes) to the increased PA at school and out of school (Section 8.4.3). Therefore, the results of this thesis suggest a revised model which identifies the importance of the school environment as identified in Figure 9.1.

After the intervention, it was apparent that children played outside more, in parks, their garden or street. This was due to parental supervision, support and may also be due to the increased time available outside of school due to the season. Children also discussed playing with family members or friends, and thus the role of the social environment and physical environment on their increased PA is of importance.

Prior to the intervention, children spent large proportions of their time indoors. SA children especially spent more time indoors and were less active indoors than White children. From focus group discussions with parents and children it was clear that the perceived unsafe physical and social environment outside of their house restricted PA opportunities to indoors. However, parents reported that their children were indoors they watched TV and the limited space meant they were unable to do much indoors. Children also identified media entertainment as a barrier to their PA. Following the intervention, the physical environment changes (i.e. skipping rope) meant that children increased their PA indoors by skipping indoors and instead of watching TV they would just be more active.

Despite the intervention not solely focusing on the home environment, the effects of the intervention and challenge appeared to have an indirect effect on the home environment. Firstly, the moveable play equipment provided (i.e. skipping rope) meant that the children could skip indoors as reported from qualitative interviews with the children (study four). Secondly, children reported that they played outside more and didn't watch as much TV. It was apparent that parental supervision outside meant they were able to play outdoors more (study four identified the role of parents taking them to local parks). Thus, the intervention had a positive effect on the physical (i.e. skipping ropes to keep and take home) and social home environment (i.e. parental support) for children's PA, consistent with the determinants identified in Figure 3.2. This resulted in a total increase post 6- weeks of +2376 steps/day. This again supports the contextual model by Grow and Saelens (2010), that the physical environment is a determinant of PA and changing this to a more positive environment will result in increased total PA, and outdoors PA.

9.8 Critique of the contextual model

The findings from this thesis highlight the role of physical and social environmental influences on children's PA and are supportive of the contextual model (Grow & Saelens, 2010). However, the model fails to include the role of the school as an independent factor for PA. It is apparent though, that the school where a child attends is dependent upon the neighbourhood that they live in. The opportunities and quality of these opportunities that are available at each school are also different but they do provide a safe place to play. Secondly, the thesis found the importance of the social environment at school on children's PA. Teachers modelling behaviour, their perceived importance of PA, their commitment and other peer's engagement in activity, were all reported as facilitators to increased engagement in PA. Thirdly, it was apparent that an intervention based around school by changing the physical and social environment, had a positive impact on overall PA, time spent in outdoors playing and resulted in increased activity at school (Table 8.1). The qualitative analysis with the children in the intervention study highlighted the impact of the social environment (e.g. teachers' supportive behaviour and modelling for PA) and physical environment (e.g. after-school clubs, curriculum lessons and skipping ropes) to the increased PA at school and out of school. Therefore, the results of this thesis suggest a revised model, which identifies the importance of the school environment as identified in Figure 9.1.

9.8.1 A revised model of SES effects on Physical Activity

Grow and Saelens (2010) conceptual model (Figure 3.2) of how physical and social environments and SES interact to affect PA provides an appropriate model of the independent and interacting factors affecting children's PA patterns. The results from this thesis focused on low SES environments and are supportive of Grow and Saelens (2010) (Figure 3.2). However, the findings also suggest that the contribution of school is an important factor providing both social and physical environmental factors , which modify PA behaviours. The intervention findings in study four support the addition of a school feature by providing support that a school based intervention in low PA SA children alone can double PA levels. Therefore, the thesis would suggest a contextual model whereby SES determines the school attended because the school is determined by the catchment area, based on where they live (see Figure 9.1). At school the child is subjected to a physical environment (e.g. equipment, school break times, lunchtimes, clubs), which can directly affect their outdoors PA and active transport thus affecting total PA. The social environment at school (e.g. peers, teachers role modelling) can also affect outdoor PA and active transport and thus total PA. The physical and social environment can affect one another also (see Figure 9.1).

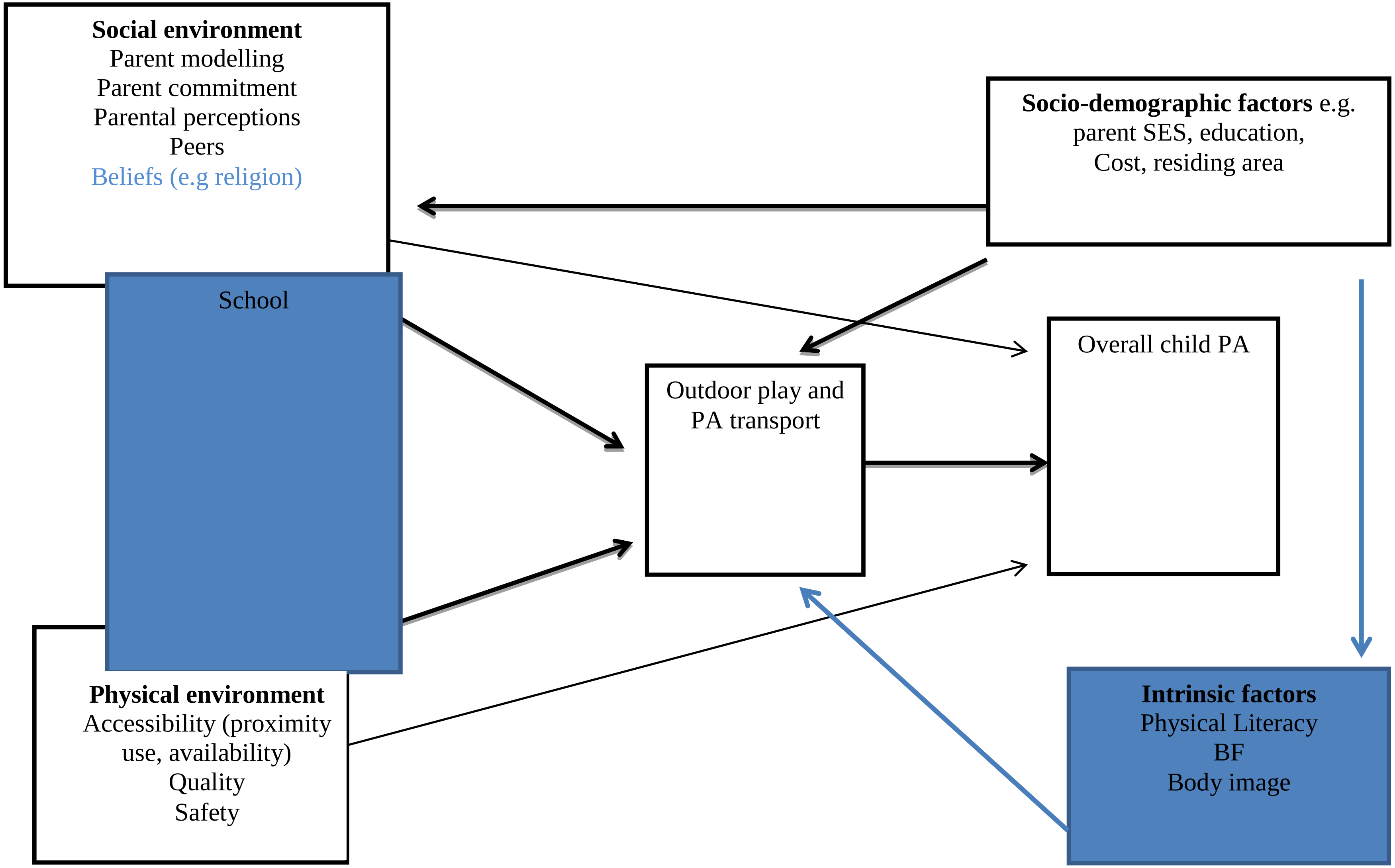


Figure 9.1 *Revised conceptual model of how physical, social and socio-demographic factors interact to affect youth PA.*
Adapted from Grow and Saelens (2010), Page 99.

9.9 Summary and future directions

This thesis addresses 5 of the top 10 international research priorities for children as set out by Gillis et al., (2013, Chapter 1.0). The thesis does this in the following ways:

- To develop effective and sustainable intervention that can increase children's PA long term. The thesis successfully identifies an effective and sustainable intervention in the short term that can increase children's PA for up to 6 weeks post intervention. Further research now needs to consider the long term sustainability of this project beyond 6 weeks (1st priority, Gillis et al., 2013). The programme of work developed and tested an evidence based intervention in SA children.
- Policy and/or environmental change and their influence on children's PA and sedentary behaviour. The thesis addresses the second research priority by changing the physical and social environment through school which resulted in increased PA. Qualitative findings also suggests that sedentary behaviour was reduced although this was not directly assessed. Further research would seek to directly assess sedentary behaviour as a result of the changing physical and social environment (2nd priority, Gillis et al., 2013).
- Understanding the theory behind changing children's activity levels and behaviours. The thesis is also based around a contextual environmental model proposed by Grow and Saelens (2010) and is supportive of this model for changing children's PA patterns, but proposes the addition of the school environment to changing total PA and outside PA in children from low SES environments (6th priority, Gillis et al., 2013).
- How to create effective population based-interventions for the least active children. Additionally, the study targets least active children which doubled

children's PA levels by integrating PA through school and the curriculum. This thesis provides evidence of an intervention that has the potential to be effective at the population level (7th priority, Gillis et al., 2013).

- Cultural and parental practices related to PA and children's behaviours. Finally, the thesis provides qualitative information from children and their parents from differing ethnic and cultural background about children's PA behaviours, again addressing one of the top 10 research priorities (10th priority, Gillis et al., 2013)

The thesis was undertaken in specific electoral wards in Coventry and provides information, which is specific about multi-ethnic and deprived communities in their city. The findings of facilitators and barriers to PA from these environments are similar to those reported in International studies (Table 3.1). There are likely to be similar populations in other UK cities, which all have low PA (as previously described in the CHASE study in London by Owens et al., 2009; BEACHES study in Birmingham, Pallan et al., (2013), so these findings are likely to be helpful to the most vulnerable groups for PA. The generalisability of these findings for more active populations is unknown. Future research would benefit from using multi-site interventions to ascertain the generalisability of the findings. Tracking these behavioural patterns would examine the sustainability of these approaches and the effect on long term health. Further examination of the effects of such an intervention on PA patterns during the winter is needed.

CHAPTER 10.0 GENERAL CONCLUSION

This study suggests that some of the low PA patterns in SA children (as also observed in prior research (Owens et al., 2009; Eyre et al., 2013b)) may in part be explained by some SES differences relative to the increased number of people from ethnic populations residing in the most deprived areas. It is apparent that there are some physical and social environmental barriers that can be removed (e.g. lack of moveable equipment), some that can be worked around (e.g. religion) and others that require longer term change (e.g. social fears about the environment). For example, some ethnic differences were found in religious practice. For muslin children, attending mosque daily and at weekends was an integral part of their day and thus limited the time available for other activities, especially during winter months when there is less daylight. This is important for policy makers when designing interventions as it suggests that targeted intervention around low SES are needed to increase PA, but that this needs to be channelled short-term through school.

For schools, the provision of shorter after-school clubs (45 minutes), which enabled children to get to mosque on time, moveable play equipment and social support, proved useful. Offering more opportunities on weekends and school holidays may prove a useful and safe alternative for increasing PA levels in children from deprived environments. However, in the longer-term much work needs to focus on improving the physical and social environment of people living in low SES areas to increase PA and provide safe places to play for children.

To conclude, low PA patterns as witnessed in SA children, are at least partly determined by the low SES environments they reside in, which is influenced by ethnicity (religion, social environment relating to culture). The findings provide support for the contextual model (Grow & Saelens, 2010), which outlines the effects of SES on the physical and social environment, which affects outdoors PA and total PA in children. However, the findings from this thesis propose a modified contextual model which identifies the important role of the physical and social environment at school in determining total PA of children in low SES environments. It is apparent that a targeted school based intervention, which changes the physical and social environment, can result in increased total PA in children from SA backgrounds for up to 6 weeks post intervention. Future research should seek to examine the long term sustainability of school based interventions on PA and health. Policy makers should focus on changing the physical (e.g. increased security/safety surveillance, street lighting) and social environment (e.g. reducing anti-social behaviours) in low SES areas to provide safe places for children to play.

REFERENCES

Abbot, R.A., & Davies, P.S.W. (2004) 'Habitual PA and PA intensity: their relation to body composition in 5.0-10.5 – y –old children.' *European Journal of Clinical Nutrition,* 58, 285-291.

Adams, M.A., Ryan, S., Kerr, J., et al. (2009) 'Validation of the neighbourhood environment walkability scale (NEWS) items using geographic information systems.' *Journal of Physical Activity and Health,* 6 (s1), S113 – 23.

Ahima, R.S., (2006) 'Adipose tissue as an endocrine organ.' Obesity, 14(Suppl 5), 242S-9S).

Albright, A., Franz, M., Hornsby, G., et al. (2000) American college of sports medicine position stand. Exercise and type 2 diabetes. *Medicine and Science in Sport and Exercise* 32: 1345-1360

Almanza, E., Jerrett, M., Dunton, G., et al. (2012) 'A study of community design, greenness, and PA in children using satellite, GPS and accelerometer data'. *Health place,* 18(1), 46-54.

Andersen, L.B., Riddoch, C., Kriemler, S., & Hills, A. (2011) 'Physical activity and cardiovascular risk factors in children'. *British Journal of SportsMedicine,* 45, 1063.

Andersen, L.B., & Froberg, K. (2013) 'Advancing the understanding of physical activity and cardiovascular risk factors in children: the European Youth Heart Study (EYHS).' *British Journal of Sports Medicine,* 18, PMID: 23687005.

Armstrong, N. (2005) *Paediatric Exercise Physiology.* China, Elsevier.

Balarajan, R. (1996) 'Ethnicity and variations in mortality from coronary heart disease'. *Health Trends,* 28, 45-51.

Bao, W. Srinivasan, S.R., & Berenson, G.S., (1993) 'Tracking of serum apolipoproteins A-I and B in children and young adults: the Bogalusa Heart Study.' *Journal of Clinical Epidemiolology***,** 46 (7), 609 – 16.

Bao, W., Srinivasan, S.R., Wattigney, W. A., et al. (1994) 'Persistence of multiple cardiovascular risk clustering related to syndrome X from childhood to young adulthood. The Bogalusa Heart Study.' *Archives of International Medicine,* 154, 1842 - 7.

Baquet, G., Stratton, G., Van Praagh, E., et al. (2007) 'Improving physical activity assessment in prepubertal children with high-frequency accelerometer monitoring: A methological issue.' *Preventive Medicine,* 44(2), 143 - 147.

Baranowski, T., Bouchard, C., & Bar-Or, O., et al. (1992) 'Assessment, prevalence, and cardiovascular health benefits of physical activity and fitness in youth.' *Medicine and Science in Sport and Exercise,* 24, S237 - S247

Baranowski, T., Dworkin, R. J., & Cieslik, C. J., et al. (1984) 'Reliability and validity of self-report of aerobic activity; Family Health Project.' *Research Quarterly Exercise Sport,* 55, 309 - 317

Barnett, E., & Casper, M. (2001) 'A definition of 'social environment.' *American Journal of Public Health,* 91(3), 465.

Bar-Or, O., & Baranowski, T. (1994) 'Physical activity, adiposity and obesity among adolescents.' *Pediatric Exercise Science* 6, 348 - 360.

Barr-Anderson. D.J., Neumark-Sztainer. D., Schmitz. K.H., Ward.D.S., Conway.T.L., Pratt.C., Baggett.C.D., Lytle.L., Pate.R.R. (2008) 'But I like PE: Factors associated with enjoyment of physical education class in middle school girls.' *Research Quarterly in Exercise and Sport,* 79(1); 18-27.

Bassett, D. R. (2000) Validity and reliability issues in objective monitoring of physical active *Research Quarterly Exercise Sport* 71 (supppl 2): s30 - s36

Basterfield, L., Adamson, A. J., Parkinson, K. N., Maute, U., Liu, P. X., & Reilly, J. J. (2008) 'Gateshead millennium study core team surveillance of physical activity in the UK's flawed; validation of the health survey for England physical activity questionnaire.' *Archieves Disease in Childhood,* 93(12), 1054 – 8.

Bavdekar, A., Yajnik, C.S., Fall, C.H., et al. (1999) 'Insulin resistance syndrome in 8-year-old Indian children: small at birth, big at 8 years, or both?' *Diabetes,* 48, 2422-2429.

Beets, M.W., Banda, J.A., Erwin, H.E., et al. (2011) 'A pictorial view of physical activity socialisation of young adolescents outside of school.' *Research Quarterly for Exercise Sport,* 28(4), 760 - 78.

Beets, M. W., Beighle, A,. Erwin, H.E., & Huberty, J.L. (2009) 'After-school program impact on physical activity an fitness: a meta-analysis.' *American Journal of Preventive Medicine,* 26(6), 527 – 37.

Belcher, B.R., Berrigan, D., Dodd, K.W., Emken, B.A., Chou, C.P., & Spruijt-Mertz, D. (2010) ' Physical activity in US youth: effect of race/ethnicity, age, gender, and weight status.' *Medicine and Science in Sport and Exercise,* 42(12), 2211 – 21.

Bell, L. M., Watts, K., Siafarikas, A., et al. *(2007)'* Exercise alone reduces insulin resistance in obese children independently of changes in body composition'. *Journal of Clinical Endocrinology and Metabolism,* 92, 4230 – 5.

Berenson, G.S., Srinivasan, S.R., Bao, W., et al. (1998) 'Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults.' *New England Journal of Medicine,* 338, 1650 - 6.

Berlin J.A., & Colditz, G.A. (1990) 'A meta-analysis of physical activity in the prevention of coronary heart disease.' *American Journal of Epidemiology,* 132, 612 - 628.

Berkey, C.S., Rockett, H.R.H., Gillman, M.W., & Colditz, G.A. (2003) 'One year changes in activity and in inactivity among 10-to-15 year old boys and girls: relationship to change in body mass index.' *Pediatrics*, 4, 836 - 843.

Berman, N., Bailey, R., Barstow, T.J., & Cooper, D.M. (1998) 'Spectral and bout detection analysis of physical activity patterns in healthy, prepubertal boys and girls' *American Journal of Human Biology*, 10(3), 289 - 297.

Bhopal, R., Unwin, N., White, M., et al. (1999) 'Heterogeneity of coronary heart disease risk factors in Indian, Pakistani, Bangladeshi and European origin populations: cross sectional study.' *British Medical Journal*, 319, 215 - 20.

Biddle, S., Sallis, J. S., & Cavil, N. ed. (1998) *Young and active? Young people and health enhancing physical activity – evidence and implications*. London: Health Education Authority.

Biddle, S. J. H. (2000) Emotion, mood and physical activity. In: Biddle, S. J. H. , Fox, K. R., & Boutcher, S. H. ed. *Physical activity and psychological well-being*. London: Routledge.

Biddle, S. J., & Asare, M. (2011) Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine* 45: 886 - 895.

Biddle, S.J., Petrolini, I., & Pearsons, N. (2014) 'Interventions designed to reduce sedentary behaviours in young people: a review of reviews.' *British Journal of Sports Medicine*, 48, 182 – 6.

Bilings, A. (2011) *Sports Media: Transformation, integration, consumption.* new York ; Routledge.

Blair, S.N., & Meredith, M.D. (1994) The exercise-health relationship: does it apply to children and youth? In *Health and fitness through Physical Education* (edited by R.R. Pate and R.C. Hohn), pp. 11-19. Champaign, IL: Human Kinetics.

Blair, S. N., Kohl, H. W., Paffenbarger, R. S., Clark, D. G., Cooper, K. H., & Gibbons, L. W. (1989) 'Physical fitness and all-cause mortality: a prospective study of health men and women.' *The Journal of the American Medical Association*, 262, 2395 – 2401.

Blair, S.N., Kohl, III, H.W., Barlow, C.E. et al. (1995b) 'Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men.' *Journal of the American Medical Association*, 273, 1093 – 1098.

Blohm, D., Ploch, T., & Apelt, S. (2012) 'Efficacy of exercise therapy to reduce cardiometabolic risk factors in overweight and obese children and adolescents: a systematic review.' *Dtsch Medicine Wochenschr*, 137, 2631 – 6.

Boarnet, M.G., Anderson, C.L., Day, K., McMillan. T., & Alfonzo, M. (2005) 'Evaluation of the California safe routes to school legislation: urban form changes and children's active transportation to school.' *American Journal of Preventive Medicine*, 28(2 suppl 2), 134 - 140.

Bohn-Goldbaum, E. E., Phongasavan, P., Merom, D., Rogers, K., Kamalesh, V., & Bauman, A.E. 'Does playground improvement increase physical activity among children? A quasi-experimental study of a natural experiment.' *Journal of Environmental Public Health,* doi; 10.1155/2013/109841.

Bohr, A. D., Brown, D.D., Laurson, K.R., Smith, P.J., & Bass, R.W. (2013) 'Relationship between socioeconomic status and physical fitness in junior high school students.' *Journal of School Health,* 83 (8), 542 – 7.

Bolte, G., Tamburlini, G., Kohlhuber, M., et al. (2010) 'Environmental inequalities among children in Europe- evaluation of scientific evidence and policy implications.' *European Journal of Public Health,* 20 (1), 14 - 20.

Boone-Heinonen, J., Gordon – Larsen, P., Guilkey, D.K., Jacobs, D.R., & Popkin, B.M. (2011) 'Environment and physical activity dynamics: the role of residential self-selection' *Psychology of Sport and Exercise,* 12 (1), 54 – 60.

Boonpleung, W., Park, C.G., & Gallo, A.M. (2012) 'Timing of adiposity rebound: a step towards preventing obesity' *Pediatric Nursing,* 38 (1), 37 – 42.

Boreham, C., & Riddoch, C. (2001) 'The physical activity, fitness and health of children.' *Journal of Sports Sciences,* 19, 915 - 929.

Boreham, C. A., & McKay, H. A. (2011) Physical activity in childhood and bone health. *British Journal of Sports Medicine,* 45(11): 877 - 9

Boreham, C.A., Twisk, J., Savage, M.J., Cran, M.J., & Strain, J.J. (1997)'Physical activity, sports participation, and risk factors in adolescents.' *Medicine and Science in Sports and Exercise,* 29(6), 788 - 93.

Borrud, L. G., Flegal, K.M., Looker, A.C., Everhart, J.E., Harris, T.B., & Shepherd, J.A. (2010) 'Body composition data for individuals 8 years of age and older: U.S. population, 1999-2004.' *Vital Health Statistics, 11, 250,* 1 – 87.

Boulé, N. G., Haddad, E., Kenny, G.P., Wells, G.A., & Sigal, R.J. (2001) 'Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials.' *The Journal of the American Medical Association,* 286 (10), 1218 – 27.

Bowler, D.E., Buyunh-Ali, L.M., Knight, T.M., Pullin, A.S. (2010) 'A systematic review of evidence for the added benefits to health of exposure to natural environments'. *BMC Public Health,* 10, 456.

Brage, S., Wedderkopp, N., Ekelund, U. et al. (2004a) 'Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children: the European Youth Heart Study (EYHS).' *Diabetes Care,* 27, 2141 – 8.

Brage, S., Wedderkopp, N., Ekelund, U., Franks, P.W., Wareham, N.J., Andersen, L.B., & Froberg, K. (2004b) 'Objectively measured physical activity correlates with indices of insulin resistance in Danish children. The European Youth Heart Study (EYHS).' *International Journal of Obesity Related Metabolism Disorder*, 28(11), 1503 – 8.

Brasholt, M., Chawes, B., Kreiner – Moller, E., Vahlkvist, S., Sinding M., & Bisgaard, H. (2013) 'Objective assessment of levels and patterns of physical activity in preschool children.' *Pediatric Research*, 74 (3), 333 – 8.

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

Braza, M., Shoemaker, W., & Seeley, A. (2004) 'Neighbourhood design and rates of of walking abd biking to elementary school in 34 California communities'. *American Journal of Health Promotion*, 19 (2), 128 - 136.

Brockman, R., Jago, R., Fox, K.R. (2011) 'Children's active play, self-reported motivators, barriers and facilitators.' *BMC Public Health*, 10, 461.

Brodersen, N.H., Steptoe, A., Williamson, S., & Wardle, J. (2005) 'Socio-demographic, developmental, environmental, and psychological correlates of physical activity and sedentary behaviour at age 11 to 12.' *Annals of Behavioural Medicine*, 29 (1), 2 - 11.

Brodersen, N.H., Steptoa, A., Boniface, D.R. & Wardle, J. (2007) 'Trends in physical activity and sedentary behaviour in adolescence: ethnic and socioeconomic differences.' *British Journal of Sports Medicine*, 41, 140 - 144.

Brown, H.E., Pearson, N., Braithwaite, R.E., Brown, W.J., & Biddle, S.J. (2013) 'Physical activity interventions and depression in children and adolescents: a systematic review and meta-analysis' *Sports Medicine*, 43, 195 – 206.

Bryant, E.S., James, R.S., Birch, S.L., & Duncan, M. (2014) 'Prediction of Habitual physical activity level and weight status from fundamental movement skill level', *Journal of Sport Science*, 19, 1 - 8.

Bye. A., Høydal. M.A., Catalucci. D., Langaas. M., Johan Kemi. O., Beisvag. V., Koch. L.G., Britton. S.L., Ellingsen. Ø., Wisløff. U. (2008) 'Gene expression profiling of skeletal muscle in exercise-trained and sedentary rats with inborn high and low VO_{2max}.' *Physiological Genomics*, 35(3), 213-221.

Byrd-Williams, C., Kelly, L.A., Davis, J.N., Spruijt-Mertz, D. & Goran, M.I. (2007) 'Influence of gender, BMI and Hispanic ethnicity on physical activity in children.' International *Journal of Pediatric Obesity*, 2(3), 159 – 66.

Byrne, A., & Byrne, D.G. (1993) 'The effect of exercise on depression, anxiety and other mood states; a review.' *Journal of Psychosomatic Research*, 37 (6), 565 – 74.

Cairney, J., Veldhuizen, S. Kwan, M., Hay, J., & Faught, B, E. (2014) 'Biological Age and Sex-Related Declines in Physical Activity during Adolescence.' *Medicine and Science in Sport and Exercise*, 46(4), 730 – 5.

Camhi, S.M., & Katzmarzyk, P.T. (2011) ‘Prevalence of cardiometabolic risk factor clustering and body mass index in adolescents.’ *Journal of Pediatric,* 159 (2), 303 – 7.

Carver, A., Salmon, J., Campbell, K., Baur, L., & Garnett, S.C.D. (2005) ‘How do perceptions of local neighbourhood relate to adolescents walking and cycling?’ *American Journal of Health Promotion,* 20 (2), 139 - 147.

Carver, A., Timperio, A., Hesketh, K., & Crawford, D. (2010) ‘Are safety – related features of the road environment associated with smaller declines in physical activity among youth?’ *Journal of Urban Health,* 87 (1), 29 – 43.

Carver, A., Timperio, A., Hasketh, K., & Crawford, D. (2010) ‘Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk?’ *Social Science Medicine,* 70 (11), 1799 – 805.

Cardel. M., Dulin-Keita, A. Casazza, K. (2011) ‘Contributors to Pediatric Obesity in Adolescence: More than just energy imbalance.’ *Open Obesity Journal,* 3(2), 17 – 26.

Carek, P. J., Laibsatin, S. E, &. Carek, S. M. (2011) ‘Exercise for the treatment of depression and anxiety’. *International Journal Psychological Medicine,* 41 (1), 15 – 28

Carrel, A.L., McVean, J.J., Clark, R.R., Peterson, S.E., Eickhoff, J.C., Allen, D.B. (2009) School-based exercise improves fitness, body composition, insulin sensitivity,and markers of inflammation in non-obese children. *Journal of Pediatric Endocrinology and Metabolism,* 22 (5),409 - 15.

Carson, V., Rinaldi, R. L., & Torrance, B. (2014) ‘Vigorous physical activity and longitudinal associations with cardio metabolic risk factors in youth.’ *International Journal of Obesity,* 38, 16 – 21.

Carson, V., Spence, J. C. (2010) Seasonal variation in physical activity among children and adolescents: a review. *Pediatric Exercise Science,* 22 (1), 81 – 92.

Casazza , K., Dulin-Keita, A., Gower, B.A., & Fernandez, J.R. (2009) ‘Differential influence of diet and physical activity on components of metabolic syndrome in a multi-ethnic sample of children.’ *Journal of the American Dietetic Association,* 109 (2), 236–244.

Caspersen, C. J. (1989) ‘Physical activity epidemiology: concepts, methods, and applications to exercise science.’ *Exercise Sport Science Review,* 17, 423 – 73

Caspersen, C. Powell, K., & Christenson, G. (1985) Physical activity, exercise and physical fitness; definitions for health-related research. *Public Health Reports,* 100, 126 - 135.

Chaput, J.P., Saunders, T.J., Mathieu, M.E., et al. (2013) ‘Combined associations between moderate to vigorous physical activity and sedentary behaviour with cardiometabolic risk factors in children.’ *Applied Physiology, Nutrition, and Metabolism,* 38, 477 – 83.

Chaturvedi, N. (2003) ‘Ethnic differences in cardiovascular disease’. *Heart,* 89, 681-686.

Chen, W., Srinivasan, S.R., Li, S., et al. (2005) ‘Metabolic syndrome variables at low levels in childhood are beneficially associated with adulthood cardiovascular risk: The Bogalusa Heart Study.’ *Diabetes Care,* 28 (1), 126 - 131.

Chen, S., Kim, Y., & Gao, Z. (2014) ‘The contributing role of physical education in youth’s daily physical activity and sedentary behaviour.’ *BMC Public Health*, 14, 110.

Chief Medical Officer (CMO) (2011) UK physical activity guidelines. Department of Health, UK [online]. Available from; https://www.gov.uk/government/publications/uk-physical-activity-guidelines [2nd Sepetember 2012].

Chinapaw, M. J., Mokkink, L. B., van Poppel, M. N., van Mechelen, W., & Terwee, C. B. (2010) ‘Physical activity questionnaires for youth: a systematic review of measurement properties.’ *Sports Medicine,* 40, 539 – 63

Christian, H., Trapp, G., Lauritsen, C. Wright, K. & Giles-Corti, B. (2013) ‘Understanding the relationship between dog ownership and children’s physical activity and sedentary behaviour.’ *Pediatric Obesity,* 8, 393 – 403.

Choi, P.Y.L (2000) *Feminity and the physically active woman*. Routledge: London.

Chomitz, V.R., Aske, D.B., McDonald, J., et al. (2011) ‘The role of recreational spaces in meeting physical activity recommendation among middle school students.’ *Journal of Physical Activity and Health,* 8, S8 - S16.

Cleland, V., Crawford, D., Baur, L.A., Hume, C., Timperio, A., & Salmon, J. (2008). A prospective examination of children’s time spent outdoor, objectively measured physical activity and overweight. *International Journal of Obesity,* 32 (11), 1685 - 93.

Clemes, S.A., & Biddle, S.J. (2013) ‘The use of pedometers for monitoring physical activity in children and adolescents: measurement considerations.’ *Journal of Physical Activity and Health,* 10(2), 249 - 262.

Cohen, J. (1998) *Statistical power analysis for the behavioural sciences* (second ed). United Kingdon: Lawrence Erlbaun Associates

Cohen, D.A., Ashwood, S., & Scott M. (2006) ‘Proximity to school and physical activity among middle school girls. The trial of activity for adolescent girls study.’ *Journal of Physical Activity and Health,* 3(suppl i), s129 - s138.

Cohen , D.A., Golinelli, D., Williamson, S., Sehgal, A., Marsh, T., & McKenzie, T. L. (2009) ‘Effects of park improvements on park use and physical activity: policy and programming implications.’ *American Journal of Preventive Medicine,* 37 (6), 475 – 80.

Cohen, D. Scott, M. Wang, F.X., McKenzie, T.L., Porter, D. (2008) 'School design and physical activity among middle school girls.' *Journal of Physical Activity and Health,* 5(5), 719 – 31.

Cole, T.J., Freeman, J.V., Preece, M.A. (1995) 'Body mass index reference curves for the UK, 1990.' *Archives of Disease in Childhood,* 73, 25 - 29.

Cole, T.J., Pan, H. (1999) LMS Growth, An Excel Add-in to convert measurements to Z-Scores. Centre for Epidemiology and Biostatistics [online]. CDC. Available from, http,//www.healthforallchildren.co.uk [5th September 2011].

Colley, R.C., & Tremblay, M.S. (2011) 'Moderate and vigorous physical activity intensity cut-points for the Actical Accelerometer.' *Journal of Sport Science,* 29(80, 783 - 9.

Collins, P., Al-Nakeeb, Y., Nevill, A., & Lyons, M. (2012). The impact of the built environment on young people's physical activity patterns, A suburban-rural comparison using GPS. *International Journal of Environmental Research and Public Health*, 9, 3030 - 3050.

Conrad, A., Seiwert, M., Hünken, A., Quarcoo, D., Schlaud, M., & Groneberg, D. (2013). The German Environmental Survey for Children (GerES IV) Reference values and distributions for time-location patterns of German children. *International Journal of Hygiene and Environmental Health*, 216, 25 – 34

Coombes, E., van Sluijs, E., & Jones, A. (2013) 'Is environmental setting associated with the intensity and duration of children's physical activity? Findings from the SPEEDY GPS study.' *Health and Place*, 20, 62 - 65.

Cooney. G., Dwan. K., Mead. G. (2014) 'Exercise for depression.' *JAMA,* 18 (23), 2432-3.

Cooper, A.R., Jago, R., Southward, E.F., & Page, A.S. (2011) ' Active travel and physical activity across the school transition: the PEACH project.' *Medicine and Science in Sport and Exercise,* 44(10), 1890 – 7.

Cooper, A.R., Page, A.S., Foster, L.J., & Qahwaji, D. (2003) 'Commuting to school: are children who walk more physically active?' *American Journal of Preventive Medicine*, 25(4), 273 – 6.

Cooper, A.R., Page, A.S., Wheeler, B.W., Hillsdon, M. Griew, P., & Jago, R. (2010). Patterns of GPS measured time outdoors after school and objective physical activity in English children: the PEACH Project. *International Journal of Behavioural Nutrition and Physical Activity,* 7(31). doi: 10.1186/1479-5868

Corder, K., Brage, S., & Ekelund, U. (2007) Accelerometers and pedometers: methodology and clinical application. *Current Opinion in Clinical Nutrition and Metabolic Care*, 10, 597-603.

Corder, K., Ekelund, U., Steele, R.M., Wareham, N. J., & Brage, S. (2008) Assessment of physical activity in youth. *Journal of Applied Physiology,* 105 (3), 977 – 87.

Corder, K., van Sluijs, E.M., McMinn, A.M., Ekelund, U. Cassidy, A., & Griffin, S.J. (2010) 'Perception versus reality awareness of physical activity levels of British children' *American Journal of Preventive Medicine,* 38 (1), 1 – 8.

Coventry City Council (2008) Greenspace strategy 2008- 2018 . Planning and regeneration. Coventry City Council [online] Available from, http://www.coventry.gov.uk/downloads/download/370/green_space_strategy [20 September 2011].

Coventry City Council (2011) Area Profile for people and place census 2011. Coventry City Council [online]. Available from: http://www.coventry.gov.uk [9th January 2012].

Coventry City Council (2010) Facts about Coventry. Corporate research team [online]. Available from: http://www.facts-about-coventry.com/textonly.php [20 September 2011].

Craig, R., Mindell, J., & Hirani, V. (2008) Health Survey for England 2008. NHS Information centre [online] Available from: www.ic.nhs.uk/pubs/hse08physicalactivity [12th September 2012].

Craig, C.L., Tudor-Locke, C., Cragg, S., & Cameron, C. (2010) 'Process and treatment of pedometer data collection for youth: the Canadian Physical Activity Levels among Youth Study.' *Medicine Science in Sport and Exercise*, 42(3), 430 - 5.

Crawford, D., Timperio, A., Giles-Corti, B., et al. (2008) 'Do features of public open spaces vary according to GIS to neighbourhood socio-economic status?' *Health and Place*, 14, 889 - 93.

Crews, D.J., Lochbaum, M.R., & Landers, D.M. (2004) 'Aerobic physical activity effects on psychological well-being in low-income Hispanic children.' *Perceptual and Motor Skills,* 98(1), 319 – 24.

Crouter, S.E., Schnieder, P., & Bassett, D.R. (2005) 'Spring-levered versus piezo-electro pedometer accuracy in overweight and obese adults.' *Medicine and Science in Sports and Exercise,* 37, 1673 - 1679.

Crouter, S. E., P. L. Schneider, M. Karabulut, and D. R. Bassett. (2003) 'Validity of Ten Electronic Pedometers for Measuring Steps, Distance, and Energy Cost. *Medicine and Science in Sports and Exercise,* 35, 1455 – 1460.

Crouter, S.E., Schneider, P.L. and Bassett, D.R. (2005) 'Spring Leverd Versus Piezo-Electric Pedometer Accuracy in Overweight and Obese Adults'. *Medicine and Science in Sports and Exercise* 37, 1673 – 1679.

Cruickshank, J.K., Cooper, J., Burnett, M., Macduff, J. & Drubra, U. (1991) 'Ethnic differences in fasting plasma C-peptide and insulin in relation to glucose tolerance and blood pressure.' *Lancet*, 338 (8771), 842 – 7.

Cumming, S.P., Sherar, L.B., Eslinger, D.W., Riddoch, C.J., & Malina, R.M. (2013) ‘ Concurrent and prospective associations among biological maturation, and physical activity at 11 and 13 years of age. *Scandinavian Journal of Medicine and Science in Sports*, 24(1), e20 – 8.

Dalton, M.A., Longacre, M.R., Drake, K.M. et al. (2011) ‘Built environment predictors of active travel to school among rural adolescents.’ *American Journal of Preventive Medicine*, 40(3), 312 – 9.

Davidson, K.K., & Lawson, C.T. (2006) ‘Do attributes in the physical environment influence children’s physical activity? A review of the literature.’ *International Journal of Behavioural Nutrition and Physical Activity*, 27 (3), 19.

DeBate, R.D., Koby, E.J., Looney, T.E., et al., (2011) ‘Utility of the physical activity resource assessment for child-centric physical activity intervention planning in two urban neighbourhoods.’ *Journal of Community Health*, 36(1), 132 – 40.

Deforche, B., De Bourdeaudhuil, I., D’hondt, E., & Cardon, G. (2009) ‘Objectively measured physical activity, physical activity related personaluty and body mass index in 6-to 10- year old children, a cross sectiional study.’ *International Journal of Behavioural Nutrition and Physical Activity,* 6, 25. doi: 10.1186/1479-5868-6-25

den Hoed. M., Brage. S., Zhao. J.H., Westgate. K., Nessa. A., Ekelund. U., Spector. T.D., Wareham. N.J., Loos. R.J. (2013) ‘Heritability of objectively assessed daily physical activity and sedentary behaviour.’ *American Journal of Clinical Nutrition*, 98(5), 1317-25.

De Meester, F., Van Dyck, D., Boudeaudhuij, I., Deforche, B., Sallis, JF., & Cardon, G. (2012) ‘Active living neighbourhoods; is neighbourhood walkability a key element for Belgian adolescents.’ *BMC Public Health*, 4, 7.

De Meester, F., Van Dyck, D., De Bourdeaudhuij, I., Deforche, B., & Cardon, G. (2013) ‘Do psychosocial factors moderate the association between neighbourhood walkability and adolescents’ physical activity?’ *Social Science and Medicine*, 81,1 - 9.

Department for Transport (2010) National Travel Survey 2010. Department for Transport [online] Available from: https://www.gov.uk/government/publications/national-travel-survey-2010 [5th June 2012].

Deurenberg-Yap, M., Chew, S.K., & Deurenberg, P. (2002) ‘Elevated body fat percentage and cardiovascular risks at low body mass index level’s among singaporean chinese, malaysians and indians.’ *Obesity Reviews*, 3, 209 - 15.

D’Hase, S., De Meester, F., De Bourdeaudhuij, I. Deforche, B., & Cardon, G. (2011) ‘Criterion distances and environmental correlates of active commuting to school in children.’ *International Journal of Behavioural Nutrition and Physical Activity,* doi; 10.1186/1479-5868-8 - 88.

Diabetes UK (2010) Diabetes in the UK 2010: key statistics on diabetes. Diabetes UK [Online] Available from: www.diabetes.org.uk [February 2011].

Drenowatz, C., Eisenmann, J.C., Pfeiffer, K.A., et al. (2010) ' Influence of socio-economic status on habitual physical activity and sedentary behaviour in 8 – to 11 – year old children.' *BMC Public Health,* 10, 214.

Dugas, L.R., Cao, G., Luke, A.H., & Durazo-Arvizu, R.A. (2011) 'Adiposity is not equal in a multi-race/ethnic adolescent population: NHAMES 1999 – 2004. *Obesity,* 19(10), 2099 – 101.

Dumith, S.C., Gigante, D.P., Dominques, M.R., Hallal, P.C., Menezes, A.M., & Kohl, H.W. (2012) 'Predictors of physical activity change during adolescence: 3.5 year follow up.' *Public Health Nutrition,* 15(12); 2237 – 45.

Dunford, M.D. A.J. (2012) *Nutrition for Sport and Exercise*. USA; Yolando Cossio.

Duncan, M.J., Al-Nakeeb, Y., & Nevill, A.M. (2004) 'Body esteem and body fat in British school children from different ethnic groups.' *Body Image,* 1(3), 311 – 5.

Duncan, M.J., Al-Nakeeb, Y., Woodfield, L., & Lyons, M. (2007) 'Pedometer determined physical activity levels in primary school children from central England.' *Preventive Medicine,* 44(5), 416 - 420.

Duncan, J.S., Badland, H.M., & Schofield, G. (2009) 'Combining GPS with heart rate monitoring to measure physical activity in children, A feasibility study.'*Journal of Science and Medicine in Sport,* 12, 583 – 585.

Duncan, M.J., Birch, S., Al-Nakeeb, Y., et al. (2012) 'Ambulatory physical activity levels of white and SA children in the UK.' *Acta Paediatrica,* 101, 156 - 162.

Duncan, M., Birch, S., & Woodfield, L. (2012) 'Efficacy of an integrated school curriculum pedometer intervention to enhance physical activity and to reduce weight status in children.' *European Physical Education Review,* 18(3), 396 – 407.

Duncan, E.K., Duncan, J.S., & Schofield, G. (2008) 'Pedometer-determined physical activity and active transport in girls.' *International Journal of Behavioural Nutrition and Physical Activity,* 5(2), doi: 10.1186/1479-5868-5-2.

Duncan, M.J. & Mummery, W.K. (2007) 'GIS or GPS? A comparison of two methods for assessing route taken during active transport.' *American Journal of Preventive Medicine,* 33, 51 – 53.

Duncan, J.S., Schofield, G., & Duncan, E.K. (2006) 'Pedometer- Determined Physical Activity and Body Composition in New Zealand Children. '*Medicine and Science in Sports and Exercise,* 38, 1402 - 1409.

Duncan, M.J., & Stanley, M. (2012) 'Functional movement is negatively associated with weight status and positively associated with physical activity in British primary school children.' *Journal of Obesity,* doi: 10.1155/2012/697563.

Dunton, G.F., Kaplan, J., Wolch, J., Jerrett, M., & Reynolds, K.D. (2009) 'Physical environmental correlates of childhood obesity: a systematic review.' *Obesity Reviews,* 10, 393 – 402

Dunton, G.F., Kawabata, K., Intille, S., et al. (2011) 'The social and physical contexts of children's leisure-time physical activity: an ecological momentary assessment study. '*Journal of Physical Activity and Health,* 26(3), 135 - 42.

Dunton, G.F., Liao,Y., Intule, S., Wolch, J., Pentz, M.A. (2011) 'Physical electronic survey and social contextual influences on children's leisure- time physical activity an ecological momentary assessments study.' *Journal of Physical Activity and Health,* 8, S103 - 8.

Durant, R. H., Linder , C. W., & Mahoney, O. M. (1983) 'Relationship between habitual physical activity and serum lipoprotein levels in white male adolescents. '*Journal Adolescent Health Care,* 4, 235 - 9.

Edwards, N.M., Khoury, P.R., Kalkwarf, H.J., Woo, J.G., Clayton, R.P., & Daniels, S.R. (2013) 'Tracking of accelerometer-measured physical activity in early childhood.' *Pediatric Exercise Science,* 25 (3), 487 – 501.

Ehtisthan, S., Barrett, T.G., & Shaw, N.J. (2000) 'Type 2 diabetes mellitus in UK children – an emerging problem.' *Diabetic Medicine* 17, 867 - 71.

Ehtisham, S., Crabtree, N., Clark, P., Shaw, N., & Barrett, T. (2005) 'Ethnic differences in insulin resistance and body composition in United Kingdom adolescents. '*Journal of Clinical Endocrinology Metabolism* 90 (7): 3963 –3 969

Ehtisham, S., Hattersley, A. T., Dunger, D. B., & Barrett, T. G. (2004) 'First UK survey of paediatric type 2 diabetes and MODY. ' *Archives of Disease in Childhood,* 89(6), 526 – 529.

Eisenmann's, J.C. (2007) 'Aerobic fitness, fatness and the metabolic syndrome in children and adolescents.' *Acta Paediatrica,* 96, 1723 – 9.

Ekelund, U., Brage, S. Froberg, K., et al. (2006) 'TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study.' *PloS Med,* 3(12), e488.

Ekelund, U., Luan, J., Sherar, L.B., et al. (2012) 'Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents.' *The Journal of the American Medical Association,* 307(7); 704 – 12.

Ekelund, U., Neovuis, M., Linné, Y., Brage, S., Wareham, N. J., & Rössner, S. (2005) 'Associations between physical activity and fat mass in adolescents: The Stockholm weight development study. '*American Journal of Clinical Nutrition,* 81, 355 - 60.

Ekelund, U., Sardinha, L.B., Anderssen, S.A. et al., (2004) 'Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old

European children: a population- based study from 4 distinct regions in Europe (the European Youth Heart Study).' *American Journal of Clinical Nutrition*, 80 (3), 584 – 90.

Ekelund, U., Tomlinson, G., & Armstrong, N. (2011) 'What proportion of youth are physically active? Measurement issues. Levels and recent time trends.' *British Journal of Sports Medicine,* 45, 859 – 865.

Elegethun, K., Fenske, R.A., Yost, M.G., & Palcisko, G.J. (2003) 'Time-location analysis for exposure assessment studies of children using a novel global positioning system instrument.' *Environmental Health Perspective*, 111, 115 - 22.

Eyre, E.L.J. (2012) *Physical Activity and Body Composition differences between White EU and South Asian Primary School Children*. Unpublished MSc thesis. Coventry; University of Warwick.

Eyre, E.L.J., & Duncan, M.J. (2013a) 'The impact of ethnicity on objectively measured physical activity in children.' *ISRN Obesity*, 1-15, doi: 757431.

Eyre, E.L.J., Duncan, M.J., Smith, E., & Matyka, K.A. (2013b) 'Objectively measured patterns of physical activity in primary school children in Coventry, the influence of ethnicity. '*Diabetic Medicine*, 30, 939 - 45

Eyre, E.L.J., Duncan, M.J., Birch, S.L., & Cox, V. (2013c) 'Environmental and school influences on physical activity in South Asian children from low socio-economic backgrounds: A qualitative study.' *Journal of Child Health Care*, 21, doi: 136749513508845.

Erens, B., Primatesta, P., & Prior, G. (2001) *Health survey for England: the health of ethnic minority groups 1999*. London, UK: The stationary office Erens, Primatesta & Prior, 2001.

Ewing, R., Schroeer, W., & Greene, W. (2004) 'School location and student travel. *Transportation Research Record*, 1895, 55 - 63.

Fagot-Campagna, A., & Narayan, K. (2001) 'Type 2 diabetes in children.' *British Medical Journal*, 322, 377 - 87.

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

Fairclough, S.J., & Ridgers, N. D. (2010) ' Relationship between maturity status, physical activity, and physical self-perceptions in primary school children.' *Journal of Sport Science*, 28(1), 1 - 9.

Faulkner, G., Faulkner, G. E., Richichi, V., Buliungm R, N., Fusco, C., & Moola, F. (2010) 'What is "quickest and easiest "parental decision making about school trip mode.' *International Journal Behavioural Nutrition and Physical Activity* 6(7), 62

Faulkner, G., Faulkner, E., Richichi, V., Buliung, R.N., Fusco, C., & Moola, F. (2011) 'What's 'quickest and easiest?' Parental decision making about school trip mode.' *International Journal of Nutrition and Physical Activity,* 7, 62.

Faulkner, G., Stone, M., Buluing, R., Wong, B., & Mitra, R. (2013) 'School travel and childrens' physical activity: a cross sectional study examining the influence of distance.' *BMC Public Health,* 13, 1166.

Ferdinand, A.L., Sen, B., Rahurkar, S., Engler, S., & Menachemi, N. (2012) 'The relationship between built environments and physical activity: A systematic Review.' American Journal of Public Health, 102(10), 7 – 13.

Ferguson, M. A., Gutin, B., Le, N. A., et al. (1999) 'Effects of exercise training and its cessation on components of the insulin resistance syndrome in obese children.' *International Journal of Obesity Related Metabolic Disorder,* 23, 889 – 95.

Ferguson, K.J., Yesalis, C.E., Pomrehn, P.R., & Kirkpatrick, M.B. (2009) 'Attitudes, knowledge, and beliefs as predictors of exercise intent and behaviour in schoolchildren.' *Journal of School Health,* 59 (3), 112-115.

Fernandes, M., & Sturm, R. (2010) 'Facility provision in elementary school; correlates with physical education, recess, and obesity.' *Preventative Medicine,* 50 (s1), s30 - 5

Fjortoft, I., Kristoffersen, B., & Sageie, J. (2009) 'Children in schoolyards, Tracking movement patterns and physical activity in schoolyards using global positioning system and heart rate monitoring.' *Land Use and Urban Planning,* 2, 210 – 217.

Fjortoft, I., Lofman, O., & Thoren, K.H. (2010) 'Schoolyard physical activity in 14-year-old adolescents assessed by mobile GPS and heart rate monitoring analysed by GIS.' *Scandinavian Journal of Public Health,* 38, 28 – 38.

Field, T. (2012) 'Exercise research on children and adolescents.' *Complementary Therapies in Clinical Practice,* 18(1), 54 – 9.

Fischbacher, C. M., Hunt, S., & Alexander, L. (2004) 'How physically active are South Asians in the United Kingdom ? A Literature Review.' *Journal of Public Health,* 127, 726 - 33

Fishbein, M., & Ajzen, I. (1975) *Belief, Attitude, Intention, and Behaviour: An introduction to theory and research*. Reading, MA: Addison-Wesley.

Fisher, A., Hill. C., Webber, L. Purslow, L., & Wardle, J. (2011) 'MVPA is associated with lower weight gain in 8 – 10 year old children: a prospective study with 1 year follow-up.' *PloS one,* 6(4), e18576.

Fisher, A., Reilly, J. J., Montgomery C., Paton, J. Y., Reilly, J. J., & Williamson, A. (2005) 'Seasonality in physical activity and sedentary behaviour in young children.' *Pediatric Exercise Science,* 17, 31 – 40.

Fletcher, G. F., Balady, G., Blair, S. N., et al. (1996) 'Statement on exercise: benefits and recommendations for physical activity programs for all Americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association.' *Circulation,* 94, 857 – 862.

Fox, K. R. (1999) 'The influence of physical activity on mental well-being.' *Public Health and Nutrition,* 2(39), 411- 418.

Freedman, D. S., Srinivasan, S. R., Valdez, R. A., Williamson, D. F., & Berenson, G.S. (1997) 'Secular increases in relative weight and adiposity among children over two decades: the Bogalusa Heart Study.' *Pediatrics,* 99, 420 - 426

Franzini, L., Taylor, W., Elliot, M. N. et al. (2010) Neighbourhood characteristics favourable to outdoor physical activity. disparities by socioeconomic and racial/ethnic composition. *Health and Place,* 16(2), 267 – 74.

Fraser, S.D., & Lock, K. (2010) 'Cycling for transport and public health: a systematic review of the environment on cycling.' *European Journal of Public Health*, 21(6), 738 – 43.

Foster, S., Villanueva, K., Wood, L., Christian, H., & Giles-Corti, B., et al., (2014) 'The impact of parents' fear of strangers and perceptions of informal social control on children's independent mobility.' *Health and Place*, 26, 60 – 8.

Franzini, L., Taylor, W., Elliot, M.N., Cuccaro, P., Tortolero, S.R., Gilliland, J.M., Grunbaum, J., & Schuster, M.A. (2010) 'Neighbourhood characteristics favourable to outdoor physical activity. disparities by socioeconomic and racial/ethnic composition.' *Health and Place,* 16, 267 - 74.

Frisard, M.I., Greenway, F.L., & Delany, J.P. (2005) 'Comparison of methods to assess body composition changes during a period of weight loss. 'Obesity *Research,* 13, 845–854.

Gielen, S., Schuler, G., & Adams, V. (2010) 'Cardiovascular effects of exercise training: molecular mechanisms'. *Circulation*, 122 (12), 1221 – 38.

Gillis, L., Tomkinson, G., Olds, T., et al. (2012) 'Research Priorities for child and adolescent physical activity and sedentary behaviours: an international perspective using a twin-panel Delphi procedure. *International Journal of Behavioural Nutrition and Physical Activity,* 10, 11.

Goldberg, L., & Elliot, D.L. (1987) 'The effect of exercise on lipid metabolism in men and women.' *Sports Medicine,* 4(5), 307 – 21.

Gordon – Larsen, P., McMurray, R.G., & Popkin, B.M. (2000) 'Determinants of adolescent physical activity and inactivity patterns. *Pediatrics,* 105 (6), e83.

Gordon - Larsen, P., Nelson, M. C., Page, P., & Popkin, B. M. (2006) 'Inequalities in the built environment underlies key health disparities in physical activity and obesity.' *Paediatrics*, 117, 417- 424.

Gregory, J. R., & Lowe, J. A. (2000) *National Diet and Nutrition Survey: children aged 4-16 years, volume 1: report of the Diet and Nutrition survey,* London: HMSO.

Grøntved, A., Reid-Larsen, M., Møller, C.N., Kristensen, P. L., Froberg, K., Brage, S., Andersen, L.B. (2015) Muscle strength in youth and cardiovascular risk in young adulthood (the European Youth Heart Study). *British Journal of Sports Medicine*, 49, 90-94.

Grow, M.G., & Saelens, B.E. (2010) Physical Activity and Environments which promote active living in Youth (US) *In Obesogenic Environments,* edited by A.A Lake, T.G. Townshend, & S. Alcanides; West Sussex; Blackwell Publishing Ltd.

Guinhouya, B.C., Lemdani, M., Vilhelm, C., Hubert, H., Apete, G.K., & Durocher, A. (2009) 'How school time physical activity is the 'big one' for daily activity among schoolchildren: a semi-experimental approach.' *Journal of Physical Activity and Health*, 6(4), 510 – 9.

Guinhouya, B.C., Samouda, H., & de Beaufort, C. (2013) 'Level of physical activity among children and adolescents in Europe: a review of physical activity assessed objectively by accelerometry.' *Public Health,* 127(4), 301 – 11.

Guinhouya, B.C., Fairclough, S.J., Zitouni, D., Samouda, H., Vilhelm, C., Zgaya, H., de Beauford, C., Lemdani, M., & Hubert, H. (2013) 'Does biological maturity actually confound gender-related differences in physical activity in preadolescence?.' *Child: Carew, Health and Development*, 39(6), 835-844.

Guthold, R., Cowan, M. J., Autenrieth, C. S., et al. (2010) 'Physical activity and sedentary behavior among schoolchildren: a 34-country comparison.' *Journal of Pediatrics,* 157, 43 – 49.

Gutin, B., Cucuzzo, N., Islam, S., Smith, C., Moffatt, R., & Pargman, D. (1995) 'Physical training improves body composition of black obese 7- to 11-yr-old girls.' *Obesity Research,* 3, 305 – 312.

Gutin, B., Owens, S. (1999) 'Role of exercise intervention in improving body fat distribution and risk profile in children.' *American Journal of Human Biology*, 11(2), 237 – 247.

Gutin, B., & Owen, S. (2011) 'The influence of physical activity on cardiometabolic biomarkers in youths: a review.' *Pediatric Exercise Science,* 23(2), 169 – 85.

Gortmaker, S.L., Lee, R., Cradock, A.L. (2012) 'Disparities in youth physical activity in the United States: 2003 – 2006.' *Medicine and Science in Sports and Exercise*, 44(5), 888 – 893.

Gomez, J.E., Johnson, B.A., Selva, M., & Sallis, J.F. (2004) ‘Violent crime and outdoor physical activity among: inner city youth.’ *Preventive medicine*, 39(5), 876-881

Giles-Corti, B., Wood, G., Pikora, T., et al. (2011) ‘School site and the potential to walk to school; the impact of street connectivity and the traffic exposure in school neighbourhoods.’ *Health and Place,* 17(2), 545-50.

Goss, F., Robertson, R., Williams, A., et al. (2003) ‘A comparison of skinfolds and leg-to-leg bioelectrical impedance for the assessment of body composition in children.’ *Dynamic Medicine*, 2, 5.

Green, K. (2003) *Physical education teachers on physical education: a sociological study of philosophies and ideologies*. Chester; Chester Academic Press

Griew, P., Page, A., Thomas, S., Hulsdon, M., & Cooper, A.R. (2010) ‘The school effect on children’s school time physical activity; the Peach project.’ *Preventive Medicine,* 51, 282 - 6.

Grow, H.M., Saelens, B.E., Durant, N.H., Norman, G.J., & Sallis, J.F. (2008) ‘Where are youth active? Roles of proximity, active transport, and built environment.’ *Medicine and Science in Sports and Exercise,* 40, 2071 – 9.

Guerra, P.H., Nobre, M.R., Silveira., et al. (2013) ‘The effect of school-based physical activity interventions on body mass index: a meta-analysis of randomized trials.’ *Clinics,* 68(9), 1263 - 73.

Gustafson, S.L., Rhoes, R.E. (2006) ‘Parental correlates of physical activity in children and early adolescents’. *Sports Medicine,* 36(1), 79 - 97.

Hendrie, G.A., Coveney, J., & Cox, D.N. (2011) ‘Factor analysis shows association between family activity environment and children’s health behaviour.’ *Australia and New Zealand Journal of Public Health,* 35, 524 – 9.

Hagberg J., Mountain, S. J., Martin, W. H., & Ehsani, A. A. (1989) ‘Effects of exercise training in 60-to 69 year old person with essential hypertension.’ *American Journal of Cardiology,* 64, 348 - 353

Haines, L., Kramer, Z. (2009) Growing up with Diabetes: Children and young people with diabetes in England. Royal College of Paediatrics and Child Health; London.

Haines, L., Chong Wan, K.C., Lynn, R., Barrett, T.G., Shield, J.P.H. (2007) ‘Rising incidence of Type 2 Diabetes in Children in the U.K.’ *Diabetes Care,* 30(5), 1097-1101.

Han, B., Cohen, D., McKenzie, T.L. (2013) ‘Quantifying the contribution of neighbourhood parks to physical activity.’ *Preventive Medicine*, 57(5); 483-487.

Handy, S.L., Boarnet, M.G., Ewing, R., & Killingsworth, R.E. (2002) ‘How the built environment affects physical activity view from urban planning.’ *American Journal of Preventive Medicine,* 23 (2), 64 – 73.

Harding, J. E. (2001) 'The nutritional basis of fetal origins of adult disease.' *International Journal of Epidemiology*, 30 (1), 15 -23.

Hardy, L.L., King, L., Hector, D., & Baur, L.A. (2013) 'Socio-cultural differences in Australian primary school children's weight and weight-related behaviours.' *Journal of Paediatric Child Health*, 49(8), 641 – 8.

Hardman, A. E. (1999) 'Accumulation of physical activity for health gains: what is the evidence?' *British Journal of Sports Medicine*, 33, 87 - 92

Haroun, D., Taylor, S.J., Viner, R.M., Hayward, R.S., Darch, T.S., Eaton, S., Cole, T.J., & Wells, J.C. (2010) 'Validation of biolelectrical impedance analysis in adolescents across different ethnic groups.' *Obesity*, 18, 1252 - 1259.

Haskell, W.L., Lee, I., Pate, R.R., et al. (2007) 'Physical Activity and Public Health: Updated Recommendations for Adults From the American College of Sports Medicine and American Heart Association.' *Circulation*, 116(9), 1081-1093.

Haug, E., Torsheim, T., & Samdal, O. (2010) 'Local school policies increase physical activity in Norwegian secondary schools.' *Health Promotion International*, 25(1), 63 – 72.

Hay, J., Maximova, K., Carson, V., et al. (2012) 'Physical activity intensity and cardiometabolic risk in youth.' *Archives Pediatric Adolescent Medicine*, 166, 1022 – 9.

Health Survey for England (2008) Physical activity and fitness: summary of key findings. Department of Health: Stationary office [Online] Available from: www.ic.nhs.uk/webody fatiles/publications/hse/hse08/hse_08_summary_of_key_findings.pdf [27th March 2011].

Hegarty, B. D., Furler, S. M., Ye, J., Cooney, G. J., & Kraegen, E. W. (2003) 'The role of intramuscular lipid in insulin resistance.' *Acta physiologica Scandinavica*, 178 (4), 373 - 382

Helmrich, S.P., Ragland, D.R., Leung, R.W., & Paffenbarger, R.S. (1991) ' Physical activity and reduced occurrence of non-insulin- dependent diabetes mellitus.' *New England Journal of Medicine*, 325 (3), 147 – 52.

Henderson, E.J., Jones, C.H., Hornby – Turner, Y.C., & Pollard, T.M. (2011) 'Adiposity and blood pressure in 7 – to 11 – year old children: comparison of British Pakistani and white British Children, and of British Pakistani children of migrant and British- born mothers.' *American Journal of Human Biology*, 23 (5), 710 – 6.

Herman, K.M., Paradis, G., Mathieu, M.E., O'Loughlin, J., Tremblay, A., & Lambert, M. (2014) 'Association between accelerometer-measured physical activity intensities and sedentary time in 8- to 10-year-old children*.' Pediatric Exercise Science*, 16(1), 76 – 85.

Hesse-Biber, S.N., & Levy, P. (2010) *The practice of qualitative resear*ch. London: Sage.

Holman, R.M., Carson, V. & Janssen, I. (2011) 'Does the fractionalization of daily physical activity (sporadic vs. bouts) impact cardiometabolic risk factors in children and youth? ' *PLoS One*, e25733.

Hu, G., Eriksson, J., Barengo, N. C., Lakka, T. A., Valle, T. T., Nissinen, A., Jousilahti, P ., & Tuomilehto, J. (2004) 'Occupational, commuting, and leisure time physical activity in relation to total and cardiovascular mortality among Finnish subjects with type 2 diabetes.' *Circulation* 110: 666-673

Huberty, J. L., Siahpush, M., Beighle, A., Fuhrmeister, E., Silva, P., & Welk, G. (2011) 'Ready for recess: a pilot study to increase physical activity in elementary school children.' *Journal of School Health,* 81(5), 151- 257

Huberty, J., Beets, M., Beighle, A. (2013) 'Effects of a policy-level intervention on children's pedometer-determined physical activity: preliminary findings frommobin' Afterschool.' *Journal of Public Health Management Practice,* 19(6), 525 – 8.

Huotari, P., Nupponen, H., & Mikkelsson, L., et al (2011) 'Adolescent physical activity and fitness as predictors of adult activity.' *Journal of Sport Sciences*, 29(11), 1135 - 1141.

Hume, C., Timperio, A., Salmon, J., Carver, A., Giles-Corti, B., Crawford, D. (2009) 'Walking and cycling to school: predictors of increases among children and adolescents.' *American Journal of Preventive Medicine,* 36 (3), 195 - 200.

IPEN (2012) ALPHA Environmental Questionnaire Manual. IPEN [online] Available from:
http://www.ipenproject.org/documents/methods_docs/Surveys/ALPHA_Manual.pdf [10th January 2012].

Ivy, J. L. (1997) 'Role of exercise training in the prevention and treatment of insulin resistance and non-insulin-dependent diabetes mellitus.' *Journal of Sports Medicine,* 24, 321 – 336

Jackson, M., Crawford, D., Campbell, K., & Salmon, J. (2008) 'Are parental concerns about children's inactivity warranted and are they associated with a supportive home environment.' *Research Quarterly Exercise Sport,* 79 (3), 274-82

Jago, R., & Baranowski, T. (2004) 'Non – curricular approaches for increasing physical activity in youth: a review.' *Preventive Medicine,* 39 (1), 157 – 63.

Jakicic, J.M., & Davies, K.K. (2011) 'Obesity and physical activity.' *The Psychiatric Clinics of North America,* 34 (4), 829 – 40.

Janssen, I. & Leblanc, A. (2010) 'Systematic Review of the health benefits of physical activity in school aged children and youth.' *The International Journal of Behavioural Nutrition and Physical Activity,* 7, 40.

Janz, K.F., Witt, J., & Mahoney, L.T. (1995) ‘The stability of children’s physical activity as measured by accelerometry and self-report.’ *Medicine and Science in Sport and Exercise* 27(9): 1326-32

Jartti L., (2000) ‘Comparison of hand to leg and leg to leg bioelectrical impedance devices in the assessment of body adiposity in prepubertal children.’ *Acta Paediatrica,* 89, 781-786.

Jayaweera, H., Hockley, C.A., Redshaw, M.E., et al. (2007) ‘Demographic and socio-economic characteristics of ethnic minority mothers in England: The millennium cohort study.’ Centre for longitudinal studies.

Jebb, S.A., Cole, T.J., Doman, D., Murgatroyd, P.R., & Prentice, A.M. (2000). ‘Evaluation of the novel Tanita body-fat analyser to measure body composition by comparison with a four-compartment model.’ *British Journal of Nutrition,* 83, 115 - 123.

Jenson, J.R., (1983) ‘Biophysical remote sensing.’ *Annual Association of American Cartography,* 73, 111 – 132.

Jimenez-Pavon, D., Kelly, J., Reilly, J. J. (2010) ‘Associations between objectively measured habitual physical activity and adiposity in children and adolescents: Systematic review.’ *International Journal of Pediatric Obesity,* 5(1), 3 – 18.

Johnson, T.G., Brusseau, T.A., Darst, P.W., et al. (2010) ‘Step counts of non-white minority children and youth by gender, grade level, race/ethnicity, and mode of school transportation.’ *Journal of Physical Activity and Health,* 7 (6), 730 - 6.

Jones, A.P., Coombes, E.G., Griffin, S.J., et al. (2009) ‘Environmental supportiveness for physical activity in English schoolchildren: a study using global positioning systems.’ *International Journal of Behavioural Nutrition and Physical Activity,* 17 (6), 42.

Jones, A.P., Coombes, E.G., Griffin, S.J., van Sluijs, E.M.F. (2009a) ‘Environmental supportiveness for physical activity in English schoolchildren, A study using Global Positioning Systems.’ *International Journal of Behavioural Nutrition and Physical Activity,* 6, 1 – 42.

Jones, A., Hillsdon, M., & Coombes, E. (2009b) ‘Greenspace access, use and physical activity, understanding the effects of area deprivation.’ *Preventive Medicine,* 49 (6) 500 - 505.

Joosen, A.M., Gielen, M., Vlietinck, R., Westerterp,, K.R. (2005) ‘ Genetic analysis of physical activity in twins.’ *American Journal of Clinical Nutrition,* 82(6), 1253-9.

Katzmarzyk, P.T., Malina, R.M., Song, T.M., et al. (1998) ‘Physical activity and health-related fitness in youth: a multivariate analysis.’ *Medicine and Science in Sports Exercise,* 30 (5), 709 - 14.

Kassi, E., Pervanidou, P., Kaltsas, G., & Chorousos, G. (2011) ‘Metabolic syndrome: definitions and controversies.’ *BMC Medicine,* 5 (9), 48.

Kelly, E.B., Parra-Medina, D., Pffeiffer, K.A., et al. (2010) ‘Correlates of physical activity in black, Hispanic, and white middle school girls.’ *Journal of Physical Activity and Health,* 7 (2), 184 – 93.

Kennedy, E., & Goldberg, J. (1995) ‘What are the American children eating? Implications for public policy.’ *Nutritional review,* 53, 111 – 126.

Kessler, H.S., Sisson, S.B., & Short, K.R (2012) ‘The potential for high-intensity interval training to reduce cardiometabolic disease risk.’ *Sports Medicine*, 42(6), 489 – 509.

Khunti, K., Stone, M. A., Bankart, J., Sinfield, P. K., Talbot, D., Farooqi, A., & Davies, M. J. (2007) ‘Physical activity and sedentary behaviours of South Asian and White European childen in inner city secondary schools in the UK.’ *Family Practice,* 24 (3), 237.

Kimbro, R.T., Brooks-Gunn, J., & McLanahans, S. (2011) ‘Young children in urban areas, links among neighbourhood characteristics, Weight status, outdoor play, and television watching.’ *Social Science and Medicine,* 72, 668 - 76.

Kimm, S.Y., Gylnn, N.W., Kriska, A.M., et al. (2002) ‘Decline in physical activity in black girls and white girls during adolescence.’ *New England Journal of Medicine,* 347, 709 – 15.

King, N., & Horrocks, C. (2010) *Interviews in qualitative research*. London: Sage

King, H., Aubert, R. E., & Herman, W. H. (1998) ‘Global burden of diabetes, 1995 – 2005: prevalence, numerical estimates and projections.’ *Diabetes Care* 21: 1414- 1431

Kirby, J. Levin, K.A. & Inchley, J. (2013) ‘Socio-environmental influences on physical activity among young people: a qualitative study.’ *Health Education, Research,* 28, 954 – 69.

Klinker, C.D., Schipperijn, J., Christian, H. et al. (2014) ‘Using accelerometers and global positioning system devices to assess gender and age differences in children’s school , transport, leisure and home based physical activity.’ *International Journal of Behaviour Nutrition and Physical Activity*, 11, 8.

Lachowycz. K., & Jones, A.P. (2011) ‘Greenspace and obesity: a systematic review of the evidence.’ *Obesity Reviews,* 12(5), e183- 189.

Lake, A.A. & Townshend, T.G. (2012) ‘Exploring the built environment, physical activity and related behaviours of young people attending school, college and those not in employment.’ *Journal of Public Health,* 1 - 10.

Lambourne, K., & Donnelly, J. E. (2011) ‘The role of physical activity in pediatric obesity.’ *Pediatric Clinical North American* 58(6) 1481- 91.

Lamonte, M.J., Blair, S.N., Church, T.S. (2005) ‘Physical activity and diabetes prevention.’ *Journal of Applied Physiology,* 99(3), 1205 -12.

Lane, D., Beevers, D.G., & Lip, G.Y. (2002) 'Ethnic differences in blood pressure and the prevalence of hypertension in England.' *Journal of Human Hypertension,*16(4), 267 – 73.

Lanningham-Foster, L., Foster, R.C., McCrady, S.K., et al. (2008) 'Changing the school environment to increase physical activity in children.' Obesity, 16 (8), 1849 – 53.

LaPorte, R. E., Montoye, H. J., & Caspersen, C. J. (1985) 'Assessment of physical activity in epidemiologic research; problems and prospects.' *Public Health,* 100, 131-46

Lara, M., & Amigo, H.(2011) 'What kind of intervention has the best results to reduce the weight in overweighted or obese adult?' *Archives Latinoamerican Nutrition,* 61(1), 45 – 54.

Lau, P. W. C., Yu, C. W., Lee, A. et al. (2004) 'The physiological and psychological effects of resistance training on Chinese obese adolescents.' *Journal of Exercise Science and Physical Fitness,* 2, 115 – 20

Lavie, C. J., & Milani, R. V. (2011) 'Cardiac rehabilitation and exercise training in secondary heart disease prevention.' *Programme Cardiovascular Disease,* 53 (6), 397-403.

Laxer, R.E., & Janssen, I. (2013) 'The proportion of youth's physical inactivity attributable to neighbourhood built environment features.' *International Journal of Health Geography',* 12, 31.

Lee, C.D., Blair, S.N., Jackson, A.S. (1999) 'Cardiorespiratory fitness, body composition, and cardiovascular disease mortality in men.' *American Journal of Clinical Nutrition,* 69, 373-80.

Lee, S.L., Kuk, J.L., Katzmarzyk, P.T., Blair, S.N., Church, T.S., Ross, R. (2005) 'Cardiorespiratory fitness attenuates metabolic risk independent of abdominal subcutaneous and visceral fat in men.' Diabetes Care, 28, 895-901.

Lee, M.C., Orenstein, M.R., & Richardson, M.J. (2008) 'Systematic review of active commuting to school and children's physical activity and weight.' *Journal of Physical Activity Health,* 5(6), 930 - 49.

Lee, C., & Li, L. (2014) 'Demographic, physical activity, and route characteristics relates to school transportation: An exploratory study.' *American Journal of Health Promotion,* 28 (3), s77 – s88.

Leon, A.F.,Coast, F., Balady, G.J., et al. (2005) 'Cardiac rehabilitation and secondary prevention of coronary heart disease: An American Heart Association Scientific Statement from the Council on Clinical Cardiology and the Council on Nutrition, Physical Activity, and Metabolic, in collororating with the American Association of Cardiovascular and Pulmonary Rehabilitation.*' Circulation,* 111, 369 – 376.

Li, S., Treuth, M. S., & Wang, Y. (2010) 'How active are American adolescents and have they become less active?' *Obesity Reviews,* 11, 847 – 62.

Li, Y. P., Hu, X. Q., & Schouten, E. G. et al. (2010) ‘Report on childhood obesity in china (8): effects and sustainability of physical activity intervention on body composition of Chinese youth.’ *Biomedical Environmental Science,* 23 (3), 180-7

Lightfoot, J.T., Turner, M.J., Daves, M., Vordermark, A., Kleeberger, S.R. (2004) ‘Genetic influence on daily wheel running activity level.’ *Physiological Genomics*, 19(3), 270-6.

Liu, J.H., Jones, S.J., Sun, H. et al., (2012) ‘Diet, physical activity, and sedentary behaviours as risk factors for childhood obesity: an urban and rural comparison.’ *Childhood Obesity*, 8 (5), 440 – 8.

Long, M.W., Sobol, A.M., Cradock, A.L., Subramanian, S.V., Blendon, R.J., & Gortmaker, S.L., et al. (2013)’School-day and overall physical activity among youth.’ *American Journal of Preventive Medicine,* 45 (2), 150 – 7.

Loureiro, N., Matos, M.G., Santos, M.M. et al., (2010) ‘Neighbourhood and physical activities of portuguese adolescents.’ *International Journal of Behavioural Nutrition and Physical Activity,* 5 (7), 33.

Loureiro, N., Matos, M.G., Santos, M.M., Mota, J., & Diniz, J.A. (2010) ‘Neighbourhood and physical activities of Portuguese adolescents.’ *International Journal of Behavioural Nutrition and Physical Activity*, 5 (7), 33.

Lovasi, G. S., Jacobsen, J. S., Quinn, J. W., Neckerman, K. M., Ash-by-Thompson, M. N., & Rundle, A. (2011) ‘Is the environment near home and school associated with physical activity and adiposity of urban preschool children?’ *Journal of Urban Health,* 8 (6), 1143 - 57.

Lubans, D., Boreham, C.A., Kelly, P., & Foster, C.E. (2011) ‘The relationship between active travel to school and health-related fitness in children and adolescents: a systematic review.’ *International Journal of Behavioural Nutrition and Physical Activity,* 8, 5, doi: 10.1186/1479-5868-8-5.

Lubans, D.R., Morgan, P.J., & Tudor-Locke, C. (2009) ‘A systematic review of studies using pedometers to promote physical activity among youth.’ *Preventive Medicine,* 48 (4), 307-315

Mackenbach, J.P. Stirbu, I., Roskam, A.R., et al. (2008) ‘Socio-economic inequalities in health in 22 European Countries.’ *New England Journal of Medicine*, 358, 2468 – 81.

Maddison, R., Jiang, Y., Hoorn, S.V., Exeter, D., Mhurchu, C.N., & Dorey, E. (2010). ‘Describing patterns of physical activity in adolescents using global positioning systems and accelerometry.’ *Pediatric Exercise Science,* 22, 392 – 407.

Maffesis, C., & Tato, L., (2001) ‘Long-term effects of childhood obesity on morbidity and mortality.’ *Hormone Research*, 55 (1), 42 – 45.

Maffeis, C., Zaffanello, M., Pinell, M.L., & Schutz, Y. (1996) 'Total energy expensiture and patterns of activity in 8 -10 year old obese and no obese children.' *Journal of Pediatric Gastroenterology and Nutrition,* 23 (3), 256 - 261.

Mahon, A. D. (2000) Exercise training. In *Paediatric exercise and Medicine* (edited by N. Armstrong, & W. van Mechelen) pp. 201 – 222, Oxford: University Press.

Mairorana, A., O'Driscoll, G., Goodman, C., Taylor, R., & Green, D. (2002) Combined aerobic and resistance exervise improves glycemic control and fitness in type 2 diabetes. *Diabetes Research and Clinical Practice,* 56(2), 115 - 213.

Maitland C. Stratton G. Foster S. Braham R. Rosenberg M. (2013) 'A place for play? The influence of the home physical environment on children's physical activity and sedentary behaviour.' *International Journal of Behavioural Nutrition and Physical Activity,* 10, 99.

Malina, R.M. (1996) 'Tracking of physical activity and physical fitness across the lifespan.' *Research Quarterly for Exercise and Sport,* 97, s48 - s57.

Malina, R. M., & Bouchard, C. (2004) *Growth, Maturation and Physical Activity*. Leeds: Human Kinetics.

Manson, J.E., Rimm, E.B., Stampfer, M.J., et al. (1991) 'Physical activity and incidence of non insulin dependent diabetes mellitus in women.' *Lancet* 338, 774- 778.

Matthews, C.E., Chen, P.S., Freedson, P.S., et al. (2004) 'Amount of time spent in sedentary behaviours in the United States, 2003 – 2004.' *American Journal of Epidmiology,* 167 (7), 875 – 881.

Marshall, S.J., Biddle, S.J.H., Gorely, T., et al. (2004) 'Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis.' *International Journal of Obesity,* 28, 1238 - 1246.

Martin, K., Bremner, A., Salmon, J., Rosenberg, M., & Giles-Corti, B. (2014) 'Physical, policy, and sociocultural characteristics of the primary school environment are positively asscoaited with children's physical activity during class time.' *Journal of Physical Activity and Health,* 11 (3), 553 – 63.

McArdle, W, D. Katch, F, L. Katch, V, L. (2010) *Exercise Physiology, Energy Nutrition and Human Performance*, Philadelphia: Lippincott, Williams & Wilkins.

McAlexander, K.M., Mama, S.K., Medina, A.V., O'Connor, D.P., Lee, R.E. (2012). Concordance and correlates of direct and indirect built environment measurement among minority. *Journal of Health Promotion,* 26 (4), 239 – 44.

McAuley, P.A., & Blair, S.N. (2011) 'Obesity Paradoxes.' *Journal of Sport Sciences,* 29 (8), 773 – 82.

McClain, A.D., Hsu, Y.W., Belcher, B.R., Nguyen-Rodriguez, S., Weigensberg, M., Spruijt-Metz, D. (2011) 'Physical inactivity, but not sedentary behaviour or energy intake, is associated with higher fat mass in Latina and African American girls.' *Ethnicity and Disease*, 21(4), 458 – 61.

McCormack, G., Giles-Corti, B., Lange, A. et al. (2004) 'An update of recent evidence of the relationship between objective and self-report measures of the physical environment and physical activity behaviours.' *Journal of Science and Medicine in Sport*, 7(1suppl), 81 - 92.

McCurdy, L.E., Winterbottom, K. E., Mehta, S. S., & Roberts, J. R. (2010) 'Using Nature and Outdoor Activity to Improve Children's Health.' *Current Problem in Pediatric Adolescent Health Care,* 5, 102 – 117.

McGall, S.E., McGuigan, M.R., Nottle, C. (2011). Contribution of free play towards physical activity guidelines for New Zealand primary school children aged 7 - 9 years. *British Journal of Sports Medicine*, 45 (2), 120 - 124.

McGarrigle, J., & Kearns, A. (2009) 'Living apart? Place, identity and South Asian residential choice.' *Housing Studies*, 24 (4), 451 - 475.

McGovern, L., Johnson, J.N., Paulo, R., et al. (2008) 'Clinical review: treatment of pediatric obesity: a systematic review and meta-analysis of randomized trials.' *The Journal of Clinical Endocrinology and Metabolism,* 93 (12), 46 – 5.

McKeigue, P. M., Shah, B., & Marmot, M. G. (1991) 'Relation of central adiposity and insulin resistance and high diabetes prevalence and cardiovascular risk in South Asians.' *Lancet*, 337, 382 - 86.

McLure, S. A., Summerbell, C. D., & Reilly, J. J. (2009) 'Objectively measured habitual physical activity in a highly obesongenic environment.' *Child Care Health Development,* 35(3), 369 - 75.

McNamara, E., Hudson, Z., Taylor, S.J. (2010) 'Measuring activity levels of young people: the validity of pedometer.' *British Medical Bulletin*, 95, 121 – 37

Merriam, S.B. (2009) *Qualitative research: guide to design and implementation*. San Francisco; Wiley in print.

Metcalf, B. S., Voss, L. D., Hosking, J. Jeffrey, A. N., & Wilkin, T. J. (2008) 'Physical activity at the government-recommended level and obesity-related health outcomes: a longitudinal study (Early Bird 37).' *Archives of Disease in Childhood.* 93, 772 - 777

Metcalf, B. S., Hosking, J., Jeffrey, A. N., Voss, L. D., Henley, W., & Wilkin, T. J. (2010) 'Fatness leads to inactivity but inactivity does not lead to fatness: a longitudinal study in children (early bird 45) .' *Archives disease in childhood*, 96 (10), 942 - 67.

Messiah, S.E., Arheat, K.L., Lopez-Mitnik, G., Lipshultz, S.E., Miller, T.L. (2013) 'Ethnic group differences in cardiometabolic disease risk factors independent of body mass index among American youth.' *Obesity*, 21(3), 424 – 8.

Meyer, A. A., Kundt, G., & Lenschow, U., et al. (2006*)* 'Improvement of early vascular changes and cardiovascular risk factors in obese children after a six-month exercise program.' *Journal of American College Cardiology,* 48, 1865 – 70.

Meyer, U., Roth, R., Zahner, L., et al. (2013) 'Contribution of physical education to overall physical activity.' *Scandinavian Journal of Medicine and Science in Sports,* 23(5), 600 - 6.

Mirwald, R.L., Baxter- Jones, A.D., Bailey, D.A., et al. (2002) 'An assessment of maturity from anthropometric measurements.' *Medicine and Science in Sports and Exercise,* 34 (4), 689 - 694.

Misra, A., & Khurana, L. (2011) 'Obesity-related non-communicable diseases: South Asians vs White Caucasians.' *International Journal of Obesity,* 35 (2), 176 - 87.

Misra, A., Khurana, L., Vikram, N.K., et al. (2007) 'Metabolic syndrome in children: current issues and South Asian perspective.' *Nutrition,* 23 (11), 895 - 910.

Mitchell, R., & Popham, F. (2008) 'Effect of exposure to natural environment on health inequalities: an observational population study.' *Lancet,* 8 (372), 1655 – 60.

Mitre, N., Lanningham- Foster, L., Foster, R., Levine, J.A. (2009) 'Pedometer accuracy for children: can we recommend them for our obese populations.' *Pediatrics,* 123 (1), e127 – 31.

Molnar, B.E., Gortmaker, S.L., Bull, F.C., & Buka, S.L. (2004) 'Unsafe to play? Neighbourhood disorder and lack of safety predict reduced physical activity among urban children and adolescents.' *American Journal of Health Promotion,* 18 (5), 378 -386.

Moore, J. B., Jilcott, S. B., Shores, K.A., Evenson, K. R., Brownson, R. C., & Novick, L. F. (2010) 'A qualitative examination of perceived barriers and facilitators of physical activity for urban and rural youth.' *Health Education Research,* 25 (2), 355-67

Moore, L.L., Gao, D., Bradlee, M.L., et al. (2003) 'Does early physical activity predict body fat change throughout childhood?' *Preventive Medicine*; 37 (1), 10–17.

Montoye, H. I. (1985) Risk factors for cardiovascular diseases in relation to physical activity in youth. In *Children and Exercise (edited by* R. A. Burkhaust, H. C. Keruber. & W. H. Saris) pp. 3 – 25, Champaign: Human Kinetics.

Montoye, H. J. (1996) *Measuring physical activity and energy expenditure.* Champaign Ill: Human kinetics

Morimoto, Y., Maskarinec, G., Conroy, S.M., Lim, U., Shepherd, J., Novoty, R. (2012) 'Asian ethnicity is associated with a higher trunk/peripheral fat ratio in women and adolescent girls.' *Journal of Epidemiology,* 22 (2), 130 – 135.

Mota, J., Almeida, M., Santos, P., & Riberio, J.C. (1993) 'Perceived neighbourhood environments and physical activity and adolescents.' *Preventive Medicine,* 22, 880 - 889.

Mota, J., Silva, P., Ribeiro, J. C., Oliveiro, J., & Duarte, J. A. (2005) ‘Physical activity and school recess time: Differences between the sexes and the relationship between children’s playground physical activity and habitual physical activity. ‘*Journal of Sport Science,* 23 (3), 269 – 275.

Mota, J., Santos, R., Pereira, M., Teixeira, L., & Santos, M.P. (2011) ‘Perceived neighbourhood environmental characteristics and physical activity according to socioeconomic status in adolescent girls.’ *Annuals of Human Biology,* 38 (1), 1–6.

Mota, J., Vale, S., Martins, C. et al. (2010) ‘Influence of muscle fitness test performance on metabolic risk factors among adolescent girls.’ *Diabetology and Metabolic Syndrome,* 23 (2), 42.

Myers, J. (2003) ‘Exercise and cardiovascular Health.’ *Circulation,* 107, e2 - 5.

Murphy, M. H., Nevill, A. M., & Hardman, A. E. (2000) ‘Different patterns of brisk walking are equally effective in decreasing post-prandial lipaemia.’ *International Journal of Obesity*, 24, 1303 - 1309.

Nader, P. R., Bradley, R. H., Houts, R. M., McRitchie, S. L., & O’Brien, M. (2008) ‘Moderate to vigorous physical activity from the ages of 9 to 15 years.’ *The Journal of the American Medical Association,* 300 (3), 295 – 303.

Nakae, S., Oshima, Y., & Ishii, K. (2008) ‘Accuracy of spring-levered and piezo-electric pedometers in primary school Japanese children.’ *Journal of Physiological Anthropology,* 27(5), 233 - 9.

Nechyba, T. J., & Strauss, R. P. (1998) ‘Community Choice and Local Public Services: A Discrete Choice Approach.’ *Regional Science and Urban Economics,* 28 (1), 51 - 73.

Neel. J.V. (1962) ‘Diabetes mellitus: a ‘thrifty’ genotype rendered detrimental by ‘progress’?’ *American Journal of Human Genetics*, 4, 352-3.

New Lifestyles.Inc (2002) Using your new lifestyles Digi-Walker Pedometer [online]. Available from: http://www.new-lifestyles.com/using_your_pedometer.pdf [6 September 2011].

Newet, D., Oren, S., Pantanoqitz, M., Eliakim, A. (2013) ‘Effects of a multidisciplinary childhood obesity treatment intervention on adipocytokines, inflammatory and growth mediators.’ *Hormone Research in Pediatrics,* 79(6),325-32.

Newton, R.L., Martin, C.K., Williamson, D.A., Sothern, M., Han, L.S., & Webber, L.S. (2011) ‘Accelerometry measured ethnic differences in activity in rural adolescents.’ *Journal of Physical Activity and Health,* 8(2), 287 – 295.

Nguyen, Q. M., Srinivasan, S. R., Xu, J. et al. (2008) ‘Changes in risk variables of metabolic syndrome since childhood in pre-diabetic and type 2 diabetic subjects.’ *Diabetes Care,* 31 (10), 2044 - 2049

Nguyen, T. H. H. D., Tang, H. K., Kelly, P., van der Ploeg, H. P., & Dibley, M. J. (2010) ‘Association between physical activity and metabolic syndrome: a cross sectional survey in adolescents in Ho Chi Minh City, Vitenam.’ *BMC Public Health.* 10, 141.

NHS Information Centre (2010). National Child Measurement Programme, England 2009/2010. Department of Health [online] Available from: www.ic.nhs.uk [12 Febuary 2013].

Northern Ireland Statistics & Research agency (2008) *Young person’s behaviours and attitudes survey bulletin 2007*. Belfast: Central Survey Unit

Nielsen, G., Taylor, R., Williams, S., et al. (2010) ‘Permanent play facilities in school playgrounds as a determinant of children’s activity. ‘*Journal Physical Activity and Health,* 7 (4), 490 - 6.

Nightingale, C.M., Rudnicka, A.R., Owen, C.G., Cook, D.G., Whincup, P.H. (2011). ‘Patterns of body size and adipsity in UK children of South Asian, Black African-Caribbean and white european origin, Child heart and health study in England (CHASE study).’ *International Journal of Epidemiology,* 40, 33 - 44.

Nightingale, C.M., Rudnicka, A.R., Owen, C.G., et al. (2013) ‘Are ethnic and gender specific equations needed to derive fat free mass from bioelectrical impedance in children of South Asian, Black african – Carribean and White European origin? Results of the assessment of body composition in children study.’ *PloS one,* 8(10), e76426.

Norman, G.J., Nutter, S.K., Ryan, S., Sallis, J.F., Calfras, K.J., & Patrick, K. (2006) ‘Community design and access to recreational facilities as correlates of adolescent physical activity and Body – Mass Index. ‘*Journal of physical activity and Health,* 3 (suppl 1), s118- s128.

Olds, T., Maher, C.A., & Ridley, K. (2011) ‘The place of physical activity in the time budgets of 10 -13 year old Australian Children. ‘ *Journal of Physical Activity and Health,* 8, 584 - 57.

Oliver, M., Schofield, G.M., & Kilt, G.S. (2007) ‘Physical activity in pre schoolers, understanding prevalence and measurement issues.’ *Journal of Sports Medicine,* 32, 1045 - 70.

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

Ortega, F.B., Ruiz, J.R., & Castillo, M.J. (2013) ‘Physical activity, physical fitness, and overweight in children and adolescents: evidence from epidemiologic studies.’ *Endocrinological Nutrition,* 60, 458 – 69.

Ostergaard, L., Kolle, E., Steene-Johannessen, J., Anderssen, S.A., Andersen, L.B. (2013) ‘Cross sectional analysis of the association between mode of school transportation and physical fitness in children and adolescents.’ *International Journal of Behavavioural Nutrition and Physical Acticity,* 10, 91.

Owens, C.G., Nightingale, C.M., Rudnicka, A.R., Cook, D.G., Ekelund, U., & Whincup, P.H. (2009) ‘Ethnic and gender differences in physical activity levels among 9-10 year old children of white European, south asian and african caribbean origin. The child heart health study in england (CHASE).’ *International Journal of Epidemiology,* 18, 1082 - 1093.

Pabayo, R., Belsky, J., Gauvin, L., et al. (2011) ‘Do area characteristics predict change in moderate –to-vigorous physical activity from ages 11 to 15 years? ‘*Social Science and Medicine,* 72 (3), 430.

Paffenbarger, R. S., Hyde, R. T., Wing, A. L., Lee, I. M., Jung, D. L., & Kampert, J. B. (1993) ‘The association of changes in physical activity level and other lifestyle characteristics with mortality among men.’ *New England Journal of Medicine,* 328, 538 - 545.

Paffenbarger, R. S., & Lee, I.-M. (1996) ‘Physical activity and fitness for health and longevity.*’ Research Quarterly for Exercise and Sport*, 67, s11-s28.

Paffenbarger. R.S., Blair. S.N., Lee. I.M. (2001) ‘A history of physical inactivity, cardiovascular and longevity; The scientific contributions of Jeremy N Morris, DSc, DPH, FRCP.’ *International Journal of Epidemiology,* 30, 1184-1192.

Page, A. S., Cooper, A. R., Griew, P., & Jago, R. (2010) ‘Independent mobility, perceptions of the built environment and children’s participation in play, active travel and structured exercise and sport: The PEACH project.’ *International Journal of Behavioural Nutrition Physical Activity* 19 (7), 17.

Pallan, M., Parry, J., & Adab, P. (2012) ‘Contextual influences on the development of obesity in children: A Case study of UK South Asian Communities.’ *Preventive Medicine,* 54 (3-4), 205 - 211.

Pallan, M., Parry, J., Cheng, K.K., & Adab, P. (2013) Development of childhood obesity prevention programme with a focus on UK South Asian communities. *Preventive Medicine,* 57. 948 – 954.

Pan, X.R., Li, G.W., Hu, Y.H., et al. (1997) ‘Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The DA Qing IGT and Diabetes study.’ *Diabetes Care*, 20(4), 537 – 44.

Panter, J.R., Jones, A.P., van Sluijs, E.M., et al. (2010) ‘Neighbourhood, route, and school environments and children’s active commuting.’ *American Journal of Preventive Medicine, 38*(3), 268 - 78.

Parikh, T. Stratton, G. (2011) ‘Influence of intensity of physical activity on adiposity and cardiorespiratory fitness in 5-18 year olds.’ *Sports Medicine,* 1, 41 (6), 477 – 88.

Parsons, T.J., Power, C., Logan, S., & Summerbell, C.D. (1999) ‘Childhood predictors of adult obesity: a systematic review.’ *International Journal of Obesity Related Metabolism Disorder,* 23 (s8), s1 - 107

Pate, R .R. (1995) ‘Physical activity and health: Dose response issues.’ *Research Quarterly for Exercise and Sport,* 66 (4), 313 - 7

Pate, R. R., Freedson, P. S., Sallis, J. F., et al. (2002) ‘Compliance with physical activity guidelines prevalence in a population of children and youth.’ *Annals of Epidemiology,* 12, 303 - 308.

Pate, R. R., Long, B. J., & Heath, G. (1994) ‘Descriptive epidemiology of physical activity in adolescences.’ *Pediatric Exercise Science,* 6, 434 - 447

Pate, R. R., Stevens, J., Pratt, C., et al. (2006) ‘Objectively measured physical activity in sixth-grade girls.’ *Archives of Pediatrics and Adolescent Medicine,* 160 (12), 1262 – 8.

Patkar, K.U., & Joshi, A.S. (2011) ‘Comparison of V02max in obese and non-obese young Indian population.’ *Indian Journal of Physiology and Pharmacology,* 55(2), 188 - 92.

Pearson, N., & Biddle, S.J. (2011) ‘Sedenatry behaviour and dietary intake in children, adolescents, and adults. A systematic review.’ *American Journal of Preventive Medicine,* 41(2), 178 – 88.

Penedo, F.J., & Dahn, J.R., (2005) ‘Exercise and well-being: a review of mental and physical health benefits associated with physical activity.’ *Current Opinion in Psychiatry,* 18(2), 189 - 93.

Penpraze, V., Reilly, J., MacLean, C.M., Montgomery, C., Kelly, L., Paton J.Y., Aitchison, T., Grant, S. (2006) ‘Monitoring of physical activity in young children.’ *Pediatric Exercise Science,* 18, 483 – 492.

Pfeiffer, K. A., Dowda, M., McIver, K. L., & Pate, R. R.(2009) “Factors related to objectively measured physical activity in preschool children,” *Pediatric Exercise Science,* 21 (2), 196 – 208.

Pizzaro, A.N., Riberio, J.C., Marques, E.M., Mota, J., & Santos, M.P. (2013) ‘Is walking to school associated with improved metabolic health.’ *International Journal of Behavioural Nutrition and Physical Activity,* 10 (12), 1 – 7.

Powell, K. E., Thompson, P. D., Caspersen, C. J., & Kendrick, J. S. (1987) ‘Physical activity and the incidence of coronary heart disease.’ *Annual Reviews in Public Health,* 8, 253 – 287.

Prentice- Dunn, H., Prentice- Dunn, S. (2012) ‘Physical activity, sedentary behaviour, and childhood obesity: A review of cross sectional studies.’ *Psychology, Health and Medicine,* 17 (3), 255 – 273.

Prentice, A. M., & Jebb, S. A. (2001) 'Beyond body mass index.' *Obesity Reviews* 2, 141 – 147

Rai, D. K., & Finch, H. (1997) Physical activity ' from our point of view' Qualitative research among South Asian and Black Communities. HEA [Online] Available from: http://www.nice.org.uk/niceMedia/documents/physical_ourpov.pdf [25th August 2010].

Rainham, D.G., Bates, C.J., Blanchard, C.M., Dummer, T.J., Kirk, S.F., & et al. (2012) 'Spatial classification of youth physical activity patterns.' *American Journal of Preventive Medicine*, 42(5), e87 – 96.

Raitakari, O. T., Juonala, M., & Kahonen, M . et al. (2003) 'Cardiovascular risk factors in childhood and carotid artery intima-media thickness in adulthood: the Cardiovascular Risk in Young Finns Study. '*The Journal of the American Medical Association*, 290, 2277 - 83.

Raitaikari, O.T., Porkka, K.V.K., Taimela, R., Rasanen, L., & Viikan, J.S.A. (1994) 'Effects of persistent physical activity and inactivity on coronary risk factors in children and young adults.' *American Journal of Epidemiology*, 140, 195 – 205.

Rankinen, T., Zuberi, A., Chagnon, Y., Weisnagel, S., Argyropoulos, G., Walts, B. (2006) 'The human obesity gene map: the 2005 update.' *Obesity*, 14; 529-644.

Redberg, R.F., & Greenland, P., Fuster, V., et al. (2002) 'Prevention conference VI: Diabetes and Cardiovascular disease: writing group II: risk assessment in persons with diabetes.' *Circulation*, 7 (105), e144 – 52.

Reichert, E.F., Baptista Menezes, A.M., Wells, J.C., Dumith, C.D., Curi Hallal, P. (2009) 'Physical activity as a predictor of adolescent body fatness, A systematic review.' *Sports Medicine*, 39, 279 - 94.

Reilly, J.J. (2006) 'Diagnostic accuracy of the BMI for age in paediatrics.' *International Journal of Obesity*, 30, 595 – 597.

Reilly, J. J., Dorosty, A. E., & Emmnett, P. M. (1999) 'Prevalence of overweight and obesity in British children: cohort study.' *British Medical Journal*, 319, 1039.

Reilly, J. J., Penpraze, V., & Hislop, J. et al. (2008) 'Objective measurement of physical activity and sedentary behaviour: review with new data.' *Archives Disease in Childhood*, 93, 614 - 619.

Ribeiro, J.C., Guerra, S., Oliveira, J., et al. (2004) 'Physical activity and biological risk clustering in pediatric population.' *Preventive Medicine*, 39, 546 – 601.

Rich, C., Griffiths, L.J, & Dezateux, C. (2012) 'Seasonal variation in accelerometer-determined sedentary behaviour and physical activity in children: a review.' *International Journal of Behavioural Physical Activity* 9(1), 49.

Riddoch, C.J., Andersen, L.B., Wedderkopp, B., Harro, M., Klasson-Heggerbo, L., Cooper, A.R., Ekelund, U. (2004) ‘Physical activity levels and patterns of 9-and 15-yr-old European children.’ *Medicine and Science in Sport and Exercise,* 36, 86 - 92.

Riddoch, C.J., Mattocks, C., Deere, K., Saunders, J., Kirkby, J., Tilling, K., Leary, S.D., Blair, S.N., & Ness, A.R. (2007) ‘Objective measurement of levels and patterns of physical activity.’ *Archives of Disease in Childhood,* 92, 963 - 969.

Ridgers, N.D., Fairclough, S.J., & Stratton, G. (2010) ‘Twelve-month effects of a playground intervention on children’s morning and lunchtime recess physical activity levels.’ *Journal of Physical Activity and Health,* 7(2), 167 – 75.

Ridgers, N.D., Salmon, J., Parrish, A.M., et al. (2012) ‘Physical activity during recess: a systematic review.’ *American Journal of Preventive Medicine,* 43(3), 320-8.

Ridgers, N. D., Stratton, G. (2005) ‘Physical activity during school recess, the Liverpool sporting playgrounds project.’ *Pediatric Exercise Science,* 17, 281.

Ridgers, N.D., Stratton, G., Fairclough, S.J., & Twisk, J.W. (2007) ‘Long- term effects of a playground markings and physical structures on children’s recess physical activity levels.’ *Preventive Medicine,* 44 (5), 393 – 7.

Ridgers, N.D., Timperio, A., Crawford, D., Salmon, J. (2011) ‘Five year changes in school recess and lunchtime and the contribution to children’s daily physical activity. ‘*British Journal of Sports Medicine,* 45, 120-124.

Ridgers, N.D., Timperio, A., Cerin, E., Salmon, J. (2014) ‘Compensation of Physical Activity and Sedentary Time in Primary School children.’ *Medicine and Science in Sports and Exercise,* 31, *epub ahead of print,* available from: http://www.ncbi.nlm.nih.gov/pubmed/?term=Compensation+of+Physical+Activity+and+Sedentary+Time+in+Primary+School+children (accessed 3rd June 2014).

Rizzo, N. S., Ruiz, J. R., Hurtig-Wennlöf, A, et al. (2007) ‘Relationship of physical activity, fitness, and fatness with clustered metabolic risk in children and adolescents: the European youth heart study.’ *Journal of Pediatrics,* 150, 388 – 94

Roberts, C., Tynjaka, J., & Komkov, A. (2004) Physical activity. In *Young people’s health in context. Health Behaviour in School-Aged Children (HBSC) Study: international report from the 2001–2002 survey* (edited by C. Currie., C. Roberts., A, et al.) pp. 90 – 7, Copenhagen: World Health Organization.

Robinson, T.N. (1993) ‘Defining obesity in children and adolescents: clinical approaches.’ *Critical Review of Food Science and Nutrition,* 33 (4-5), 313 – 20.

Robinson, L.E., Wadsworth, D.D., Webster, E.K., & Bassett, D.R. (2014) ‘School reform: the role of physical education policy in physical activity of elementary school children in Alabama’s Black belt region.’ *American Journal of Health Promotion,* 28(3s), s72 – 6.

Rodríquez-Lopez, C., Villa-Gonález, E., Pérez – López, I.J., et al. (2013) 'Family factors influence active commuting to school in Spanish Children.' *Nutrición Hospitalaria,* 28(3), 756 – 63.

Rogers, A., Adamson, J.E., & McCarthy, M. (1997) 'Variations in health behaviours mong inner city 12-year-olds from four ethnic groups. *Ethnicity and Health*, 2, 309-16.

Rolland-Cachera, M.F., Deheeger, M., Besllisle, M., Sempe, M., Guilloud-Bataille, M., & Patois, E. (1984) 'Adiposity rebound in children: a simple indicator for predicting obesity.' *American Journal of Clinical Nutrition*, 39 (1), 129 – 35.

Rowlands, A. V., Eston, R. G., & Ingledew, D. K. (1997) 'Measurement of physical activity in children with particular reference to the use of heart rate and pedometer.' *Sports Medicine,* 24 (4), 258 – 72.

Rowland, T. (1996) 'Is there a scientific rationale supporting the value of exercise for the present and future cardiovascular health of children? The con argument.' *Pediatric Exercise Science,* 8, 303 – 309.

Rowlands, A.V. (2007) 'Accelerometer assessment of physical activity in children: an update .' *Pediatric Exercise Science,* 19, 252 - 66.

Rowlands, A. V., Eston, R. G., & Ingledew, D. K. (1999) 'The relationship between activity levels, body fat and aerobic fitness in 8–10-year-old children.' *Journal of Applied Physiology,* 86, 1428 – 35

Rowlands, A.V., Pilgrim, E.L., & Eston, R.G. (2008) 'Patterns of habitual activity across weekdays and weekend days in 9-11 year-old-children.' *Preventive Medicine,* 46, 317 - 324

Rudolf, M., Christie, D., McElhone, S., et al. (2006) 'WATCH IT: a community based programme for obese children and adolescents.' *Archives of Disease in Childhood,* 91, 736 - 739.

Rutten, C., Boen, F., & Seghers, J. (2013) 'The relation between environmental factors and pedometer-determined physical activity in children: the mediating role of automous motivation.' *Pediatric Exercise Science,* 25 (2), 273 – 87.

Saksvig, B.I., Webber, L.S., Elder, J.P., et al. (2012) 'A cross sectional and longitudinal study of travel by walking before and after school among eighth-grade girls.' *The Journal of Adolescent Health,* 51 (6), 608 – 14.

Sallis, J.F. (1991) 'Self-report measures of children's physical activity.' *Journal of School Health,* 61, 215 – 19.

Sallis, J.F., (1993) 'Epidemiology of physical activity in children and adolescences.' *Critical Review Food Science Nutrition*, 33 (4/5), 403 - 408.

Sallis, J.F., Bowles, H.R., Bauman, A., et al. (2009) 'Neighbourhood environments and physical activity among adults in 11 countries.' *American Journal of Preventive Medicine,* 36(6), 484 – 90.

Sallis, J.F., Conway, T.L., Proschaska, J.J., et al. (2001) 'The association of school environments with youth physical activity.' *American Journal of Public Health,* 91(4), 618-620.

Sallis, J.F., Conway, T.L., Prochaska, J.J., McKenzie, T.L., & Nelson, J.A. (1993) 'Correlates of physical activity at home in Mexican American and anglo-american preschool children.' *Health Psychology,* 12 (5), 390 - 398.

Sallis, J.F., & Glanz, K. (2006) 'The role of built environments in physical activity, eating and obesity in childhood.' *The Future of Children,*16, 89 - 108.

Sallis, J.F., Patterson, T.L., Buono, M.J., et al. (1988) 'Relationship of cardiovascular fitness and physical activit to cardiovascular disease risk factors in children and adults. ' *American Journal of Epidemiology,* 127, 933 - 41.

Sallis, J.F, Strikmiller, P.K., Harsha, D.W., et al. (1996) 'Validation of interviewer – and self-administered physical activity checklists from fifth grade students.' *Medicine Science Sport and Exercise*, 28 (7), 840 - 51.

Sampson, R.J., & Sharkey, P. (2008) 'Neighbourhood selection and the social reproduction of concentrated racial inequality.' *Demography,* 45(1), 1 – 29.

Santos, M.P., Pizarro, A.N., Mota, J., Marques, E.A. (2013) 'Parental physical activity, safety perceptions and children's independent mobility.' *BMC Public Health*, 13, 584.

Saxena, S., Ambler, G., Cole, T.J., Majeed, A. (2004) 'Ethnic group differences in overweight and obese children and young people in England, cross sectional survey.' *Archives of Disease in Childhood,* 89, 30 - 36.

Sardinha, L.B., Andersen, L.B., Anderssen, S.A ., Quiterio, A. L., Ornelas, R., & Froberg, K., et al. (2008) 'Objectively measured time spent sedentary is associated with insulin resistance independent of overall and central body fat in 9-10-year-old Portuguese children.*' Diabetes Care,* 31, 569 - 75.

Scheers, T., Philipparts, R., & Lefevre, J. (2012) 'Patterns of physical activity and sedentary behaviour in normal weight, overweight and obese adults, as measured with a portable armband device and an electronic diary.' *Clinical Nutrition*, 31(5), 756 – 64.

Schensul, J.J., LeCompte, M.D. (2010) *Designing and conducting ethnographic research: An introduction*. Walnut Creek, CA; Altamira Press.

School Census (2011) How children Travel to school. School Census [online] Available from: http://www.censusatschool.org.uk/resources [3rd September 2011].

Schneider, P. L., S. E. Crouter, and D. R. Bassett. (2004) 'Pedometer Measures of Free-Living Physical Activity: Comparison of 13 Models'. *Medicine and Science in Sports and Exercise* 36, 331 – 335.

Schrauwen, P. van Aggel-Leijssen, D.P., Hul G., et al. (2002) 'The effect of a 3-month low-intensity endurance training program on fat oxidation and acetyl-CoA carboxylase-2 expression.' *Diabetes*, 51 (7), 2220 – 6.

Shaikh,W.A., Patel, M., & Singh, S.K. (2011) Effects of gender on the association of adiposity with cardiovascular reactivity in Gujarati Indian adolescents.' *Indian Journal of Physiology and Pharmacology*, 55 (2), 147 – 53.

Sinha, R., Fisch, G., Teague, B., et al. (2002)'Prevalence of impaired glucose tolerance among children and adolescents with marked obesity.' *The New England Journal of Medicine*, 246, 802 – 820.

Singh, G., & Tatla, D.S. (2006) *Sikhs in Britain: the making of a community*. London: Zed.

Sirard, J.R., & Pate, R.R. (2001) 'Physical activity assessment in children and adolescents.' Sports Medicine, 31(6), 439 – 54.

Sleap, M., & Warburton, P. (1996) 'Physical activity levels of 5-11 year-old children in England: Cumulative evidence from three direct observation studies.' *International Journal of Sports Medicine*, 17, 248 - 253.

Smith, G. (2005) Children's perspectives on believing and belonging. National children's burea; London.

Smith, F.W., & Smith, P.A. (2002) 'Musculoskeletal differences between Males and Females.' *Sports Medicine and Arthroscopy Review*, 10(1), 98 – 100.

Souza, M.C., Chaves, R.N., Lopes, V.P., Malina, R.M., Garganta, R., Seabra, A., & Maia, J. (2013) 'Motor coordination, activity and fitness at 6 years relative to activity and fitness at 10 years of age.' *Journal of Physical Activity and Health*, 24.

Southward, E.F., Page, A.S., Wheeler, B.W., & Cooper, A.R. (2012) 'Contribution of the school journey to daily physical activity in children aged 11 – 12 years.' *American Journal of Preventive Medicine*, 43, 201 – 4.

Spengler, J.O., Floyd, M.F., Maddock, J.E., et al. (2011) 'Correlates of park-based physical activity among children in diverse communities: results from an observational study in two cities.' *American Journal of Health Promotion*, 25(5), e1-9.

Spittaels, H., Foster, C., Oppert, J., et al. (2009) Assessment of environmental correlates of physical activity: development of a European questionnaire. *International Journal of Behavioural Nutrition and Physical Activity*, 6 (6), 39.

Spittaels, H., Verloigne, M., Gidlow, C., et al. (2010) 'Measuring physical activity-related environmental factors: reliability and predictive validity of the European environmental questionnaire ALPHA. *International Journal of Behavioural Nutrition and Physical Activity,* 7(1),48.

Sport England (2013) Once a week overall physical activity factsheet AS8Q2 [online]. Available from: www.sportengland.org/research/who-plays-sport [22 December 2014].

Smith, L., Sahlqvist, S., Ogilvie, D., Jones, A., Corder, K., Griffin, S.J., & Van Sjuijs, E. (2012) 'Is a change in mode of travel to school associated with a change in overall physical activity levels in children? Longitudinal results from the SPEEDY study.' *International Journal of Behavioural Nutrition and Physical Activity,* 9, 134.

Stanfield, K.M., Wells, J.C., Fewtrell, M.S., Frost, C., Leon, D.A. (2012) 'Differences in body composition between infants of South Asian and European Ancestry: the London Mother and Baby Study.' *International Journal of Epidemiology,* 41(5), 1409 – 18.

Steele, R.M., van Sluijs, E.M., Cassidy, A., et al. (2009) 'Targeting sedentary time or moderate and vigorous-intensity activity: independent relations with adiposity in a population based sample of 10-y-old British children.' *American Journal of Clinical Nutrition,* 90, 1185 – 92.

Stergioulas, A., Tripolitsioti, A., Messinis, D., et al. (1998)' The effects of endurance training on selected coronary risk factors in children. *Acta Paediatrica,* 87, 401 – 4.

Stidder, G. & Hayes, S. (2012) *Equity and includion in physical education*. Oxon: Routledge.

Stone, M.R., Faulkner, G.E., Mitra, R., & Buliung, R.N. (2014) 'The freedom to explore: examining the influence of independent mobility on weekday, weekend and after-school physical activity behaviour in children living in urban and inner-suburban neighbourhoods of varying socioeconomic status.' *International Journal of Behavioural Nutrition and Physical Activity,* 11, 5.

Stratton, G. & Mullan, E. (2005) 'The effect of multicolour playground markings on children's physical activity level during recess.' *Preventive Medicine.* 41, 828 – 833.

Strong, W.B., Malina, R.M., Blimke, C.J.R., et al. (2005)'Evidence based physical activity for school aged youth.' *The Journal of Paediatrics,* 146 (6), 732 - 737.

Strycker, L.A., Duncan, S.C., Chaumeton, N.R., Duncan, T.E., & Toobert, D.J. (2007) 'Reliability of pedometer data in samples of youth and older women.' *International Journal of Behavioural Nutrition and Physical Activity,* 4, 4.

Sun, S.S., Chumlea, W.C., Heymsfield, S.B., Lukasi, H.C., Schoeller, D., Friedl, K., et al. (2003) 'Development of bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys.' *American Journal of Clinical Nutrition,* 77, 331 – 340.

Sung, R.Y., Lau, P., Yu, C.W., Lam, P.K., Nelson, E.A. (2001) 'Measurement of body fat using leg to leg impedance.' *Archives of Disease in Childhood*, 263 - 267.

Swinburn, B.A., Sacks, G., Hall, K.D., McPherson, K., Finegood, D.T., Moodie, M.L., Gortmaker, S.L. (2011) 'The global obesity pandemic, Shaped by global drivers and local environments.' *Lancet,* 378, 804 – 814.

Tandon, P.S., Zhou, C., Sallis, J.F., Cain, K.L., Frank, L.D., Saelens, B.E. (2012) 'Home environment relationships with children's physical activity, sedentary time, and screen time by socioeconomic status'. *International Journal of Behavioural Nutrition and Physical Activity,* 26 (9), 88.

Tappe, K.A., Glanz, K., Sallis, J.F., Zhou, C., & Saelens, B.E.(2013) 'Children's physical activity and parents' perception of the neighbourhood environment: neighbourhood impact on kids study.' *International Journal of Behavioural Nutrition and Physical Activity,* 10, 39.

Telama, R., Yang, X., Laakso, L., Viikari, J. (1997) 'Physical activity in childhood and adolescence as predictor of physical activity in young adulthood.' *American Journal of Preventive Medicine,* 13 (4), 317 – 23.

Telford, R.M., Telford, R.D., Cunningham, R.B., Cochrane, T., Davey, R. & Waddington, G. (2013) 'Longitudinal patterns of physical activity in children aged 8 to 12 years: the LOOK study.' *International Journal of Behavioural Nutrition and Physical Activity*, 10, 81.

The Telegraph (2012) Primary school league tables 2012: compare your school's performance [online]. Available from: http://www.telegraph.co.uk/education/leaguetables/9739316/Primary-school-league-tables-2012-compare-your-schools-performance.html [6 January 2013].

Thom, T., Haase, N., & Rosamond, W. (2006) 'Heart disease and stroke statistics – 2006 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommitee.' *Circulation,* 112 (6), e85 – 151.

Tillin, T., Forouhi, N.G. McKeigue, P. M. Chaturvedi, N. (2012) 'Southall and Brent Revisited: Cohort profile of SABRE, a UK population-based comparison of cardiovascular disease and diabetes in people of European, Indian Asian and African Carribean origins.' *International Journal Epidemiology,* 41(1), 33 – 42.

Tillin, T., Hughes, A.D., Mayet, J. et al. (2013) 'The relationship between metabolic risk factors and incident cardiovascular disease in Europeans, South Asians, and African Carribeans: SABRE (Southall and Brent revisited); A prospective population – based study. *Journal of American College of Cardiology,* 61(17), 1777 – 86.

Tilin T, Hughes AD, Whincup P, et al. (2013) 'Ethnicity and prediction of cardiovascular disease: performance of QRISK2 and Framington scores in a UK tri-ethnic prospective cohort study (SABRE- Southall and Brent Revisited)'. *Heart,* 100 (1), 60 - 7. *epub ahead of print*

Timmons, B.W., Proudfoot, N.A., MacDonald, M.J., Bray, S.R., & Cairney, J. (2010) 'The health outcomes and physical activity in pre-schoolers (HOPP) study: rationale and design.' *BMC Public Health,* 12, 284.

Timperio, A., Crawford, D., Telford, A., Salmon, J. (2004) Perceptions about the local neighbourhood and walking and cycling among children. *Preventive Medicine,* 38 (1), 39 - 47

Timperio, A., Ball, K., Salmon, J., et al. (2006) Personal, familial, social and environmental correlates of active commuting to school. *American Journal of Preventive Medicine*, 30 (1), 45 - 51.

Timperio A, Giles-Corti B, Crawford D, C, et al., (2008) Features of public open spaces and physical activity among children: findings from the CLAN study. *Preventive Medicine,* 47 (5), 514 - 8.

Tompkins, C.L., Moran, K., Preedom, S., & Brock, D.W.(2011) 'Physical activity-induced improvements in markers of insulin resistance in overweight and obese children and adolescents.' *Current Diabetes Reviews*, 7 (3), 164 – 70.

Tonkonogi, M., & Sahlin, K. (2002) 'Physical exercise and mitochondrial function in human skeletal muscle.' *Exercise and Sport Science Reviews*, 30 (3), 129 – 37.

Townsend, N.B.P., Wickramsinghe, K. Williams, J., Vujcich, D., Rayner, M. (2013) Children and Young People Statistics. Oxford: British Heart Foundation.

Trapp, G.S., Giles-Corti, B., Christian, H.E., et al. (2011a) 'On your bike? A cross sectional study of the individual, social and environmental correlates of cycling to school.' *International Journal of Behavioural Nutrition and Physical Activity*, 8, 123.

Trapp, G.S., Giles-Corti, B., Christian, H.E., et al. (2011b) ' Increasing children's physical activity: individual, social, and environmental factors associated with walking to and from school.' *Health Education Behaviour*, 39, 172 – 82.

Trapp, G., Giles-Corti, B., Christian, H., et al. (2013) 'Driving down daily step counts: the impact of being driven to school on physical activity and sedentary behaviour.' *Pediatric Exercise Science,* 25(3), 337 – 46.

Trayers, T., Cooper, A.R., Riddoch, C.J., Ness, A.R., Fox, K.R., Deem, R., Lawlor, D.A., (2006) 'Do children from inner city British school meet the recommended levels of physical activity? Results from a cross sectional survey using objective measurements of physical activity.' *Archives of Disease in Childhood*, 91 (2), 175 - 6.

Trayhurn, P. (2005) 'The development of obesity in animals: the role of genetic susceptibility.' *Clinical Endocrinology and Metabolism,* 13, 451 – 474.

Treuth, M,S. (2002) Applying multiple methods to improve the accuracy of activity assessments. In *Physical activity assessments for health related research* (edited by G.J. Welk) pp.213-224. Champaign, IL: Human Kinetics.

Treuth, M. S., Butte, N. F., Puyau, M., & Adolph, A. (2000) 'Relations of parental obesity status to physical activity and fitness of prepubertal girls' *Pediatrics*, 106 (4), e49.

Treuth, M.S., Schmitz, K., Catellier, D.J., et al. (2004)' Defining accelerometer thresholds for activity intensities in adolescent girls.' *Medicine and Science in Sports and Exercise,* 36, 1259–66.

Trioiana, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., & McDowell, M. (2008) 'Physical activity in the United States measured by accelerometer.' *Medicine and Science in Sports and Exercise,* 40(1), 181 – 8.

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

Trost, S.G., Pate, R.R., Freedson, P.S., et al. (2000) 'Using objective physical activity measures with youth: how many days monitoring are needed?' *Medicine and Science in Sport and Exercise,* 32, 426 - 431

Trost, S.G., Sirard, J.R., Dowda, M., Pfeiffer, K.A., & Pate, R.R. (2003) 'Physical activity in overweight and non-overweight pre school children.' *International Journal of Obesity,* 27, 834 - 839.

Tudor – Locke, C., Ainsworth, B.E., Thompson, R.W., & Matthews, C.E. (2002) 'Comparison of pedometer and accelerometer measures of free-living physical activity.' *Medicine in Science and Sports Exercise,* 34 (12), 2045 - 51.

Tudor – Locke, C., Pangrazi, R.P., Corbin, C.B., et al. (2004) 'BMI-references standards for recommended pedometer-determined steps/day in children.' *Preventive Medicine* 38 (6), 857 - 864.

Twisk, J.W., Kemper, H.C., van Mechelen, W. (2000) 'Tracking of activity and fitness and the relationship with cardiovascular disease risk factors.' *Medicine and Science in Sports and Exercise,* 32(8),1455-61.

Tyrrell, V.J., Richards, G., Hofman, P., Gillies, G.F., Robinson, E., & Cutfield, W.S. (2001)'Foot-to-foot bioelectrical impedance analysis, a valueable tool for measurement of body composition in children.' *International Journal of Obesity Related Metabolic Disorders*, 25, 273 - 8.

Umpierre, D., Riberio, P.A., Kramer, C.K. et al. (2011) 'Physical activity advice only or structured exercise training and association with hbA1C levels in type 2 diabetes: a systematic review and meta-analysis.' *The Journal of the American Medical Association*, 305 (17), 1790 – 9.

van Loon, J., Frank, L.D., Nettlefold, L., & Naylor, P.J. (2014) 'Youth physical activity and the neighbourhood environment: examining correlates and the role of neighbourhood definition.' *Social Science Medicine,* 104, 107 -15.

Van Mechelen, W., Twisk, J.W., Post, G.B., et al. (2000) 'Physical activity for young people: the Amsterdam longitudinal growth and health study.' *Medicine in Science and Sports Exercise*, 32, 1610 - 16.

van Sluijs, E.M.F., Kriemler, S., McMinn, A.M. (2011) 'The effect of community and family interventions on young people's physical activity levels: a review of reviews and updated systematic review.' *British Journal of Sports Medicine,* 43, 914 – 922.

van Sluijs, E.M., Skidmore, P.M., Mwanza, K., Jones, A.P., Callaghan, A.M., Ekelund, U. Harrison, F., Harvey, I., Panter, J., Wareham., N.J., Cassidy, A., Griffin, S.L. (2008) 'Physical activity and dietary behaviour in a population-based sample of British 10-year old children: the SPEEDY study (Sport, Physical Activity and Eating behaviour: environmental determinants in young people). *BMC Public Health*, 14 (8), 388.

Veitch, J., Salmon, J., Ball, K. (2010) 'Individual, social and physical environmental correlates of children's active free-play, a cross sectional study'. *International Journal of Behavioural Nutrition and Physical Activity*, 2, 7 – 11.

Veitch, J., Timperio, A., Crawford, D., Abbott, G., Giles – Corti, B., Salmon, J. (2011)' Is the neighbourhood environment associated with sedentary behvaiours outside of school hours among children?' *Annuals of Behavioural Medicine,* 41(3), 333 – 41.

Verstraete, S. J.M., Cardon, G.M., De Clercq, D.L.R. & De Bourdeaudhuij, M.M. (2006) 'Increasing children's physical activity levels during recess periods in elementary schools; the effects of providing game equipment.' *European Journal of Public Health*, 16 (4), 415 – 419.

Vincent, S.D., & Pangrazi, R.P. (2002) An examination of the activity patterns of elementary school children. *Pediatric Exercise Science*, 14, 432 - 441.

Wareham, N.J., & Rennie, R. I. (1998) 'The assessment of physical activity in individuals and populations. Why try to be more precise about pa is assessed.' *International Journal of Obesity Metabolism Disorder*, 22 (s2), s30 - s38.

Wagner, D.R., & Heyward, V.H. (2000) 'Measures of body composition in blacks and whites: a comparative review.' *American Journal of Clinical Nutrition*, 71(6), 1392 – 402.

Walker, K. Z., O'dea, K., Gamez, M., & Colagiuri, R. (2010) 'Diet and exercise in the prevention of diabetes. *Journal of Human Nutrition and Diet,* 23 (4), 344 - 52.

Wannamethee, S.G., & Shaper, A.G., & Alberti, K.G. (2000) 'Physical activity, metabolic factors and the incidence of coronary heart disease and type 2 diabetes.' *Archives International Medicine,* 160, 2108 – 2116.

Warburton, D. E. R., Nicol, C.W., & Bredin, S.S.D. (2006) 'Health benefits of physical activity: the evidence.' *Canadian Medical Association Journal,* 174 (6), 801 – 809.

Warren, J.M., Ekelund, U., Besson, H., et al. (2010) 'Assessment of physical activity – a review of methodologies with reference to epidemiological research:a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabiltation.' *European Journal of Cardiovascular Prevention and Rehabilitation*, 17 (2), 127 – 39.

Wedderkopp, N., Froberg, K., Hansen, H.S., Riddoch, C., & Andersen, L. B. (2003) ‚Cardiovascular risk factors cluster in children and adolescents with low physical fitness. The European Youth Heart Study EYHS.’ *Pediatric Exercise Sci*ence, 15, 419 - 427.

Wei, M., Gibbons, L.W., Mitchell, T.L., Kampert, J.B., Lee, C.D., & Blair (1999) ‘The association between cardiovasrespiratory fitness and impaired fasting glucose and type 2 diabetes mellitus in men. *Annals International Medicine,* 130, 89 - 96.

Wells, J.C.K., & Fewtrell, M.S. (2006) ‘Measuring Body Composition.’ *Archives Disease in Children,* 91(7), 612 – 617.

Wheeler, B.W., Cooper, A.R., Page, A.S., & Jago, R. (2010)’ Greenspace and children’s physical activity, A GPS/GIS analysis of the PEACH project.’ *Preventive Medicine,* 51, 148 - 152.

Whincup, P., Gilg, J., Papacosta, O., Seymour, C., Miller, G. J.,& Alberti, K. G. M. M., et al. (2002) ‘Early evidence of ethnic differences in cardiovascular risk: Cross sectional study comparison of British South Asian and White Children.’ *British Medical Journal,* 324, 1-6

Whincup, P.H., Owen, C.G., Orfei, L., McKay, C., & Cook, D. G. (2007) ‘Ethnic differences in risk factors for chronic disease have their origins in early life: evidence for the CHASE study.’*Early Human Development* , 83, S63.

Whitaker, R.C., Pepe, M.S., Wright, J.A., Seidel, K.D., & Dietz, W.H. (1998) ‘Early adiposity rebound and the risk of adult obesity’ *Pediatrics,* 101 (3), E5.

White, J., & Jago, R. (2012) ‘Prospective associations between physical activity and obesity among adolescent girls: racial differences and implications for prevention.’ *Archives Pediatric Adolescent Medicine,* 166 (6), 522 – 7.

WHO (2009) Global health risks: mortality and burden of disease attributable to selected major risks. WHO [online]. Available from: http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf [5th September 2011].

WHO (2010) Global recommendation on physical activity for health: WHO [online]. Avaialble from: from http,//whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf . 2010 (accessed on 5th September 2011).

WHO (2011) Noncommuicable diseases country profiles 2011: WHO Global report [online]. Available from: http://www.who.int/nmh/publications/ncd_profiles2011/en/ [5th September 2011].

Wilkin, T.J., Mallam, K.M., Metcalf, B.S., Jeffery, A.N., Voss, L.D. (2006) ‘Variations in physical activity lies with the child, not his environment: evidence for an ‘activitystat’ in young children (EarlyBird16).’ *International Journal of Obesity,* 30(7), 1050-5.

Wilkinson, S. (2004) Focus Group Research. In *Qualitative Research, Theory, Method and Practice* (edited by D. Silverman) pp. 178 - 199.   London: Sage.

Wilks, D.C., Besson, H., Lindroos, A.C., & Ekelund, U. (2011) 'Objective measurement of physical activity and obesity prevention in children, adolescent and adults: a systematic review' *Obesity Reviews*, 12(5), e119 - 29.

Williams, E.D., Steptoe, A., Chambers, J.C., Kooner, J.S. (2009). Psychosocial risk factors for coronary heart disease in the united kingdom. South Asian men and women. *Journal of Epidemiology and Community Health*, 63, 986-991.

Williams, E.D., Stamatakis, E., Chandola, T., & Hamer, M. (2011) 'Physical activity behaviour and coronary heart disease mortality among South Asian people in the UK: an observational longitudinal study. '*Heart*, 97, 655 – 659.

Williams, A.J., Wyatt, K.M., Hurst, A.J., Williams, C.A. (2012) 'A systematic review of associations between primary school built environment and childhood overweight and obesity.' *Health and Place,* 18, 504 - 14.

Wolfarth, B., Bray, M.S., Hagberg, J.M., Perusse, L., Rauramaa, R., Rivera, M.A. et al. (2005) ' The human gene map for performance and health-related phenotypes: the 2004 update.' *Medicine and Science in Sport and Exercise,* 37, 881-903.

Wong, B. Y., Faulkner, G. Buliung, R. (2011) 'GIS measured environmental correlates of active school transport: a systematic review of 14 studies.' *International Journal Behavioural Nutrition and Physical Activity,* 8, 39.

Woodcock, J., Franco, O.H., Orsini, N., & Roberts, I. (2011) 'Non vigorous physical activity and all-cause mortality: systematic review and meta – analysis of cohort studies. '*International Journal of Epidemiology,* 40 (1), 121 - 38.

Woodward-Lopez. G., Davis-Ritchie. L., Gerstein, D.E., Crawford, P.B., (2006) *Obesity: Dietary and Developmental Influences.* United States; Taylor and Francis Group.

Wojtaszewski, J.F., Hansen, B.F., Kiens, B., Markuns, J.F., Goodyear, L.J., & Richter, E.A. (2000) 'Insulin signalling and insulin sensitivity after exercise in human skeletal muscle.' *Diabetes*, 49 (3), 325 – 31.

Yajnik, C. S., Lubree, H.G., Rege, S.S., et al. (2002) 'Adiposity and hyperinsulinemia in Indians are present at birth'. *Journal of Clinical Endorcrinology Metabolism,* 87(12), 5575 - 80.

Yiannakis, A., & Melnick, M.J. (2001) *Contemporary issues in sociology of Sport*. Champaign IL; Human Kinetics.

Zachwieja, J., Toffolo, G., Cobelli, C., Bier, D., & Yarasheski, K. (1996) 'Resistance exercise and growth hormone administration in older men: effects on insulin sensitivity and secretion during stable-label intravenous glucose tolerance test.' *Metabolism*, 45, 254 – 260.

Zimmet, P.Z., McCarthy, D.J. & de Courten, M.P. (1997) 'The global epidemiology of non-insulin-dependent diabetes mellitus and the metabolic syndrome'. *Journal of Diabetes Complications*, 11(2), 60 - 8.

Zimmet, P. (2000) 'Globalization, coco-colonization and the chronic disease epidemic: can the Doomsday scenario be adverted?' *Journal of International Medicine*, 247 (3), 301 - 10.

Zhu, X., & Lee, C. (2008) 'Walkability and safety around elementary school, Economic and ethnic disparities.' *American Journal of Preventive Medicine,* 34, 282 – 290.

Zhu, X., Lee, C., Kwok, O.M., & Varni, J.W. (2011) 'Context-specific correlates of walking behaviours to and from school: do they vary across neighbourhoods and populations?' *Journal of Physical Activity and Health*, 8 (s1), s59 – 71.

Zou, C.L.L., Hong, F., Fu, J. F.,& Zhao, Z.Y., (2005) 'Serum adiponectin, resistin levels and non-alcoholic fatty liver disease in obese children.' *Endocrine Journal*, 52, 519 - 24.

APPENDIX I

Focus group interview questions for children

Topic: Knowledge and beliefs about physical activity
1. What is physical activity? What does it mean to them?
2. What do you think/feel about physical activity? (important)
3. Why do you think physical activity is good or bad? (health/fitness)
Topic: key sources of knowledge and beliefs
1. Who is your role model for physical activity (parents, religious figures, peers)
2. Where else do you learn information about physical activity?

Topic: physical activity patterns
1. What activity do you do now? (where? Clubs? types)
2. When do you think you are most active?
3. What do you do after school and at Weekends
4. How does what you do at school influence your activity out of school?
5. Past experiences of physical activity or past physical activity
6. How much physical activity do you think you should do?
7. Do you play outside? Why?

Topic: Barriers to physical activity
1. What stops you from doing physical activity at school, outside of school and at home (after school, weekends)
Prompts: practical, environmental. Attitudes and beliefs
2. why do you think some people might do less activity than others?
3. what would make you do more physical activity
4. how could we encourage others to do more physical activity

APPENDIX II

Sources of beliefs and knowledge of PA

BENEFITS OF PA		
Psychological	Feel Healthy	*'I do exercise because it makes me feel healthy'* (S2, G2).
	Intrinsic rewards	*'When it was our sports day I was exercising every day and i had a race and I was first and I had a gold medal. Miss it makes me feels the champion…. my heart was beating really fast'* (S2, G2).
	Happy	*'Exercise makes me happy because when I exercise I get more good like basketball'* (S2, G1).
	Enjoyable	*'it is fun and we have really fun activities to do*'(S1, G1) '*All of the games and the extensions that we do. Like the warm ups and the little things*'(S1,G1)
Physiological	Muscle and bone growth/strength	'*you should do exercise because it makes your Bones strong and its good for you and Will make you stronger'* (S2, G1).
	Muscle and bone Growth/ strength for adult health	*'I think PA is good because like [child's name]said when you are older you tend to have more ,you can move your back a bit more than just sitting down on the couch feeling old '*(S2, G2).
	<u>Health and fitness</u>	
	'fit'	*I think PA is good for you because you get fit and if you want to get fitter then you have to Exercise more to so you can get fitter'* (S2, G2).
	Prevent disease	'*It stops you getting cancer.. diseases and diabetes'*(S2, G2),
	Dental health	*'Because if I am not healthy then it will make my teeth fall out'* (S1, G2).

	Weight Management	*'If you didn't do exercise then you would end up being fat'* (S2, G1).
	Skill	*'I think you should exercise because if you don't do more exercise then like somebody kick this ball in the air you won't kick it up very far because you don't do much exercise'* (S2,G1).
Key sources of belief	Teacher	*'Yeah he runs these clubs' '[teachers' name] does all these activities'* (S1, G1).
	Family	*'my dad sometimes teaches me to do star jumps and lifts*' (S2, G3)' *'my dad because he was running around the whole park by our house and he got me to do it with my bike'* (S2,G2), *'my dad because we go to the park'* (S2, G2) *'My mum because she is a member so she can tell me what is good and bad'* (S2, G2).
	'ME'	*I did it myself …I just do it by myself then I don't have to get moaned at by my mum when I do it wrong*' (S2, G2).
Media	TV	*'…I saw this exercise programme it was called keeping your arms, your bum, your hips healthy ….it showed you how you keep your bum and your legs fit. It was to keep the muscles on your bum'* (S2,G3))
	Book	*' erm I have a book and it is called 'keeping fit and healthy* ' (S2, G3)
	Website	'*….and sometimes I go on a website called Olympic exercise* (S2, G3)'
Role models	PE Teacher	' *[PE teachers name] …make sure that you are good…make sure that we enjoy them …at lunch we play a skipping game and [teachers name] helps me to skip, he holds the rope'* (S1, G1,).
	Footballer	*Wayne Rooney, he plays football, so I play football just like him* (S1, G2)
	Athlete	*'Miss my role model is Usain Bolt …because he is like me, running faster'* (S2, G2).

APPENDIX III

Focus group interview questions for parents

Topic: Knowledge and beliefs about PA
1. What is PA? What does it mean to them?
2. What do you think/feel about PA? (Important)
3. Why do you think PA is good or bad? (Health/fitness)

Topic: Key sources of knowledge and beliefs
1. Who is your role model for PA (parents, religious figures, peers?)
2. Where or who do you learn information about PA?

Topic: PA patterns (child)
1. What activity does your child do? (Where? Clubs? Types)
2. When do you think they are most active?
3. What do you they do after school and at Weekends?
4. How does what they learn at school influence their activity out of school?
5. Past experiences of PA or past PA
6. How much PA do you think your children should be doing a day?
7. Do they play outside and where? I.e. front garden, back garden? Grass, pavement?

Topic: Barriers to PA
1. What stops your child and you from doing PA at school, outside of school and at home (after school, weekends)
Prompts: practical, environmental. Attitudes and beliefs
2. Why do you think some people might do less activity than others?
3. What would make you or your child do more PA?
4. How could we encourage others to do more PA?
5. How could we encourage children and parents to be active together?

Topic: Environmental influences
1. How do you feel about your local neighbourhood? Is it safe (day and night)? Is it pleasant i.e. graffiti, trees etc.? Can you get around it easy? Footpaths, safe crossing of roads, etc.
2. What do you have local to your home? I.e. shops, leisure centres, swimming pool, parks, open spaces etc. and are they well maintained?
3. Do you have local footpaths, special lanes for cycling? Are these well maintained?
4. How do you feel about walking or cycling around your neighbourhood?
5. How do you feel about local play areas? Parks? And other open spaces available for children in the neighbourhood?

APPENDIX IV

Facilitators and barriers to children's PA from parental perspective

THEME	Quote
Knowledge and beliefs about PA?	
Activity/exercise	'*Being active' (*PG1 & PG2) '*Doing exercise'* (PG1 & PG3)
Informal play children	'*When the kids are out playing their games, football, skipping'* (PG2)
Movement	'*Movement over a sustained amount of time'* '*Movement'* (PG2)
Playing outside not being sedentary	*'Not just sitting watching the TV and playing on the play stations, something where they can get outside and do something but you can't in this day and age'* (PG2)
Tiring	'*It makes me feel tired depending on what activity you were doing'* (PG1)
Benefits of exercise	
good for you	'*Being healthy while you're doing the exercise'* (PG1)
Healthy	'*Yeah but then again you have to think about it that's it's better for you, you know' (*PG1)
Sources of beliefs	
Internet	*'Internet'* (PG1)
Husband	*'Husband'* (PG1)
Leaflets	'*Leaflets through the door they have activities coming'* (PG1)
School knowledge	*'General knowledge, things you have picked up over the years from school'* (PG1)

ACTIVITY LEVELS OF CHILDREN	
Few hours per day	'*A few hours a day'* (PG1)
Knowledge of clubs	'*I don't know of any clubs ….I don't know, even in summer holidays'* (PG3)
Interest	
Children want to play and exercise	'*They want to play, they want you know some exercise'* (PG3)
Parents want children to play safely	'*You want to be on your own and the child is playing knowing they are safe* '(PG3)
Theme 2: Distance to local facilities	
Shops local (crime affect travel to)	'*Even the shops are just here from my house and you would have to walk past all that [drugs, drink, dogs and gangs] on the way'* (PG1)
Takeaway/fruit stalls	'*We have loads of shops, rammed with takeaways and shops, we do have fruit stalls as well'* (PG1)
Gym	'*There are some gyms on the Foleshill road but it's more to the bottom. We are pleased with the women's gym as its ladies only and 24 hours, you can use the gym and sauna. You can go whenever you want, when kids are off to bed'* (PG1)
Pleasant parks outside 1mile radius but special trip than regular trip	'*You have to go right out to like coomb abbey or somewhere its ok there ….But that's really far away Or memorial park that's… But then that's not something you can do every night…. So you just have to make that effort once in a while'* (PG1)
Sports clubs/activities location	'*Your girl guides, scouts and things like that; if you haven't got a car then you can't get to them and then you pay bus fare for what'* (PG2)
Lack of sports clubs in the surrounding neighbourhood	'*There's not enough. I mean, my son was interested in football and there's not one place in Coventry that does football. No, No. Erm the what do you call it, the sports and leisure centre in erm, what do you call it, by pool meadow they don't, they don't do football. Not at weekends, not after school, not nothing. So the only way we found football was at another school which is walking distance but you know it's a trek and you have to pay for it*'(PG3)
Lack of youth clubs	'*They need somewhere safe to go. There is nowhere for them to go...If you go from the top of Foleshill road right through into town and you show me somewhere where there is a community centre for kids for them to play'* (PG2)

Too many pubs	*'Got too many pubs around here'* (PG3)
Improvements Local youth clubs	' *If they did like a youth club or something like that , then maybe they can do sessions like karate or self-defence ...Yeah so then if anyone does go to grab them then they can handle themselves to get away'* (PG2)
Theme 5: Neighbourhood safety (crime/traffic)	
Prostitutes	'*Because where I am, there are prostitutes as well in the morning… They're there from morning till evening… It's not as if they make it discrete either is it? they're so obvious, They're so blatant'* (PG3)
Gangs and season	'*The gangs they come out earlier on dark nights….. They think it is dark and that they can get up to all sorts because it is darker quickly'* (PG1)
Rough	'*Very rough [The people], It is very rough. It is not your kid it's the people around. A lot of crime'* (PG1)
Trouble/fights	'*Because unfortunately you do get trouble... In my area they don't wait for the dark. They are kicking off all the time, over drugs and stupid things'* (PG1)
Attacks	'*And for people getting attacked because an incidence happened at the back of my house err a few weeks ago which was pretty bad'* (PG3)
Thief and sense that someone is watching you	'*You feel like somebody is watching you aren't it? I just did the bag and I put sticker yeah. I was just tidying up yeah and I put that bag out then I was finishing tidying up my rubbish to put in because Friday they supposed to pick. By the time I come to, there wasn't even ten minutes, by the time I come to that bag wasn't there They took the bag with the clothes in it. Yeah it was supposed to be collected the next day between 8 and 6oclock. Obviously somebody's lifted it. The bag wasn't, I just felt like somebody was watching me. Very scary, very scary. It reminded me to lock the door. In a small time yeah something huge can happen. It just frightened me'* (PG3)
Unsafe streets	'*my streets aren't safe'* (PG1) …'*I won't let my daughter walk to school. We live literally around the corner but I won't let her walk'* (PG2)
Fear that the streets have been taken over	*'Not really no they [Teenage youth, gangs, crime] have taken over* '(PG1)

Nostalgia of how it used to be safer compared to now	'*Where we were allowed to do it when we were younger'* (PG2) '*When we were younger my dad use to go and collect us from the park at 8 saying come home you need to have your dinner. I use to go by myself, my brothers would go by themselves but now you would trust your own child to go alone to the park. It is not safe. What it is with our time when we were 10-20 or 30 odds years we could go by ourselves to the shops to the parks and we could stay out late at night but now I wouldn't let my daughter out of the house, even my 15 year old son'* (PG1)
Traffic	
Drive too fast	'*Erm traffic, I live on the Foleshill road and the traffic down there I could not let my daughter out , She has road sense, you've got Kashers Lane and Foleshill road and they come up and down there like idiots, so there is no barriers so if they are going to have a car crash then it is coming in your house whether you like it or not* (All agree)' (PG2)
Speed over speed bumps	'*Young lads driving their cars thinking they, what makes me laugh is at the top of my road they drive so fast they have to stop when they get to the bottom. We have the speed humps in our road and they're still doing it'* (PG3)
Car accidents	'*We've had a few accidents down my road* '(PG3)
Inability to follow traffic riles	'*Yeah, I say to my daughter don't cross just because there is zebra cross. If you see a car, wait for it to stop before you crossing because some of them yeah they can pass you whilst you are looking…you know they never intended to stop* '(PG3)
Busy roads	'*My road is very busy, lots of shops'* (PG3)
Child abduction fears	*'I am just scared of letting my daughter out to play. You do not know who is about. They could put them in a car; take them off or anything…. So many incidents have happened ….. It is so easy just to pick them up and take them '(*PG2)
Incident reports	'*There were warning them… Yeah up by [local school name] up by winginton road, up sandy lane. They were approaching young girls and showing them things on his phone. They had to walk into a shop'* (PG2)
Police won't do anything until something has happened	' *there was a man hanging by our school because he had special needs, he was allowed to talk to the children and do what he wanted because the police couldn't do anything because he hadn't done anything yet…….It has to happen before they will do anything. It is a worry* '(PG2)
Anti-social behaviour	
Streets	
Alcohol drinking on the streets in groups	'*The cans, they drink in groups, they are just very scary. So you can't take your child there when they are like standing there*' (PG3) '*And it's like more adults than children in the park. Like older teenagers. They in their hoodies and you can't*

	see their face' (PG3)
Drinking outside local hostel	'*There is a hostel around the corner from my house. There are people; they sit on my wall drinking at night time. I hate it; it really winds me up to be honest. There is not much I can do about it. The police say to give them a ring when it happens and not to approach them but by the time you have done that they have gone* '(PG2)
Drug dealing	'*You have drug dealers* '(PG1)
Pubs local	'*a pub across the road, they are very rough'* (PG1)
Dogs	' *there is dogs, pit bulls that are just running up and down the streets'* (PG1)
Gangs	'*And gangs* '(PG1)
Vandalism	*'Vandalism'* (PG1)
Bullying / mugging	'*They become very loud and they pick on kids that are on their own and they mug them and take away whatever they've got off them. …That's happened quite a few times* '(PG1)
Parks	
Young adults hangout	'*And people just go to sit there at the weekends and as it gets later they collate there. They are not going there to play they are going there to sit but it's like gangs of children. My daughter will say can we go there and it's not even safe to go because I don't feel safe to go. ….Its teenagers….. Yeah teenagers that are mostly bored…… Yeah that has nothing to do …..Yeah they bang on the shops* '(PG1)
Drugs in local parks	'*19/20 year olds smoking whacky backy (weed)'* (PG3)
Traffic/drugs	'*is a park just one park and you can't let your children, there is a lot of traffic and drugs'* (PG3)
Alcoholic drinking in local parks	'*Especially the Swanswell park because there are groups of people who sit down there in the summer and they drink. Big groups'* (PG3)
Sexual behaviour	'*They are trying to have rumpy pumpy in the bushes'* (PG2 & PG3)
Dogs not on leads	'*There is also something else wrong there. You know dogs, they are so so dangerous. Sometime you don't know… Most of the time, the young lads with their hoods up, with their pit-bulls be walking beside them or whatever not on a lead'* (PG3)

Intimidating	'*It can be intimidating. I mean it use to do doors and I will quite openly admit that it can be intimidating these days out and about. It's just one of those things…….It can be intimidating like [person's name] said; the other day I left my house. I was then going around the corner to go to the shop and they were daring each other to give me a dig and give me a quick smack'* (PG2)
Racism	'*Your misses got abuse didn't she'* (PG2) *'Yeah even she did because they are together. You know what I mean. The abuse she got up by Livingstone road was unreal. All she had done was go to the shop. And its kids that probably weren't at school. Yeah it was school time'* (PG2)
Throwing things at house	'*By my house it is a dead end you can't get any cars through their so the gangs they just hang about there, my daughter is looking out the window and she can see all sorts of stuff. She says mummy why is that man doing that and I say come away from the window because you don't know If they are going to throw anything you know we have had things thrown at the window before, or shouting. You have to tell her to stay away from the window'* (PG1)
Garden	
Unsafe to play in garden	*You can't leave them. You can't leave your children to play on their own its dangerous. I never leave my children in back garden. …the area is difficult* ' (PG3)
Throwing things into garden	*'And they throw and they can just knock on our door and check all of back garden because they chuck something….they are hanging around there with drug. You can't leave your children outside'* (PG3)
Safe DAY vs night	
Safer in the day	*'I feel safe in the day I am quite confident ... Yeah more confident during the day'* (PG1)
Less safe at home and alone	*'More towards the night no or by myself at night... towards 5 or 6 it starts getting darker'* (PG1)
Less crime with lighting	*'There would be less crime with lighting so I would feel safer with lighting'* (PG1)
Lack of lighting at night (streets)	*'When you go out at night the streets are too dark. The lights, the street lights are too high up and it's not lighting the pavements up for you to see … It's far too dark…You can't see that far and you don't know what is lurking'* (PG3)
Lack of lighting (garden)	*'But my garden it backs onto you know the sky blue way. You know I've been there what over 11 years. When we first moved in, what I call although it was dark you could see all the floodlights you know on the sky blue way. But now at night my back garden it's pitch, even my even my dog won't go out for a wee because my garden is pitch'* (PG3)
Lack of warden presence	*'Well, we're supposed to have wardens around here but you don't see them very often'* (PG3)

Makes it easy for burglars	'*What I mean, if someone's there if someone's there you wouldn't be able to see. It's a lot easier for burglars as well with no lighting in the street'* (PG3)
Improvements	
Surveillance	'*There is never enough police around at the right time'* (PG1)
Policing	'*Higher police presence'* (PG2)
Cameras	'*There should be more cameras* '(PG2)
Cut through/alleyways	'*You know they have these alleyways that are supposed to be cut through maybe has some cameras in there and lights'* (PG1)
Wardens	'*We need wardens to watch the streets* '(PG1)
Parks	'*These stupid people that go around supposed to be council wardens put them on the parks, its I their job to make it safe. It's a 24 hour job. Like they would do for security if there was building work going on. Put the wardens on the parks and surveillance and things like that'* (PG2)
Increased lighting	*'There are some areas where there isn't much lighting as well. There is a road station street west , where the kids go to mosque, there is no light there.... more lightening'* (PG1)
role modelling from local public services	'*Yeah if police were there then they could teach them while they were there, you know get them into being a firewoman or whatever. Interests The army could come in. You know the TA to help them and keep them off the streets. To make 'me do something. If they are off the streets then they are not going to be doing drugs or drinking or hanging around with everyone. There isn't going to be pregnancies. If they are shown a bit of respect* and *authority'* (PG2)
Children to learn self-defence (street wise)	'*It is one of those areas where if you are not street wise enough then you could find yourself in positions that you can't handle. Yes like [persons' name] has done boxing, karate etc., he can show the other children the right way to do it. Not the 'I'm going to punch your head in la de dah'. If it is shown the right way then kids will listen. If you do not show authority then you cannot be given authority and animals and children are the same. If you do not show authority then they will walk all over you and they don't give a damn but you show them'* (PG2)
Media/ gossip incidents of crime circulation	
Drug incidents	'*There was one on Facebook the other day he was in bore hill getting the dirty water out of the puddle (all repeat) and injecting himself on the street. So what is that saying? You are not going to let your children anywhere with people like that'* (PG2)
Dog incidents	

	'*Yeah and you've heard a lot of stories about pit bulls and how they have attacked* '(PG1)
Child abduction	'*You hear about kids being snatched on the street it is when they are playing so you know it makes you worry'* (PG1)
Theme 6. Pleasant/aesthetic neighbourhood	
Unpleasant	'*It's not a pleasant area to look at ...No it is not maintained'* (PG3)
Dog mess	'*There is lots of mess, dog muck everywhere...... You walk down there and slip on it or tread in it , it is disgusting'* (PG2)
They don't obey the signs	'*We do have the dog wardens coming around sticking up signs but it's not going to work They don't follow it up. There is no cameras or anything'* (PG2)
Rats	*'The Foleshill road is wriggled with rats; literally you walk down the Foleshill road. They are not like rats they are like puppy dogs. You come out the bus stop on the Foleshill road at night and a rat will run across your feet'* (PG2)
People feeding pigeons,	'*I told some people off before because they were feeding them... they just pile chapattis and things on the floor for the ducks ...down there. Because they are not just feeding the ducks and the geese they are feeding the pigeons, the rats they are feeding whatever, anyone that sleeps there really'* (PG2)
Rubbish on the streets	*'Terrible. See half the time the rubbish around here is just disgusting'* (PG2 & 3)
People trailing through bins leaving stuff on the floor	'*You know what's been happening a lot in our street? I don't know if they are Romanians or whatever. Looking in the bins. They take what they want and leave what they took from it. If you find something you like in the bin okay that alright but put everything back how you found it. Now you are leaving me looking like you know like I don't know what I'm doing with all the black bags and rubbish outside. Yeah it's not fair* ' (PG3)
Fly tipping	*'But there's people fly tipping as well isn't there? The odd sofa, the odd mattress, the odd yeah'* (PG3)
Graffiti	*'Graffiti as well'* (PG3)
Urinating on property	*'People after they are drunk, they pee next to the door'* (PG3)
Walking to school	
Used contraception	'*on our route taking our child to school we would find used contraception on the floor'* (PG2)

Empty syringes	'*And empty syringes'* (PG2)
Canals	
Drug needles	*'Even if you take a walk down the canal… It's no good. The council says o were cleaning up the canal were doing this, where?? Because there is drug needles. I go fishing and my little girl goes fishing with us and we sit there and I have to leave my fishing rod with my partner and take her home to go to the toilet because she can't do anything around there because there are needles. She can't play around there, she can't do anything. She has to just sit there and fish. You know what I mean. Sometimes they get bored. But they are using drug needles'* (PG2)
Parks	
Broken equipment	*'The council do not do the parks for the young ones. His kid is only 6 and mine is 8. But he can't take his kid to the park. No not around here. There was but the big ones have broken them'* (PG2)
Broken bottles	*'Yeah there is loads of broken bottles'* (PG2) *'There is a park on Stoney Stanton road. By the doctors. I pass it when I go to the doctors, or go over that way. And he will say can we go in there and I have to say no 'sorry kid' not that one. I won't take him into that park because I know that state of it... Broken bottles and needles. It is just not very well maintained'* (PG2)
Needles	'*needles as well'* (PG2)
Streets	
Bins not put back	*'It sounds stupid but obviously being a lollypop lady obviously but every Friday you'll see the dustbin men come ….Now, whether its common sense to me, if I took a bin from number I'd put it back to number four. But no on a Friday when I walk up to my spot basically I have got a bin number four is at number twelve. Number twelve bin is basically at number ninety four. You know it takes me twenty minutes to sort out people's bins. It's not part of my job but if I see a, see a I don't know erm a female with a pram and she has to go in the road because the bins in the way and then apparently I get sacked'* (PG3)
Bins block walk route	*'Even for children it stops them to come with their own bike to school and they'll give them a prize you know. But Friday you can't come on bike because of that'* (PG3)
Managing local facilities	
Lack of surveillance	*'There is no security or anything like that'* (PG2)
Improvements	
Dog mess bins	*'Dog bins for dog owners.... A glove as well and bags'* (PG1)
Clean the streets	*'Erm it needs to be a lot cleaner. I mean, the clean, the streets don't get cleaned very often'* (PG3)

Theme 7: cycle/walking network (connect)	
Good connections	
Traffic lights	*'Yes I feel that's safe, they have traffic lights. The lights they have done are really and because its busy they have done a good job'* (PG1)
Lack of zebra crossings away from school	*'We've only got, we've only got one crossing here and that's because we've got a school…. Apart from that, I don't know of any crossing around here'* (PG3)
Don't stop for lollipop lady	*'Yeah if [lollipop lady's name] is trying to stop them and they're passing her, then they're passing the kids aren't they?* '(PG3)
Roads	
People don't follow rules	*'On the one way streets no one ever follows the rules... so it's not safe for the kids'* (PG1)
Improvements	*'You need cameras there they should get a fine like they do with traffic lights'* (PG2)
Cycle paths unsafe	'love to go cycling but I just take her around the block and back in as I just don't know what to do with her…If the parks where safe then we could actually go ourselves and do some activity, you know walking or an evening stroll We could take our kids with us and do activity but they are not safe ' (PG1)
People drive in cycle paths	*'It doesn't matter if there is a cycling lane or bus lane, people still drive in them'* (PG2)
More cycle lanes and clear guidance	*'Cycle lanes…So you know it clear guidance with the bikers who want to ride… You see bike, usually on pavements, we are pavement with our foot and dog walker is using pavement. I can ride the bike but I scared to ride here because the pavement... Is very small and sometime small pavement and the bins also two three bins. There no space and bikes '(*PG3)
Speed on the roads at night	*'It is like a race track along the Foleshill road at night from half 8 or 9 onwards ... They come from along the Foleshill road and down cashers lane and then onto Kingfield. It is unreal. It is mad'* (PG2)
Improvements (move to crime)	
Speed bumps	'*Sleeping policemen'* (PG2)
Education	'*A lot of that is education. ..It's a melting pot Coventry.... It is multi-cultural beyond belief. Absolutely, you've got so many cultures all squeezed into so much space, not everyone has sufficient language skills or education. It is a matter of timing really isn't it. It has been easy enough for everybody to get driving licences without enough focus being placed on the*

	education behind it. The green cross code... you know like not knowing about filter lanes' (PG2) *'They don't know our roads. If they don't know them they should be made to take a test, they come into the country and they don't know the roads. A driver should be made to take a test for our roads. ....They need the rules, regulations, speeds what they are allowed to do and what they are not allowed to do because they come over here , they get on our roads , then they know one of our children over and they are like well I don't know… they have a licence from Poland or whatever or not insured'* (PG2)
Theme 8: Home environment	
Weekdays (afterschool) **Indoors** TV and games	'TV and games' (PG1 & PG2 & PG3)
Dinner, homework, TV	*'come home from school, put the dinner on, lock the door at 6, she gets changed into her Pj's and does her homework or whatever she has got to do. She sits there and watches Cbeebies or whatever is on tele '(*PG2)
Mosque, homework, bed	*'Kids have to go mosque so by the time they have gone to mosque come home, done their homework it is bedtime. ......so no time to do any other activities apart from at the weekends'* (PG1)
Weekends **Indoors**	*'It is the weekend; they are always inside the house. Yeah, there's nothing that goes on in the weekend. They are always inside the house. We don't trust the area.... To let your children go out and play* '(PG3)
Play with toys	*'Play with their toys'* (PG1)
TV	'*For children , The whole day school and when they come back they just in living room or dining room sitting and watching TV.. No cycling, no exercise and that's why they get'* (PG1, 2 & 3)
Outside of home environment (active child) Youth Clubs	*'He goes to youth clubs, Monday, Tuesday, Wednesday and Thursday. They do different activities like table tennis and snooker and he rides his bike there'* (PG1)
Sports clubs	'*He plays football* '(PG1)
Recreational facilities	*'Swimming on Saturdays'* (PG1)

Bike rides	*'Go on bike rides'* (PG1)
Garden	
Anti –social behaviour / safety	*'Mine is a back garden but because I live on the corner we have a back gate but then you get people looking through the gate through the hole and you get people throwing things over the gate, just for the fun of it or* whatever '(PG1)
People jumping into the garden or throwing things over	*'Where I live my garden is quite small I have got my own entrance at the back but it's not safe and that's where mostly the dealing goes on and stuff, so I've got people jumping into my garden and you know throwing stuff and stuff like that. The kids are really scared as well'* (PG1)
Crime	'*Behind the garden... there is a passageway where people cut through to go to the shops, so we get all the drunken people at the back of there and one has even jumped over the back of our fence and nicked a motorbike. They got into my husband's garage and they nicked the motorbike but the police couldn't do anything about it'* (PG1)
Small gardens	*'Yeah because you can't really do much because the gardens aren't that big'* (PG2)
House	*'Your house isn't that big (PG2)… Not enough room to put exercise machines'* (PG3)
School environment	
Main environment for PA	*'The school plays an important role in their activity, They mainly [get PA] through school ….. because they are here most of the time'* (PG1)
Building block for future/continued PA	*'My son use to play football at school and he has continued it because the PA was so good here'* (PG1)
Positive perception of facilities	*'Yeah because they pick it up from school in year 5 and 6 and then some children continue the sport so it's a good thing'* (PG1)
Playground	'*They have loads in this school and I think this school is brilliant for that …. but every other school hasn't got that '(PG2)* *'Running around the playground, running here and running there… erm they do a lot. In this school they give them quite a lot'* (PG2)
Gym trainer	'*They have the gym trainer'* (PG1)
Adventure playground	'*The swings, and climbing frames they have loads in the school'* (PG1) .
Omega	'*The Mooga'* (PG1)

Camping at school site (safety)	'*Like ours go camping don't they..... We still have to pay but they camp in their school site. It is all safety. That is the only time I would let my daughter do it. But it is all money, money'* (PG2)
Sports clubs at school Range of opportunities	*'My son does at school basketball football everything. .. They do, in the school we have a lot of activities everyday going on in school. Like on a Monday there's a judo class, they do acro, they do street dance they do lots of activities after school. We have lots of, quite a lot of sport activities here; football, netball. My daughter's in football and netball. But That's just 3 to 4oclock.It's for one hour though'* (PG3)
Other : environmental factors	
Seasonal affects (dark nights are early)	*'But in the summer it is different because it's lighter at night so they can play out like skipping, running around. My boys play football but in the winter it is cold, wet and dark….. Summer is different because you know it is not getting darker'* (PG1)
Parental constraints	
Parental supervision outside	'*kids are limited because they are younger so they need supervision and they can't do things on their own'* (PG1) '*You cannot let them out by themselves …. Even though there are parks and shops just around the corner… But there isn't much they can do'* (PG1)
Won't let kids run around on the streets or park... youth centre ok.	'*I wouldn't let my kids run around on my street… I mean we say we are more protective with daughters but even my sons I would not let out. So it is your sons as well now. … As I said I let my son go to youth club erm on broad street but I wouldn't let him go to the park on his own'* (PG1)
Age differences	'*I wouldn't let my younger kids ... you know my 9 year old daughter or my 7 year old son I wouldn't let them out. But because he is a bit older and responsible (15 years)*' (PG1) '*I mean my oldest is only 6 so naturally I would go with him. Yeah but even if they are older you still have to take them with you. You can't allow them to walk down that street alone'* (PG2) '*You can't keep them locked up but you do have to be wary'* (PG1)
Nostalgia of how they were brought up in safer conditions	'You can't let your kids play out on the street like when we were young I lived in wood end; we were out all over the place. *We could go out at 6 o clock in the morning if we wanted to, come home at 6 o clock at night'* (PG2)
Barriers for parents	
Lack of energy	'*Sometimes you're ..... knackered when you get home from school'* (PG2)

Lack of time	*'Our kids are missing out because we haven't got the time. We have to go to work; you've got to do other things in the house. So the kids are missing out'* (PG2)
Overcoming parental constraints for playing outside	
Responsible adult with them	*'Obviously it would have to be a responsible parent, an older person not just another teenagers* '(PG1)
Well run	*'I wouldn't take my daughter anywhere unless there were proper people. You go and then you get all these big bullies and things like that and they take over it'* (PG2)
Cost	
Limited spare cash	*'I would love to take my daughter something like that [karate] ...But I have £7 left out of my wages, I can't do nothing with that. By the time I have paid my bills and everything else. What can I get my daughter for £7 from a youth club? You can't and no one else is going to help you'* (PG2 & PG3)
Costly when more than one child	*'But if you've got one child that's fine but when you have three or four or five* children' (PG2)
Work hard to afford activities/trips ...can't afford bills	*'All the activities at school, the trips and stuff like that. We have to work hard to pay for those trips. Yeah to pay to take them there....When the bills come in we haven't got the money to pay the bills because we are helping the children out to give them that experience'* (PG2)
Lack of free facilities in Coventry	*'And everything in Coventry costs. The only thing in Coventry that is free is Queen Mary's hall, car museum (because you only have to give the postcode), she's been to the cathedral, she has been to the car museum, and she's been to queen Mary's hall. I've run out of places now. So holidays come and they are bored. You don't want to take them up to the park because the big ones are sitting up there drinking, swearing, don't get me wrong I can swear as good as the next but I do not want my child hearing it when she is trying to play*' (PG2)
Maintenance of transport facilities (buses)	*'The buses are like tramps, it stinks, and then you get abuse or something.... it's pretty* poor' (PG2)
Supportive manager	'*He plays football with club. The manager comes to pick up my son. The training nights* everything' (PG3)
Why are some children less active	

Parental constraints on outdoor play because of safety	'*because their parents children don't let them out....because they are too scared'* (PG1)
Sedentary behaviour	*'some kids don't get as much activities they do as many activities they watch* TV' (PG1)
Parents work	*'Some parents work' (*PG1)
Mosque/homework limits time available on weekdays	*'Kids have to go mosque so by the time they have gone to mosque come home, done their homework it is bedtime. ......so no time to do any other activities apart from at the weekends'* (PG1)
Best way to get children active	
Activities in the house	*'Indoors in the house* ' (PG1)
Weekends	'*Weekend activities'* (PG1)
All activity at school	*'get as much as they can at school'* (PG1)
Space	'*All we need is space..... I would be happy to volunteer my* time' (PG1)
Sports centre/youth club	*'So it would be nice if you could drop them off at a centre or something....like a youth club or something. You would know that they are safe and that they are getting looked after; there are no drugs or drink. None of all the bad language of anything like that. ...They are safe. Yeah they are supervised'* (PG2)
Run by public services	*'If you've got authority there then the TA's, their doing nothing really. They can do a bit of training; they could come and do a youth thing. They stand in town you know what I mean. Do a bit of you thing, children. Get them into the army. Get them to learn respect. Discipline. Do you know what I mean? That is what is wrong with most of them. They haven't got any respect and they haven't got any discipline. They run the street like hooligans....There is not enough youth centres and authority to keep them under control'* (PG2)
Invest more money into school activities	*'Council are spending it here there and everywhere. Instead of giving it to the schools. If they gave the schools the activity. Yeah so they can give them some more activities'* (PG2)
Public services to visit school for role modelling	*'Then they should have like I just said TA come in, the police come in , you've got the territory army , the cadets , the police , the police service, the ambulance service, why can't they come in and encourage the kids to do something with their lives. Instead of walking around in town and getting money, so they can get the kids, given them that encouragement to get out*

	there and do it. Do you know what I mean? There is too many kids walking the streets, they have nothing to do and nowhere to go' (PG2)
Encouragement for children by:	
Rewards	'*Children need reward and stuff, something at the end of it'* (PG1)
Achievements	*'Achievement if they get something'* (PG1)
Working towards a goal	*'Working towards something, something at the end that they can be proud off... I don't think they will do it off their own back it's hard to get them motivated'* (PG1)
How to encourage parents to be active with children	
Encourage parents to take responsibility	'*You need to encourage parents to take some* responsibility' (PG1)
Get parents involved	*'You need to involve the parents somehow as well as if the child just comes home and says mum I want to do this it's not going to work. The parents need motivation as well. You know we will do this some type of* plan' (PG1)
Find out what they do and reach out to the parents that don't do things	'*Some parents probably are motivated and probably do a lot of activities. So some need more so maybe find out from the children themselves what activities they do and the ones that don't do things reach out to their parents '* (PG1)
More youth clubs for families: inclusive	*'I don't think we have many youth clubs or centres where families can go together I mean it seems focused on one age group. My son goes but the youngest child that can go is 10 or 11 til 16. ....Youth clubs for younger kids'* (PG1)
Activity centres	*'More activity centres that are well managed '* (PG1)
Well maintained	*'Parents could come or even having a coffee room next to the activity place so the parents could actually watch the kids so then they don't have to leave them'* (PG1)
Activity pack could do at home (indoor and outdoor)	*'You would try activities in your garden if you were given them. If they came home with a pack then you would do it. ..but If it was an outdoor pack then nobody would want to do it in the winter....It would be nice in the summer but not the winter'* (PG1)
Discipline issues in the community	'*We have a few discipline issues. People are brought up to do what they want, they want an easy life and there are no consequences. I see it in adults. Our mum and dads had authority. The population, kids are having kids, they have no authority themselves. The kids are growing up to kids you know what i mean. You have an 18 year old with a 2 or 3 year old*

	kid. Kids are having kids there is no authority there for the kids. SO if they have no authority then they will not give authority where as my mum and dad, they had to work they looked after us and we started. He kids these days are having kids though, they have no authority so what are they going to show their kids. They need authority and respect put into them nothing will come out if you don't put it in' (PG2)

APPENDIX V

Questions for post intervention interviews

TOPIC: Video

1. What did you think of the video?
Prompts: was it enjoyable? How could it be improved?

2. What can you remember from the video?
Prompts: did you understand what you had to do?

TOPIC: Walk to Weston

1. What can you tell me about walking to Weston?
2. How many steps a day did you need to achieve? Were you able to do this and how? Easy /hard
3. How did you change your behaviour to reach the targets? What days were harder to reach the target?
4. Recording steps and using the maps
5. The feedback
6. How could it be improved?
7. What was your best bit?
8. What did you think of the skipping rope? Did you use it? How often? Where and when? Do you still use it now?

TOPIC: science lessons
1. What did you do in lessons?
2. Did you like it?
3. What was your favourite bit?
4. Did you use any of what you learnt in lessons to make you more healthy or active i.e. change behaviour.

TOPIC: Afterschool sessions
1. What did you do in the after-school sessions?
2. What did you like the most? And why?
3. What would you change?
4. Would you attend more sessions if we held them?
5. What would you like to do?

TOPIC: Sustainability
Have you done any activity since the intervention? And what?
How could you use what you have learnt and done to get other people active and healthy?
Do you think you are healthier now?
If you could do this again would you and why?

APPENDIX VI

Descriptive variables from baseline to 6 weeks post by gender

	CONTROL BOYS		INTERVENTION BOYS		CONTROL GIRLS		INTERVENTION GIRLS		
	Baseline	post 6 weeks	Baseline	Post 6 weeks	Baseline	post 6 weeks	Baseline	Post 6 weeks	*P* for gender difference
PA (steps/day)									
Daily PA*	12319 ± 4485	9766 ± 9237	8769 ± 4531	18231 ± 9337	8639 ± 4106	8952 ± 8459	6922 ± 4235	14847 ± 8725	0.772
Week PA*	13659 ± 5253	7620 ± 9089	9685 ± 5310	19052 ± 9192	9426 ± 4809	7392 ± 8325	7533 ± 4960	15753 ± 8585	0.549
Weekend PA*	4028 ± 5336	16164 ± 9129	5058 ± 5082	16087 ± 7604	6512 ± 4362	16497 ± 11121	2812 ± 4980	10460 ± 7260	0.526
School PA*	6429 ± 4197	5421 ± 7449	4823 ± 4313	9976 ± 7659	5417 ± 3854	4605 ± 6839	4608 ± 4110	7830 ± 7290	0.592
Afterschool PA*	10914 ± 5977	5985 ± 6385	9623 ± 4916	12159 ± 6189	7140 ± 4928	6533 ± 6202	7171 ± 4610	9388 ± 5800	0.197
Body Fat									
BMI (kg/m^2)	22.73 ± 7.10	18.62 ± 4.54	17.86 ± 6.29	17.62 ± 9.46	17.62 ± 6.80	17.66 ± 4.62	17.68 ± 6.19	17.48 ± 4.18	0.06
BMI SDS	0.50 ± 1.40	0.54 ± 1.47	0.59 ± 1.31	0.41 ± 1.38	-0.41 ± 1.42	-0.49 ± 1.49	0.07 ± 1.29	-0.09 ± 1.35	0.61
WC (cm)	62.51 ± 12.48	66.50 ± 11.25	64.69 ± 11.69	60.35 ± 10.53	64.83 ± 12.66	65.61 ± 11.42	61.55 ± 11.48	57.32 ± 10.37	0.29
WC SDS	0.97 ± 1.55	0.79 ± 1.51	1.20 ± 0.38	0.28 ± 1.41	0.75 ± 1.57	0.71 ± 1.53	0.43 ± 1.42	-0.31 ± 1.39	0.58
Body fat (%)	21.08 ± 9.27	19.61 ± 9.16	22.28 ± 8.68	17.40 ± 8.57	22.37 ± 9.40	21.66 ± 9.28	22.41 ± 8.52	18.38 ± 8.41	0.52

Mean ± SD, * Adjusted for baseline BMI Z-score

Abbreviations: BMI- body mass index**, CI –** confidence interval, **PA –** physical activity, **WC** – waist circumference

APPENDIX VII

Mean change, 95% CI of differences and effect sizes by group and gender from baseline to post 6-weeks

	BOYS CONTROL	BOYS INTERVENTION			GIRLS CONTROL	GIRLS INTERVENTION		
	mean change from baseline to post 6 weeks	**mean change from baseline to post 6 weeks**	**CI of difference between group and gender boys**	**Effect size boys**	**mean change from baseline to post 6 weeks**	**mean change from baseline to post 6 weeks**	**CI of difference between groups and gender girls.**	**Effect size girls**
PA (steps/day)								
Daily PA*	-2553 ± 6908	9462 ± 6472	7459, 16497	1.73	313 ± 3689	7925 ± 4191	5124, 10099	2.06
Week PA*	-6039 ± 8654	9367 ± 5818	10730, 20081	1.78	-2034 ± 5296	8220 ± 4440	7381, 13127	1.94
Weekend PA*	12136 ± 12561	11029 ± 10677	-8858, 6594	-0.09	9985 ± 8629	7648 ± 8326	-7570, 2896	-0.27
School PA*	-1008 ± 3807	5153 ± 5271	2842, 9476	1.62	812 ± 2403	3222 ± 3379	516, 4304	1
Afterschool PA*	-4929 ± 7970	2536 ± 10421	-13491, -1439	-0.72	-607 ± 3966	2217 ± 4368	206, 5443	0.71
Body Fat								
BMI (kg/m^2)	-4.11 ± 1.28	-0.24 ± 0.82	3.19, 4.55	3.02	0.04 ± 0.48	-0.2 ± 0.99	-0.76, 0.28	-0.5
BMI SDS	0.04 ± 0.49	-0.18 ± 0.45	-0.54, 0.10	-0.45	-0.08 ± 0.05	-0.6 ± 0.37	-0.70, -0.34	-10.4
WC (cm)	3.99 ± 3.87	-4.34 ± 2.97	-10.57, -6.09	-2.15	0.78 ± 3.19	-4.23 ± 5.59	-8.01, -2.01	-1.57
WC SDS	-0.18 ± 0.58	-0.92 ± 0.6	-1.15, -0.33	-1.28	-0.04 ± 0.58	-0.74 ± 1.29	-1.37, -0.03	-1.21
Body fat (%)	-1.47 ± 3.37	-4.88 ± 5.54	-6.80, -0.02	-1.01	-0.71 ± 1.51	-4.03 ± 2.87	2.01, 4.63	1.16

Mean ± SD, * Adjusted for baseline BMI Z-score

Abbreviations: BMI- body mass index**, CI –** confidence interval, **PA –** physical activity, **WC** – waist circumference

APPENDIX VIII

Qualitative feedback on the intervention about the challenge

Thoughts on the video

OVERARCHING THEMES	**Group 1: low activity group (n = 6)**	**Group 2: Average activity group (n = 6)**	**Group 3: high activity group (n = 6)**
	3 boys, 3 girls	3 boys, 3 girls	3 boys, 3 girls
Thoughts about the video: presenting the project and pedometer challenge			
PSYCHOLOGICAL			
Funny	*'it was quite funny' (B)* *'PE teacher was dancing' (A)*	*'It was quite funny and made us curious about what we were going to do …so many people were dressed up and they were doing exercise and stuff' (G)*	
Exciting	*'no, it got us excited' (A)* *'Some people got really excited, they were like, I want my pedometer now so I can do loads of steps' (G).*		*'because it made us more excited and wanted to do it more' (B)*
Good/enjoyable	*'That was good' (A)*	*'It was awesome' (B).*	*'I liked it '(A), 'Good' (A)*
EDUCATION			
Activity statistics	*'at the park no one was there so you was saying that some parents don't keep their parents healthy ' (G)* *'I think you were saying that something like 75% of the parents were not healthy '(B)* *'and one out of 5 people don't eat their fruit and vegetables a day' (B)*		*'the way you included the statistics, it made us do more because they were shocking' (B)*
Range of activities			*'It shows you a range of activities that you can do' (B)*

ROLE MODELLING			
Positive role modelling			*'it showed us what other people were doing and why it was good for us' (G)* *'David Beckham' (G)* *'I liked it because its shows you other people doing exercise and if we exercise more we will show people that they can exercise as well '(G)*
IMPROVEMENTS			
More information about fitness and diet			*'yes add more fitness things and tell them to do it' (B)* *'you could include about food… healthy foods to eat, food groups' (g)*
Slow some bits down		*'I didn't like it because I thought it was a bit confusing' (l26-b)… 'When you were jumping over those yellow things, [hurdles] you were too fast and it was confusing because I couldn't see what the shapes were and how you were jumping over it like hopping (l26-32-b)*	
No music when text		*'The music, it was annoying because I was watching the TV' (B)* *' no, need to make it more ' (B)* *'music in the parts where you not looking at stuff, like watching something and then hearing it' (B)* *'On the slide shows, like over the pictures' (ALL)*	
UNDERSTAND PURPOSE OF THE VIDEO			
Walk to Weston Super Mare	*'to make it to Weston Super Mare and back in 6 weeks' (ALL)* *'18,000 steps a day' (ALL)*	*'And asking us to do enough steps to walk to Weston Super Mare and back'.... (B, ALL)* *'18,000 a day '(ALL) '6 weeks' (G).*	*'We had to walk to Weston '(ALL)*
After-school clubs		*'It was asking us to come to the club and to do more steps' (B)*	

Qualitative responses about the pedometer challenge
Pedometer challenge – virtual walk to Weston

OVERARCHING THEMES	**Group 1: low activity group (n = 6)**	**Group 2: Average activity group (n = 6)**	**Group 3: high activity group (n = 6)**
	3 boys, 3 girls	3 boys, 3 girls	3 boys, 3 girls
DIFFICULTY Easy	*6/6* *'because children are more active' (G)*	*4/6*	*0/6*
Children are more active	*'because children go to school so they get the whole playground so its not like parents'(G)*		
School environment	*'I thought it was quite easy because you have to walk to school' (B)*		
Home environment	*'yeah and at home you just run around and you've got to do all the housework and helping my mum' (G)* *'I think it was pretty easy because really I am out til around 7 or 8 o clock at night playing' (B)*		
Hard	*0/6*		
Impossible		*2/6*	*6/6*
Negative feelings about their ability		*'I didn't think it was easy because I don't actually walk that much' (G)* *'At first I thought it was going to be really hard, but the first week I didn't do 18,000 each day but by the second week I was doing it. It got easier' (B)*	*'I actually thought that it was impossible to do' (ALL)* *'I thought it would take a long time and be really tricky' (G)* *'You know I thought that because we had to do 18,000 steps a day, I thought we wouldn't be able to do that' (G).*

BEHAVIOUR CHANGE: TO MEET TARGETS			*'But then in the end I got to Weston super mare and back' (A)'and I went further' (G)*
More active general daily behaviour			
Walking for transport	*'Just walking around and stuff' (G)*	*'Like everyday walking to the park' (B)*	
Free play i.e. Skipping, jumping on the Trampoline, bike riding, running, playing	*'skipping' (B)* *'jumping on the trampoline' (B)* *'yeah the trampoline, because it keeps on going up and down, so you get lots of steps '(G)* *'yeah the thing is you have the housework, that's not exactly a good thing but in my garden I have a trampoline, so I have that, and I was skipping out there as well as doing it inside. I have to jump around and that ' (G)* *'got one and we go to her dads house as well (my cousin) and he's got one and we jump around' (G)* *'riding my bike' (B)*	*'skipping, doing curve balls' (A)*	*'I did it with like more exercising, skipping and that in the day. I didn't recognise that I was doing so much' (B)* *'mostly running and playing' (B)*
Sport specific activities		*'I carried on playing cricket non-stop' (B)* *'Football' (B)*	
More active School behaviour walk to school		*'I use to walk to school' (G)*	
lunchtime		*'if you came at lunch or play anytime the whole school at the moment would be skipping' (B)*	*'But at because at lunch times we would do more things, we managed to get more than' 18,000' (G)*

Active free play			*'mostly from skipping and running, skipping' (B/G, 3/6)*
Outside of school			
Engage in more active free play	*'We did more things out of school' 6/6*		*'outside of school I took part in some activities, so then I would get even more steps as well' (G)*
Less sedentary and more active	*'But it was quite hard because you couldn't do your general stuff you do like watching TV' (G)* *'yeah watching TV and reading books ' (G)* *'Yeah it's not like that, you're not meant to just sit on the sofa. You have to actually do it and play'(G)*		*'Instead of watching TV I went outside and did more sports' (G)* *'I did skipping, it got our muscles going and more active because before I use to watch TV and play games' (G)*
Family activities Activities outdoors (park)	*'I go with my family sometimes for walks. Saturday and Sunday we just got for walks, Webstar park, or sometimes we go anywhere else' (G)* *'Yeah I went to this place, it was a country park and it had like a spreaded field and play and we took balls and everything. SO, In the hockey bit there was a play area and everyone enjoyed it because we had lots of space to do everything' (G)*	*'My cousin every Friday, Saturday and Sunday, goes over to his dads house and we will go to the park and run around the massive field at the park, about 5 times'(B)*	*'me and my brother when we come back from mosque we like do lots of exercise, first we play on our bikes, then we play football, then we go to the local park and play football there. We race and challenge each other' (B)*
Friends activities Outdoors (walk and bike races)	*'Me and my friend went to walk to the park and play there for at least 4 hours, then we walk back, took a rest and then to this place called munchbosters and he made us salad' (B)* *'me and my friend did that 12 mile walk' (B)*		*'Before I use to stay inside all the time but now i go outside and challenge my friends to races, bike races and other stuff as well' (G)*

SKIPPING ROPES Use of skipping ropes	*'skipping ropes they were the main thing '(3/6 G)* *I use it about 4 times a day for at least half an hour (l69-B) once a day (l170-B)*	*'Used them a lot' (A) 'everyday' (B)*	
Mastery of skipping for boys	*'the girls were going a bit crazy with the skipping rope' (G)* *'none of the boys did as much as much as the girls did. We did do it a lot but not as much as the girls' (B)* *'because not many of the boys knew how to skip, only 6 of the boys in class knew how to skip' (B)* *'but by learning with you, we learnt forward skip, backwards skip, crossover etc' (G). 'then more boys skipped' (3/6 G)* *'yeah when they taught people how to skip, they skipped more and they got faster and faster every day…' (3/6 B)* *'they [GIRLS] skipped more' (3/6 B)* *I learnt skipping when I was 6 so it was actually really fun for me because I really enjoyed skipping (G)*	*'I tried to do skipping but I could hardly do it..then I learnt how to do it' (B)*	
School environment			
Break periods		*'at lunchtime' (6/6)* *'if you came at lunch or play anytime the whole school at the moment would be skipping' (B)*	
equipment			*'and we have more long ropes and people jump in, more people jump in now at lunch, and school brought loads so there is lots of people doing it now' (B)*
social skipping		*'skipping at school because I get to skip with my friends' (G)*	

mastery of skills	*'Fun' (6/6), 'it was fun because I knew how to skip after about 2 weeks' (B) 'I really enjoyed skipping '(B)*	*'school because you can learn more tricks in school' (B)* *'tried to do skipping but I could hardly do it..then I learnt how to do it' (B)*	*'I learnt kriss kross' (B)* *'I learnt backwards' (G)* *'some people in our class didn't know how to skip but they have learnt now, so they join in with skipping now' (G)*
Outside of school Home (indoors)		*'Skipped indoor' (A)*	*'skipping indoors' (A)* *'you know that skipping rope you gave us, the free one I would go up to my bedroom and I was skipping' (B)*
Home (outdoors)	*'I use it, because I was in the garden and everyone else was inside, so for about 2 to 3 hours at least' (G)*	*'I skipped in my garden' (G)*	*'skipping outdoors' (A)*
Social skipping at home outdoors	*'if you have your skipping rope you can teach your brothers and sisters. My brother he is in year 2 and he didn't know how to skip, now he can do it with me so it's like double and we can do criss crossing and backwards, and it's so cool because before I didn't have someone to say to skip with me, but now they can. I have my little sister in nursery and she can do at least 4 skips without stopping, so she is learning. Yeah fantastic' (G)*	*'I liked skipping at home in the front garden because my friend she lives next to me and she comes around and we play' (G)*	
Local park		*'at the local park '(3/6 B)*	
PEDOMETERS Lost	*'yeah I didn't like using the pedometer because it kept falling off and I thought OMG I have been so many places I don't know where it has gone. So I didn't know what number to write down until I had found it, because it recorded the steps in the memory, so you could just write it in there' (G)*		

Useful	*6/6*	*6/6*	*'The pedometers were useful '(B)* *'I liked the memory button as well because you could see what you had done' (B)*
MAPS			
Easy to use	*6/6*	*6/6* *'it was easy because it had 9 o clock and 3 o clock on it, so you knew when to record it' (G)* *'I found it easy because we just had to write a few numbers' (B)* *'I found it easy because all you had to do was open your pedometer, look what was there and write it' (B)*	*6/6* *'*
Feedback			
Positive feedback about steps (daily steps, weekly steps and improvements)	*'I liked the comments part because then you told us how many steps we did and overall how many steps, so we knew whether we made it or not. I made it the week before the last, so on week 5 I made it to Weston supermare '(G)*	*'Helpful' (6/6)* *'because it tells us.. yeah it tells us, you told us how much steps we got everyday '(B)* *'yeah it told us how many steps we got. So we know what we can beat next' (B)* *'We got some stickers if you do good steps' (G)*	*Yeah we looked at the steps in our maps and we could then improve the next day and we thought about how we could improve them' (B)* *'and also I like the comments box, I like when you write how many steps we did and the comments I liked that '(B)* *yeah and at the end of the week you tell us how many , yeah and how much we had improved, you've done this and really improved. (l142-143) 2/6-b.g*
Positive feedback about location and distance		*'the map shows you exactly where you are so you know how long you have to go to get to the next location' (B)* *'its like you know where you are on the map and you just have to aim for what you need to do and the paper is already set up for it…' (G)*	*'it was quite useful because where you are and how many more miles you have to go' (G)* *'I liked it when you wrote how many miles we had walked so far ' (G)* *'Because you think you've walked a lo't (B)*
Improvements			
childrens comments box	*'yeah we could do comments where we could say yeah I really enjoyed It and it rained so I couldn't go out, something like that '(G, ALL)*		

new destination (another country and longer)	*'Manchester or Pakistan or something twin lakes' (B)* *'Pakistan is quite far' (G)* *'you could do another country and do it for 12 weeks' (B)*	*'to nicolodeon land or Russia and china' (B)* *America' (G), 'Hollywood' (B)*, space (B) *'everywhere' (G)*	*'Somewhere longer…another country' (B)* *'Or to Dover or Ireland' (B)* *'We could have how much we can walk around the globe' (G)*
'Go there for real''	*'we could do it over 3 terms'(B)* *'yeah if we did that then our families would let us go because we would have an opportunity to see the every country and how their life is' (G)* *'yeah and how they exercise'(B)* *'we could actually go there at the end '(B)*	*'Miss how come we didn't go to Weston instead of virtually, can we go their for real (B) go on a bus if we did the steps here then we could have visted there' (A)*	

Qualitative feedback on curriculum lessons

OVERARCHING THEMES	Group 1: low activity group (n = 6) 3 boys, 3 girls	Group 2: Average activity group (n = 6) 3 boys, 3 girls	Group 3: high activity group (n = 6) 3 boys, 3 girls
CURRICULUM LESSONS			
Fun	*'that was really fun' (G)*	*'yeah it was fun' (5/6)* *'I liked it because it was fun and we got to come outside and act it out' (G)*	
useful	*'it was useful' (All)*	*'I thought it was interesting because we got to learn more about our lungs' (B)*	*'I think they were really useful' (B)*
increased learning	*'we learnt a lot' (l223-b)* *'the teachers they teach us but you're a bit of a professional or something, so it helped us to learn a bit more than the teachers' (G)*	*'yeah in science, it was very good because I learnt how much more you can breathe when you are exercising and how hard your lungs work to make you exercise' (B)*	*'You learnt a lot from them. Before the school didn't focus much on science but now since we've done that, it's really interesting science because when you say science people say yeah, but people like really get into it' (B)* *'Before you came in we didn't much do them, we did it like once a week, and now we do them 3 times a week, a lot of experiments and new learning. We focus on one topic for 2 weeks, then another for 2 weeks, that means we learn a lot' (B, ALL)*
Experiments			*'and I think for science we should improve having tests (experiments – in future' (B)* *Interesting because….* *'coming and doing the experiments, the*

			fitness' (B)
Breathing and exercise	*'o yeah when I think it was [child's name] and [child's name], they had to put those masks on ' (G)* *'that was really fun' (G)* *'so that all the air could collect in their, it was quite amazing how much air you do in about 2 to 3 minutes' (G)*	*'breathe when you are exercising and how hard your lungs work to make you exercise'(B)*	*'that breathing machine, you know the bag (G) we were exercising and breathing into them and putting that thing around our mouth' (All)*
HR and PA	*'and we all put on our pedometers and we stayed out and and did non stop running' (B)* *'We found out that the more running you do the more beats you get from running. The pulse beat I got was over a hundred, which was a bit much but when you run a lot that's how many beats you get from the pulse.' (G)* *'We had to run from this pole to that pole, and we had to do it. We did it for 1 minute and then we had to check the pulse. Then we had to get back to the resting pulse and we compared boy to girl and we found out that mine was higher. Childs name went down faster than mine '(G)*		
Video sessions			
making a video to get others active	*'we did some statistics that you did, so we were in groups and it was not like higher to lower, it was mixed up so we had to*		*showing us the shocking results , I was like I need to get fitter (G)*

	work with them and made a video., the one we showed you. We found it quite exciting to get to go out and try out what you have been learning, some statistics, so we could go anywhere in the school, the field anywhere but the thing is we learnt a lot with you. Because it helped us wit our future as well because if we have a drug we will know what to do now. '(G) *'the acting as well it was really cool and we had to do where [child's name] was sitting on the sofa, eating and everything and I was saying you will die earlier if you eat too much fat. '(G)*	
The heart		*'also learning about the heart, that one side is oxygenated and the other side is deoxygenated' (B)* *'and has carbon dioxide, yeah about your heart, that you should look after it' (G)* *'and about the beats per minute, the average (B)* *pulse '(G)* *'and that you should exercise more' (G)*
Healthy and unhealthy drugs	*'it was important learning about why you shouldn't do drugs and stuff' (G)* *yeah we did a drugs lesson and that was good I like that because your not meant to tell the younger ones because they wont understand it and they will go and tell the*	

	'teachers' (G) *'yeah if you have too much of something then you will die and get ill, so you should learn about that because you will know when you get older' (G)* *'some people take it for stress' (B)* *'yeah we watched a programme about it '(G)*	

Qualitative feedback on afterschool sessions

OVERARCHING THEMES	**Group 1: low activity group (n = 6)**	**Group 2: Average activity group (n = 6)**	**Group 3: high activity group (n = 6)**
	3 boys, 3 girls	3 boys, 3 girls	3 boys, 3 girls
AFTERSCHOOL SESSION			
	5/6 attended , come again (6/6)	*5/6 Attended/come again*	*4/6 attended/come again (6/6)*
good work out	*'I really liked it because we did a lot of exercise' (B)* *'think it was fun '(B)*	*'it was brilliant' (B)* *'The amount of exercise that was done and that you get to do it with your friends '(B)*	*'the afterschool clubs helped us even more' (4/6)* *'it was a good work out , really fun and it helped us' (B)*
activities			
- penalty shout out	*'I liked doing the penalty shoot-out '(B)*		
- athletics	*'Running athletics' (B)*		
- playground games (dodgeball)		*'when we did the bulldog, we had to take other peoples bibs' (B)* *'yeah that was cool …and we had to count how many there were and some teams won' (B)* *'Playing games' (B)*	*'the strips and you had to get them off other people and the last one was the winner' 'dodgeball' (G)' that made us get the most steps because you had to run away from each other' (B)* *'I liked the game where you had to get the balls and bring them back.. and the team that brings them all back wins and dodgeball as well' (G)*
- plyometric circuit			*'the ladders and the ones were there was the cones and the sticks.. . yeah they were really good for your legs and tired and do more and more and it makes them fitter' (B)*
improvements			
different venues (swimming centres)	*'yeah go to centres' (G)* *'yeah swimming centres' (B/G)*		

	'no we could have it in school sometimes but we should do different activities and different placesG (B) swimming because swimming is a life skill '(G)		
different activity (use bmx track and bike at school)			*'the school has bikes and we don't use them that much because the school we have a shed there, and there are lots of bikes like 10 or 20, that [teachers name] brought for us and I think we should be using them '(B) 'we have BMX track that we never use' (G)*
lunchtime			*'because we can't do them at school maybe lunch because more people will come, yeah like loads of people, should be year 4, 5, and 6' (l130-131-b)*
mosque		*if I am 1 second late then I will get a detention (l189-b) I have to be at mosque for 4 o clock (ll20-b) I have to be at mosque for 4:30 and I go there for 2 hours (l201-b) I go there until 8 o clock(l202-b) 5 o clock until 7 o clock (l203-g) 5 til 7(l204-b)*	
club longer and more often		*more time for the sessions, make it one hour (l196-b)*	*that the clubs should be longer and twice a week (l253-b)*
Sports day			*we should have one day of lots of sports, normally we have sports day (25 yeah we should do a whole day of sports and all of the activities (l256-b) for sports day we only have it once a year, so we don't get to do it much*

			(l257-g)
MOTIVATORS ***Teachers*** *PE/ lesson time*	*'because in lesson time when we had the pedometers and ropes' (G)*	*'in PE they made us do like more exercise, so they made us play cricket to make our body more move' (B)*	*'they did skipping sessions in the afternoon '(G)* *'teachers made us sit down and look at them, one day we done better at that and why? At first we were getting like just getting 400 and then after we were doing more like 3000 an it was a lot' (B)*
Doing exercise with the children 'exercising together'	*'[teachers name] after lunch we had to skip for at least 15 minutes, so if we maintained that then that would be really good' (G)*	*'[teachers name] was doing it too as well as making us exercise we were making him exercise. '(B)*	
Goal setting			*'they told us to skip more, and that would be more steps and you will pass everyone else. That made me think o let me pass them, let me pass them. O we should really do this again '(B)*
Dinner ladies	*'we do it with our dinner ladies, we have the long ropes out everyday* *And we see how many jumps we can do, yeah it is really good now' (G)*		
Extrinsic rewards *Class trophy for most steps*			*'and the class that did the most steps gota trophy. SO it was more than just being active for ourselves, we were working as a team as well' (B)*
Best effort trophy each week for activity club			*'we got two trophies and it was good'.(B)' it was encouraging us to get more fit so we could get the trophy.' (G)*

Qualitative feedback on sustaining PA

OVERARCHING THEMES	Group 1: low activity group (n = 6) 3 boys, 3 girls	Group 2: Average activity group (n = 6) 3 boys, 3 girls	Group 3: high activity group (n = 6) 3 boys, 3 girls
SUSTAINING PA			
More active now	***6/6*** *'everyone is more active now'.*	*6/6*	***6/6***
Change from sedentary activities to active	*'yeah I have changed a lot we don't watch TV that much …so what I did was I told my cousins to come outside… I made them come outside and I made this obstacle thing that they had to run and jump over. It was really fun'(G)* *'I spent at least half of my day watching TV and so half of the day nothing, so I have stopped the nothing bit'. (G)*		
Free play (running, skipping)		*'we carried on doing skipping challenges' (B)*	*'we do more exercise, before we didn't do much but now we do a lot more' (B)* *' more running' (G)*
Walking			*'I go and do a lot of walking with my cousin near Bedworth we ddnt go much in the car anymore. We walk to school but on the way back we go in the car '(B)* *'most Friday I try and walk with my sister really far and one day we walked to Bedford.' (G)*
Park		*'I've carried on, I still every Saturday and Sunday go to the park, do about 5 laps' (B)*	*'most nights I go to the park by school and I walk around there and play '(B)*

garden			'go to the park' (B) 'mostly at the weekends I go in the garden, run around and play sports games'. (G)
Sports		'we have done more sports' (B)	'every Friday I will do tennis or rounders
Weather Play outside til later	*'because the weather has got better sometimes I will ride my bike to school an since the weather has picked up I stay out later at night' (All))*		
Family activies (park or garden)	*'yeah what I did with my parents is we were going to go Webster park and the my family were a bit behind than me and my cousin, so we kept chasing each other around '(G)*	*'Me and my dad started going in the garden more' (B)*	
Friends activities		*'i walk more with my friends, we usually walk '(B)*	*'or cricket or go to park with my other friends and do lots of games' (l221-22-g)*
Some not as active as before	*'Some of them stopped doing it. Some people in the class has got less active [childs name] when we was doing the skipping and that he realised he wasn't a good skipper, but after 3 weeks he got really good and really fast at skipping then the term finished and he stopped' (B)*		
School environment		*6/6*	*6/6*
Teachers don't come out and do it with us anymore	*'because most of the teachers don't come out and actually do this with us anymore' (B)* *'Thing is we want a teacher to do it with us at least once a week or something'(G)*		

Dinner ladies	*'we do it with our dinner ladies, we have the long ropes out everyday..And we see how many jumps we can do, yeah it is really good now' (G)* *'yeah we do who can stay in the rope the longest '(G)*		
Healthier ***Weight loss***	*6/6*		
Still use skipping rope	*6/6*	*6/6* *I've lost like 5kg because I was sweating (B) and we did lots of running (B)*	*6/6*
Impact on others			
Family members (brothers, cousins, friends)	*'my cousins and my brother because I told him if he is going to sit inside and eat loads then he is going to be lazy and he will die earlier and he said I don't want to die earlier, so I told him to walk more and now he does' (G)* *'my cousin and my brother because they use to play the xbox too much and now I play outside so I told them to play and then they did play and we played cricket all the time and football '(B)*	*6/6*	*6/6*
Community (make posters around the school, run activities)			*'We should use the statistics and make them do it, since we've been doing it it's made a lot of improvements in life. For fat people it is bad for them and can kill them'. (B)* *'also we could like as a class, we could make different activities at the park for people to come.' (G)* *'we could do posters around the school to encourage people' (G).*
Do it again	*6/6*	***6/6*** *I loved it (B), It was fun (B)*	*6/6*