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Children’s active school travel: The effect of a school-based intervention and an investigation of psychological predictors

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This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed: *Date:*

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'Trust in the Lord with all thine heart; and lean not unto thine own understanding. In all thy ways acknowledge him, and he shall direct thy paths.'

Proverbs 3: 5-6

Abstract

Background: Studies are needed that rigorously evaluate active travel interventions using objective physical activity outcome measures. Additionally, little is known about the psychological predictors of children's school travel behaviour. Increased understanding in these two areas will aid in the promotion of active school travel.
Purpose: This thesis reports the rationale, methods, and results for an evaluation of the Travelling Green intervention and identifies important psychological predictors of children's school travel behaviour.
Method: Participants were 166 children (age 8-9 years, 60% male) from five Scottish primary schools and 143 parents (mean age 40, 13% male). Children's school travel behaviour was measured across 5 days pre- and post-intervention using accelerometers. Children and parents completed a travel questionnaire that gathered data on various aspects of and attitudes towards walking to school. The questionnaire also generated data on psychological factors (self-efficacy and outcome expectations) related to school travel. A quasi-experimental design with an intervention (n = 79) and comparison (n = 87) group was used to investigate the effects of Travelling Green on commuting behaviour. Baseline cross-sectional data were used to identify the psychological predictors of walking to school. **Results:** Commuting-related physical activity decreased from pre- to post-intervention in the intervention and comparison groups. Daily physical activity decreased less in the intervention group compared to the comparison group. Parental self-efficacy for their child's ability to carry out commuting-related tasks was the only psychological predictor of commuting behaviour. Parents were the primary decision makers regarding their child's travel mode. **Conclusion:** Travelling Green does not result in an increase in school travel-related physical activity, but may attenuate a seasonally-related decrease in daily physical activity levels in 8-9 year old children. School travel interventions should be focused on parents of younger children as they are the gatekeepers of their child's behaviour at this age. Alternatively, interventions should be developed for older children who have the autonomy to change their travel behaviours.

Contents

List of Appendices

List of tables

List of figures

Chapter 1

Introduction

Physical activity has been defined as 'any bodily movement produced by skeletal muscles that results in caloric expenditure' (Caspersen, Powell, & Christenson, 1985, p.126). Activities that fall into this category include walking the dog, gardening, playing in the park, cycling to work, and washing the car. The causal links between regular physical activity and health benefits are well established (Blair, Cheng, & Holder, 2001). In contrast, physical inactivity and sedentary behaviour have been shown to increase the risk of several health threatening conditions including obesity, diabetes, and cancer (Blair & Brodny, 1999; Vuori, 2004). It is known that physical activity behaviours may track from childhood into adulthood (Malina, 2001), and so it is important to encourage healthy behaviours from a young age. Furthermore, there are various additional benefits to children from participating in regular activity including reduced risk of metabolic syndrome (Kelishadi, et al., 2007), increased bone mineral density (McKay, et al., 2000), and reductions in various cardio vascular risk factors (Meyer, Kundt, Lenschow, Schuff-Werner, & Kienast, 2006).

Walking to school has been identified as a key opportunity to promote physical activity in children (Tudor-Locke, Ainsworth, & Popkin, 2001), and it has been shown that children who walk to school achieve more physical activity than those who travel inactively (Cooper, Page, Wheeler, Griew, et al., 2010; Ford, Bailey, Coleman, Woolf-May, & Swaine, 2007). Despite this knowledge, rates of walking to school have declined over the past 40 years in a number of developed countries, whilst rates of inactive commuting have increased (Grize, Bringolf-Isler, Martin, & Braun-Fahrlander, 2010; McDonald, 2007; van der Ploeg, Merom, Corpuz, & Bauman, 2008).

Several interventions have been designed in an effort to reverse these trends. Examples include the introduction of school travel coordinators (Ward, et al., 2007), walking buses (Collins & Kearns, 2010), safe routes to school programmes (Staunton, Hubsmith, & Kallins, 2003), and changes to the physical environment surrounding the school (Boarnet, Anderson, Day, McMillan, & Alfonzo, 2005). These interventions have achieved varying degrees of success (Davison, Werder, & Lawson, 2008).

Travelling Green is a primary school based intervention that has been implemented in Scotland in an attempt to increase walking to school among children aged 8 and 9 (i.e. children in primary 5). The intervention lasts for six weeks and is comprised of teacher-led curricular lessons covering various health-related issues, and goal setting exercises where children aim to walk to school a little more on each week of the project. A small scale evaluation of Travelling Green found that children who took part in the project increased the mean self-reported distance travelled by active modes following the intervention (389% increase) whilst children in the control school only changed marginally (17% increase) (McKee, Mutrie, Crawford, & Green, 2007). Furthermore, a large proportion of children in the intervention school moved to a higher commuting-related 'stage of behavioural change' (Prochaska & DiClemente, 1983) after taking part in the project. Despite these positive results, the study conducted by McKee et al. (2007) was relatively small (n = 31 intervention and n = 29 control) and used self-reported distance travelled by mode as the outcome measure. Additionally, there were no follow-up measures to determine if the intervention had any lasting effect on travel behaviour. The first aim of this thesis therefore, is to conduct a more robust evaluation of Travelling Green, addressing the identified limitations by using objectively measured physical activity as the outcome and by using a larger sample. Investigation of the long term effect of Travelling Green is outside the scope of this thesis.

In addition to the need for a more robust evaluation of Travelling Green, it has been suggested that more work is needed to understand the correlates of active commuting to school (Davison, et al., 2008). Most studies to date have investigated demographic and environmental correlates; however there is a gap in the literature regarding the role that psychological variables play in children's school travel behaviour. It is also unclear whether parent or child psychological variables have more bearing on a child's travel behaviour. The second aim of this thesis, therefore, is to address this gap in the literature by investigating the psychological predictors of children's active travel, using Social Cognitive theory and a recently developed conceptual framework (Panter 2008) to guide the study. This thesis also investigates the relative importance of parent and child psychological variables, and determines whether the parent or child is the main decision maker regarding mode of school travel.

1.1 Epistemological Stance of the study

Epistemology, from the Greek word episteme, meaning knowledge, is a philosophical branch concerned with the origins and nature of knowledge. Qualitative and quantitative research paradigms exemplify different epistemological views on the nature of knowledge and truth; therefore researchers in each paradigm operate under different epistemological assumptions. These assumptions affect the way research is conducted in terms of study design, data collection techniques, and the interpretation of data. The following section gives a brief overview of these paradigms and justifies the research approach taken in this study.

The qualitative paradigm, also known as the interpretive paradigm, holds that there is not a single measurable 'truth' or 'reality', but that each individual constructs their own reality based on life experiences and personal beliefs (Neuman, 2007). Qualitative researchers, therefore, seek a sympathetic understanding of the worldview of those they are studying. In doing so, they place little value on repeatability, causal explanations, or the generalisability of their results. Typical researcher techniques and data sources in this paradigm include case studies, observations, interviews, documents, and audiovisual materials, relying on text and image data over numerical data (Creswell, 2003).

The quantitative, or positivist, paradigm holds that there is a single reality constructed of independent facts that can be quantitatively measured (Guba & Lincoln, 1994). Researchers in this paradigm rely on the scientific method in their efforts to establish truth, with the aim of understanding the world sufficiently in order to predict and control certain events (Krauss, 2005). Emphasis is placed on the replication of results – with the belief that reality is better understood and knowledge is increased when different researchers following the same protocol independently achieve identical results (Neuman, 2007). In addition, quantitative researchers seek to generalise their findings from a sample to the wider population that the sample represents (Davies, 2007). The main study designs used by quantitative researchers are true experiments, quasi-experiments, and correlational studies. Complex multi-variable designs are also used to identify causal relationships and the collective strength of these variables (Creswell, 2003).

The main factor dictating the research approach used in this study is the research problem (purpose/questions). This study aims to objectively measure the effect of an intervention on commuting-related physical activity. The experimental design used in this study combined with the variables being measured necessitates the use of quantitative research methods. This is not to say that qualitative techniques could not be incorporated. For example, qualitative methods could generate data regarding participant, teacher, and parent experiences within the context of the intervention. Providing useful information to help understand why the intervention worked or did not work.

1.2 Theoretical Base: Social cognitive theory

Social Cognitive Theory (SCT) is the underlying psychological framework used to understand children's school travel behaviour in this study. This theory has been widely used in research examining different health behaviours, and has been used extensively in the field of physical activity for health (Dishman, et al., 2004; Griffin-Blake & DeJoy, 2006; Netz & Raviv, 2004; Petosa, Suminski, & Hortz, 2003; Ryan, 2005).

The person who developed SCT, Albert Bandura, stated that individuals are not viewed as being controlled by inner forces nor controlled by external forces (Bandura, 1986). Instead, human agency is explained using what has been called *the model of triadic reciprocality*. In this model, human functioning is explained in terms of reciprocal interaction in which 'internal personal factors in the form of cognitive, affective, and biological events; behaviour; and environmental events all operate as interacting determinants that influence one another bidirectionally' (Bandura, 1997, p.6). Put simply, the environment, the person, and the person's behaviour continuously change and simultaneously influence one another (Petosa, et al., 2003).

In addition to the model of triadic reciprocality, SCT posits five fundamental determinants that can be used to predict health behaviours. These determinants are *knowledge* of certain health risks and benefits of health behaviours; *perceived self-efficacy* for control over health behaviours; *outcome expectations* for the pros and cons of different health behaviours; *goals* and plans for achieving health benefits; and *perceived facilitators and impediments* for achieving changes in health behaviours.

Regarding knowledge, Bandura suggested that knowledge of the benefits of developing healthy lifestyle habits (e.g. walking to school) must be present before any change in behaviour can occur (Bandura, 2004). An individual is unlikely to change their lifestyle behaviours, particularly if the new behaviours seem labour intensive or uncomfortable, if they are unaware of the benefits of doing so. In a simplistic example, a child may be more inclined to walk to school if they are aware of the potential health benefits of doing so. Conversely, a child may be happy to be driven to school if they are unaware of the dangers of sedentary behaviours i.e. they lack the necessary knowledge to change their travel behaviours. Knowledge can therefore be viewed as a precondition to change.

Although knowledge must precede behaviour change, the act of changing one's behaviour for the purpose of achieving health benefits requires the individual to possess the *self-efficacy* (or confidence) to carry out the necessary actions required (Bandura, 1997). Self-efficacy is central to the theory of human motivation and action. If an individual is not confident that they can carry out certain actions to change their behaviour, there is little chance that the individual will indeed change their behaviour. Self-efficacy is not a general condition that one possesses, rather it relates to a specific task; an example is a school child's self-efficacy for crossing busy roads on their journey to school.

In addition to knowledge and self-efficacy, SCT postulates *outcome expectations* as a determinant of health behaviour. Outcome expectations refer to the anticipated consequences of performing certain actions (Bandura, 2004). These expectations fall into three categories (Bandura, 1997) and can be both positive and negative (Ryan, 2005), serving to encourage or discourage an individual from participating in certain activities. The first of these expectations are *physical outcomes* that include the positive and negative effects of the behaviour, and resultant material gains and losses (Bandura, 2004). Positive physical outcome expectancies that an individual may have for walking to school include improved heart and lung health. As mentioned, outcome expectancies may be negative as well as positive, for example getting sore feet from walking a long distance to school. The second set of outcomes is concerned with the *social reactions* that certain behaviours produce. For example, children may achieve peer approval (Ryan, 2005) if they begin to walk to school rather than be taken in the car and dropped off by a parent. The final set of outcomes is concerned with an individual's *self-evaluation* of the behaviours that they are carrying out. A person is more likely to engage in behaviours that result in personal satisfaction than engage in behaviours that result in personal dissatisfaction (Bandura, 2004). In the school travel setting this may translate to the gratifying sense of achievement a child may feel by walking to school independently of their parent for the first time. A negative example of this may be feelings of dissatisfaction when walking in bad weather, or being bullied on the way to school.

Goals are also determinants of behaviour, serving as self-incentives and guides to health behaviour (Bandura, 1997). SCT identifies two types of goals; distal and proximal (Bandura, 2004). Distal (or long term) goals encompass an individual's ultimate aim e.g. to travel to school actively every day next term. Proximal (or short term) goals provide a regulating and guiding role in an individual's present situation, helping them to achieve their distal goals. Proximal goals are necessary to provide an individual with progress feedback and motivation as they strive towards their ultimate goal. Achieving proximal goals along the way will make an individual more likely to achieve their distal goals. Goals are not 'simply a discrete predictor to be tacked on a conceptual model' (Bandura, 1998, p.7), rather they act as a motivational mechanism linked with self-monitoring and personal aspirations.

The final determinants within SCT are *perceived facilitators and social and structural impediments* to change. If there are no impediments for an individual to overcome then it will be easy for that individual to carry out healthy behaviours. If, however, there are several obstacles to overcome in order to carry out health behaviours e.g. long distance to school, parents drop child off at school on way to work etc., then that individual must possess the required self-efficacy in order to overcome those obstacles.

In this thesis the role of children's *self-efficacy* and *outcome expectations* are investigated as potential correlates of active school travel. In doing so, aspects of a novel theoretical framework (Panter, Jones, & van Sluijs, 2008) for the determinants of school travel in children will be tested. This model is described in more detail later in the thesis.

Chapter 2

Literature Review

2.1 History of School Travel Research

Despite a recent growth in school travel studies (Davison, et al., 2008), research in this field has been conducted for over 50 years. This section provides a brief history of how school travel came to be the highly researched topic it is today.

To the author's knowledge the first study resulting in a peer reviewed publication concerned with children's school travel was conducted in 1957 (Lee, 1957). This study assessed the relationship between the mode and length of school journeys and emotional adjustment in rural infant children. The results suggested that there was an association between long school journeys and maladjustment. Furthermore, children who travelled by inactive transportation (school bus, car) had higher levels of maladjustment compared with children who travelled by walking. This study provides a glimpse of what subsequent school travel studies would focus on, hinting at the themes of physical and psychological benefits of walking to school, the barrier of distance to active commuting, and the role of parental decision-making in children's school travel. These topics would become central to later works in the field of school travel research (Mackett, Lucas, Paskins, & Turbin, 2005; McDonald, 2008c; Nelson, Foley, O'Gorman, Moyna, & Woods, 2008).

The next school travel-related study to be conducted was concerned with children's independent mobility. The study assessed changing travel trends and parents' perceptions of danger between 1971 and 1990 in English and German schools (Hillman, Adams, & Whiteclegg, 1990). There were two main findings. First, in 1971, 80% of children aged 7 and 8 were allowed to travel to school without an adult. By 1990 this had dropped to 9%, suggesting a decrease in independent mobility had occurred. Second, parents' fears (e.g. traffic and molestation) were identified as major contributing factors to this restriction in children's independent mobility. Hillman et al. (1990) concluded that increases in road traffic only serve to exaggerate these fears, causing a further cycle of fear of traffic, leading to more children being taken by car.

The first study to consider the potential physical health benefits of walking to school was conducted by Sleap and Warburton (1993) following concerns that children were not participating in enough physical activity to reduce the risk of coronary heart disease. Data on school travel modes and distance to school were collected from children aged 4-11 years. The authors concluded that although more than half of participants (51.5%) walked to school every day, few children walked far enough to gain heart health benefits. The authors acknowledged however, that even small bouts of physical activity (such as a short walk to school) contribute to general wellbeing. Perhaps more importantly, the authors highlighted that these small contributions of physical activity are important for developing positive active lifestyle habits. Conversely, those children who are transported (driven) over short distances are reinforcing unhealthy inactive habits that may be detrimental in later life.

A study by Lee and Rowe (1994) investigated how a sample of primary school children's travel modes differed from how their parents travelled when they were at school. The study also explored a range of hazards that may act as deterrents to walking to school and the perceptions of these hazards by parents and children. Results indicated a marked decrease in walking to school and an increase in car and bus use across one generation. Parents perceived *risk of road traffic accidents* to be the most serious hazard of walking to school. Interestingly, children did not rank this highly as a risk. Overall, there was a low correlation between children's perceived risk and their actual experiences of hazards.

In a short letter to the British Medical Journal, Roberts (1996) concisely encompassed the concerns of the previously mentioned authors. Roberts highlighted that the journey to school accounts for a large proportion of children's daily trips, and has the potential to make a significant contribution to physical activity levels. Furthermore, Roberts pointed out that children's behaviours track from childhood into adulthood and that children who are driven to school cannot be expected to become 'the ambulant adults of tomorrow' (p.1229). Roberts' final observation was that a healthy transport policy would do more to promote physical activity than two hours of sport each week.

Finally, three studies conducted in the nineties investigated the reasons for choosing mode of school travel. Bradshaw (1995) found that car ownership and distance travelled were the main factors determining mode choice. In 1997 a study investigated the determinants of walking to school in Australian primary aged children (Carlin, et al., 1997). The strongest predictors of walking were attending a government school and number of cars owned. The following year a similar study was conducted in England (DiGuiseppi, Roberts, Li, & Allen, 1998). Greater distance to school, attending an independent school, car ownership, and parental worry about abduction were found to be the strongest predictors of car use. Interestingly, Carlin et al. found attending a government school and car ownership to be predictors of walking, and DiGuiseppi et al. found attending an independent school and car ownership to be strong predictors of car use. In all three studies distance was identified as one of the main factors determining mode choice.

The studies mentioned thus far were relatively unique when they were published and were the first to probe the topic of school travel. In particular, they began to investigate aspects related to modes of transport to school and the importance of walking. There are likely two reasons for this. First, in the past most children walked to school and few children travelled by car or bus. There was therefore little need to research this topic until trends began to shift towards an increase in journeys made by inactive modes. Second, compelling evidence has only relatively recently become available to show that health benefits can be achieved through moderate intensity activity such as walking (Blair, et al., 2001). Previously, it was believed that vigorous exercise was required to enhance health (American College of Sports Medicine, 1975). Furthermore, it is now known that various lifestyle activities (e.g. walking the dog, gardening, washing the car etc.) can improve health (Dunn, Andersen, & Jakicic, 1998). Walking to school is one such activity. As a result of this increased knowledge there has been an exponential increase in published articles relating to lifestyle activities, including school travel. To demonstrate this increase in published literature, the current author conducted a search for school travel related journal articles using electronic databases (Pub Med, SPORTS Discus, and Science Direct). The following search terms were used: (child* OR adolescent OR youth OR young people) AND (walking OR active travel OR active transport* OR cycling OR riding OR travel mode OR trip) AND (school). The author then searched his own collection of articles to identify any missed by the electronic search. Year of publication was identified for each article and the frequency of published articles per year was plotted on a histogram. Figure 2.1 illustrates the increase in the number of school travel related articles published in recent years. Articles identified at this stage were subsequently used to inform the rest of the literature review in this thesis. Additional relevant articles were identified as the current author read the articles that had been returned via the electronic search. It is acknowledged that this process is not strictly a systematic review, rather a structured and logical approach to identifying literature.

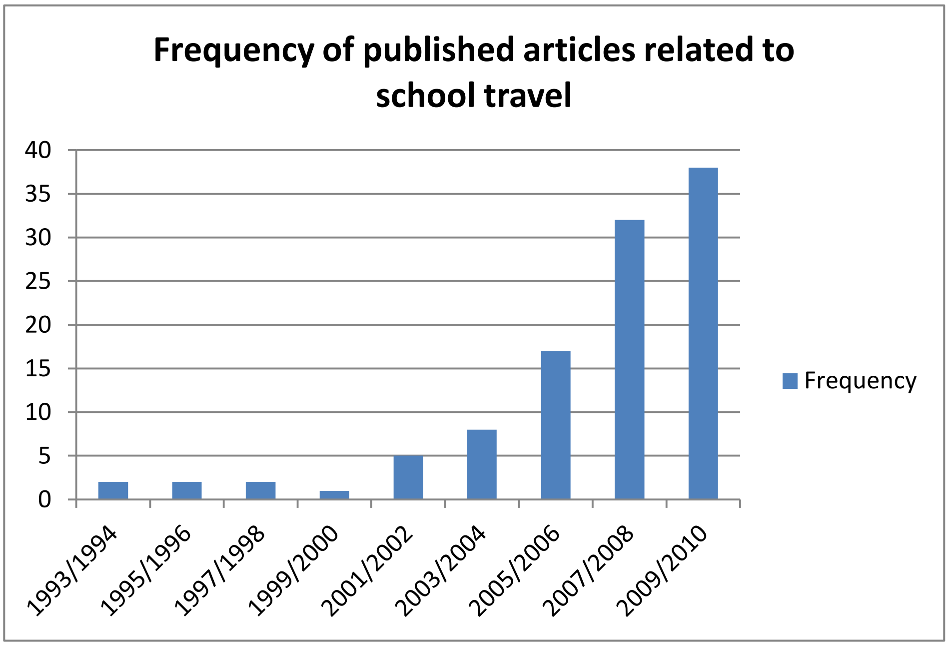

Figure 2.1. Frequency of published articles related to school travel over time

2.2 Trends in School Travel Modes

This section aims to identify current trends in school commuting modes, the most prevalent modes of transport, and where possible how these trends have changed over time. Participants in the present study are primary 5 aged children (aged 8 and 9 years) therefore information from the literature is concerned with primary school aged children. Studies concerning secondary school aged pupils are not dealt with in this review. A review of the secondary school travel literature is out-with the scope of this thesis. However, it should be noted that the factors influencing secondary school travel are likely very different to those affecting primary school travel. This is because those at secondary school are at a different stage in life (adolescence), will on average live farther from their school, and will have more autonomy over their behaviour than primary aged children. In the following section of the literature review international commuting trends are identified before focusing on Scottish travel trends.

Articles and reports from the school travel literature were searched for statistics on the prevalence of different modes of travel to school. Where the piece of literature was a national survey or report (e.g. the National Household Survey) the percentage of children who travelled by a particular mode (i.e. walk, car, cycle, bus/train) was identified and recorded. In peer reviewed journal articles, where often the main purpose of the research was not to identify travel modes, tables displaying descriptive statistics were used to identify the percentages of each mode. Sample sizes from each study/report vary, as do the methods of mode identification, therefore comparisons between countries should be made with caution.

Three predominant study types emerged from the literature: (a) national transportation/household surveys, (b) general school travel studies that reported figures on the commuting modes of the participants, and (c) studies comparing school travel trends over periods of time for specific countries. Table 2.1 displays a summary of the findings from the national transportation/household surveys and the general school travel studies. Table 2.2 displays the results from studies comparing school travel trends over periods of time for specific countries.

Table 2.1
Trends in school travel across different countries

National Transportation/Household Survey Data						
Authors	**Year of pub.**	**Country**	**Age**	**Sample size**	**Data collection technique**	**Findings**
Cooper, A. R., Wedderkopp, N., Wang, H., Andersen, L. B., Froberg, K., & Page, A. S.	2006	Denmark	9-10	530	European Youth Heart Study Questionnaire	Bike 38.3%, Walk 25.8% , Car 23.2%, train/bus 12.6%
Fulton, J. E., Shisler, J. L., Yore, M. M., & Caspersen, C. J.	2005	U.S.	9-12	493	Telephone interview	20.5% walked or cycled
Martin, S. L., Lee, S., & Lowry, R.	2007	U.S.	9-15	7,433	Youth Media Campaign Longitudinal Survey	47.9% active travellers
McDonald, N. C.	2008b	U.S.	5-18	14,553	2001 National Household Travel Survey	Between 10% and 30% actively commuted, depending on race.
Merom, D., Rissel, C., Mahmic, A., & Bauman, A.	2005	Australia	5-12	808	Telephone interview survey	Between 22% (all ten trips in a week) and 46% (one or more trips per week) actively commuted.
The Scottish Government	2008	Scotland	5-11	1,420	Survey NTS and SHS	59% walked, 28% driven, 11% bus
Sustrans	2009	Scotland	5-11	260,505	Hands up survey	51.6% walk, 25.3% driven, 3.4% cycle
Tudor-Locke, C., Neff, L. J., Ainsworth, B. E., Addy, C. L., & Popkin, B. M.	2002	Russia	7-13	1,094	Parent-survey	91.6% walk, 12.7% car, 0.2% bike

Table 2.1

Trends in school travel across different countries

Studies reporting travel participant travel modes						
Abbott, R. A., Macdonald, D., Nambiar, S., & Davies, P. S.	2009	Australia	10	878	Healthy Kids Queensland physical activity and nutrition survey	18.5% of males and 15.5% females undertook active transport to and from school
Baslington, H.	2010	U.K.	7-11	545	Self-report	66% walked, 34% non-walkers
Beck, L. F., & Greenspan, A. I.	2008	U.S.	5 – 14	2,274	Second Injury Control and Risk Survey	46.3% car, 39.6% school bus, 14.2% walk
Black, C., Collins, A., & Snell, M.	2001	U.K.	5-10	4,214	Parent-report	66.9% walked, 0.9% cycled, 28.8% own car, 1.8% friends car
Braza, M., Shoemaker, W., & Seeley, A.	2004	U.S.	9-11	2,993	Hands-up survey	33% walked or biked to school
Bricker, S. K., Kanny, D., Mellinger-Birdsong, A., Powell, K. E., & Shisler, J. L.	2002	U.S.	5-15	1,656	Georgia Asthma Survey, a state-wide, representative, random-digit--dialled telephone survey	4.2% walked, 48.9% rode a school bus, and 43.3% driven.
Bringolf-Isler, B., Grize, L., Mader, U., Ruch, N., Sennhauser, F. H., & Braun-Fahrlander, C.	2008	Switzerland	6-14	1,345	Parent survey	78% usually actively travelled, 12% driven at least once per week

Table 2.1
Trends in school travel across different countries

Carlin, J. B., Stevenson, M. R., Roberts, I., Bennett, C. M., Gelman, A., & Nolan, T.	1997	Australia	5-10	Melbourne = 3,198 Perth = 2,781	Parent self-administered questionnaire Self-report	Melbourne – 30.6% walked to school, 60.2% driven to school. 35.6% walked home, and 54.5% driven home. Perth – 27% walked to school, 62.4% driven to school. 29.4% walked home, 59% driven home.
Chillon, P., Ortega, F. B., Ruiz, J. R., Veidebaum, T., Oja, L., Maestu, J., et al.	2010	Estonia and Sweden	9-10	2,271		50.8% walked, 10.1% biked, 25.3 bus or train, 13.8% used car or motorcycle
Cooper, A. R., Page, A. S., Foster, L. J., & Qahwaji, D.	2003	U.K.	10	114	Self-report	64% Walked, 35.1% driven, 0.9% cycled
Cooper, A. R., Andersen, L. B., Wedderkopp, N., Page, A. S., & Froberg, K.	2005	Denmark	9	323	Self-report	24.1% walked, 38.9% biked, 24.7% driven, and 12.3% by bus
Cooper, A. R., Page, A. S., Wheeler, B. W., Griew, P., Davis, L., Hillsdon, M., et al.	2010	U.K.	11	137	Self-report	51.1% walked, 34.3% driven, 13.1% bus, 1.5% cycled
Dellinger, A. M., & Staunton, C. E.	2002	U.S.	5-18	611	National HealthStyles Survey	19% walked, 6% biked
DiGuiseppi, C., Roberts, I., Li, L., & Allen, D.	1998	U.K.	6-10	2,086	Parent questionnaire	69% walked, 26% travelled by car, 0.2% cycled, 4.8% public transport
Dollman, J., & Lewis, N. R.	2007	Australia	9-15	1,643	Parent-report	Males: 33% active transport, 67% motorised transport Females: 29% active transport, 71% motorised transport
Evenson, K. R., Huston, S. L., McMillen, B. J., Bors, P., & Ward, D. S.	2003	U.S.	11-14	2,151	Youth Risk Behaviour Survey	9.4% walked, 4.1% biked

Table 2.1
Trends in school travel across different countries

Ewing, R., Schroeer, W., & Greene, W.	2004	U.S.	5-18	709 (trips)	Household survey	77% car, 15% school bus, 5% walked, 3% biked
Ford, P., Bailey, R., Coleman, D., Woolf-May, K., & Swaine, I.	2007	U.K.	5-11	239	Parent-report	45% walked, 55% driven
Heelan, K. A., Donnelly, J. E., Jacobsen, J. A., Mayo, M. S., Washburn, R., & Greene, L.	2005	U.S.	9-11	320	Self-report	66.7% driven, 25.7% walked, 5.3% biked, 2.3% scooter/skate (% of trips)
Heelan, K. A., Abbey, B. M., Donnelly, J. E., Mayo, M. S., & Welk, G. J.	2009	U.S.	6-11	691	Self-report	26-28% actively commuted at least once per week
Kerr, J., Rosenberg, D., Sallis, J., F, Saelens, B., E, Frank, L. D., & Conway, T. L.	2006	U.S.	5-18	259	Parent-report	18.1% Walked or biked
Leslie, E., Kremer, P., Toumbourou, J. W., & Williams, J. W.	2010	Australia	6-14	2,922	Self-report survey	40.9% walked, 39.8% driven, 15.1%cycled, 4.1% bus/tram/train (to school)
McDonald, N. C., Deakin, E., & Aalborg, A. E.	2010	U.S.	10-14	357	Parent-report	32% actively travelled, 55% driven, 13% school buses
McMillan, T., Day, K., Boarnet, M. G., Alfonzo, M., & Anderson, C.	2006	U.S.	8-11	1,244	Caregiver-report	21% walked/biked, 69% automobile
Mendoza, J. A., Levinger, D. D., & Johnston, B. D.	2009	U.S.	5-11	653	Hands-up survey	41-47% driven, 15-20% walked, 31-40% school bus

Table 2.1
Trends in school travel across different countries

Metcalf, B., Voss, L., Jeffery, A., Perkins, J., & Wilkin, T.	2004	UK	5	275	Questionnaire	67% walked, 33% driven
Pabayo, R., & Gauvin, L.	2008	Quebec	9	1,260	Quebec Child and Adolescent Health and Social Survey	40.3% walked, 33.1% school bus, 14.3% car, 10.7% multiple modes
Page, A. S., Cooper, A. R., Griew, P., & Jago, R.	2010	UK	10-11	1,307	Self-report	Boys 24.9% driven, 69.6% walked, 4.7%cycled, 0.8% bus/train Girls 23.6% driven, 74.4% walked, 1.5% cycled, 0.5% bus/train
Panter, J. R., Jones, A. P., van Sluijs, E. M. F., & Griffin, S. J.	2010a	U.K.	9-10	2,012	Self-report	40% walked, 9% cycled, 51% motorised transport
Salmon, J., Salmon, L., Crawford, D., Hume, C., & Timperio, A.	2007	Australia	4-9	477	Parent survey	24% walked, 71% driven, 7% public transport, 1% cycled
Sirard, J., Ainsworth, B. A., McIver, K. L., & Pate, R. R.	2005	U.S.	10	219	survey	84% non-active commuters, 5% active commuters
Sleap, M., & Warburton, P.	1993	U.K.	4-11	1,133	Activity diary filled in by parent	51.5% walked every day
Spallek, M., Turner, C., Spinks, A., Bain, C., & McClure, R.	2006	Australia	4-12	871	Parent-report	75% driven
Staunton, C. E., Hubsmith, D., & Kallins, W.	2003	U.S.	5-14	1,743	Hands-up survey	13% walked, 6% biked, 10% car pooled, 64% driven alone
Timperio, A., Crawford, D., Telford, A., & Salmon, J.	2004	Australia	10-12	919	Parent-report	Boys – 65.1% walked/cycled, Girls – 56.8% walked/cycled

Table 2.1
Trends in school travel across different countries

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., et al.	2006	Australia	10-12	656	Parent-report	60.4% walked, 6.3% cycled
van Sluijs, E. M. F., Fearne, V. A., Mattocks, C., Riddoch, C., Griffin, S. J., & Ness, A.	2009	U.K	11	4,688	Avon Longitudinal Study of Parents and Children	43.5% walked or cycled, 35.2% car, 21.3% public transport
Voss, C., & Sandercock, G.	2010	U.K.	10-14	5,927	East of England Healthy Hearts study questionnaire	49.9% walked, 25.7% public transport, 16.4% car, 8% cycled
Wen, L. M., Fry, D., Merom, D., Rissel, C., Dirkis, H., & Balafas, A.	2008	Australia	10-12	1,996	Self-report	17.3-23.9% walked all the way every day, 30.4-30.9% took the car every day, 7.1-7.7 took public transport on some days
Witlox, F., & Tindemans, H.	2006	Belgium	6-25	1,226	Flemish Transport Behaviour Research Surveys	18% walked, 31% car, 31% bikes, 17% public transport
Yarlagadda, A. K., & Srinivasan, S.	2008	U.S.	<18	4,352	Household survey	15.45% actively travelled to school, 84.55% travelled inactively
Yelavich, S., Towns, C., Burt, R., Chow, K., Donohue, R., Sani, H. S., et al.	2008	New Zealand	6-13	1,157	Hands-up survey	34.5% had walked to school that day
Yeung, J., Wearing, S., & Hills, A. P.	2008	Australia	4-12	324	Parent-report	33% actively commuted, 67% passively commuted

Table 2.2 Changes in school travel trends over time

School travel trends over time						
Author	**Year of pub.**	**Country**	**Age**	**Sample size**	**Data collection technique**	**Findings**
Department for Transport	2009	UK.	5-10 (5-15)	95/97 = 1,955 2003 = 1,572 2008 = 1,343 (2009 = 6,251,672)	7-day diary (School census data)	95/97 – 53% Walked, 38% driven 2003 – 51% walked, 41% driven 2008 – 48% walked, 43% driven (2008 – 50% walk, 29% driven)
Grize, L., Bringolf-Isler, B., Martin, E., & Braun-Fahrlander, C.	2010	Switzerland	6-14	1994 = 956 2000 = 1,535 2005 = 1,753	Swiss population based national travel behaviour surveys	1994 – 78.4% walked 2000 – 72.1% walked 2005 – 71.4% walked
Ham, S. A., Macera, C., & Lindley, C.	2005	U.S.	5-15	3,114 trips (1995) 4,073 trips (2001)	National Personal Transportation Survey (1995) and National Household Travel Survey (2001)	1995 - 31.3% walked 2001 - 35.9% walked (Data for trip 1 mile or less only)
McDonald, N. C.	2007	U.S.	5-18	1969 = (6,000 households) 2001 = 14,553	National Personal Transportation Survey	1969 - 40.7% walked or biked 2001 - 12.9% walked or biked
Scotland's Chief Statistician	2010	Scotland	5-16	1986/86 = 310 1995/97 = 331 2006/07 = 532	National Travel Survey Interview and 7-day travel diary	1985/86 - 69% walked, 6% car 1995/97 - 53% walked, 25% car 2006/07 - 47% walked, 27% car
van der Ploeg, H. P., Merom, D., Corpuz, G., & Bauman, A. E.	2008	Australia	5-9	1971=2,109 1981=2,355 1991=339 1999-2003=419	Household Travel Surveys from the New South Wales Government Department of Planning	1971- 57.7% walked 1981 - 44.5% walked 1991 – 35.3% walked 1999 – 2003 – 25.5% walked

The majority of surveys/studies in Table 2.1 were conducted within the past 10 years. Percentages of children who commuted actively vary greatly, ranging from 5% in the U.S. (Ewing, Schroeer, & Greene, 2004; Sirard, Riner, McIver, & Pate, 2005) to 91.8% in Russia (Tudor-Locke, Neff, Ainsworth, Addy, & Popkin, 2002). Walking and car use account for most trips; cycling and school bus/public transport are minority modes. Denmark and Belgium are exceptions to this pattern, where 38.3% and 31% of participants cycle to school, respectively (Cooper, et al., 2006; Witlox & Tindemans, 2006). The U.S. and Australia appear to have the lowest rates of active commuting (typically less than 50% of children). European countries such as England, Scotland, Belgium, Denmark, and Switzerland have higher active commuting rates (around 50% and above).

Table 2.2 indicates that in all but one case (Ham, Macera, & Lindley, 2005) rates of active commuting have declined over time. This unusual finding (i.e. an increase in active commuting over time) may be accounted for by a change in methodology; the survey instrument was changed between timepoints. The U.S. and Australia have seen particularly marked decreases in active commuting; from 40.7% (1969) to 12.9% (2001) (McDonald, 2007) and from 57.7% (1971) to 25.5% (2003) (van der Ploeg et al., 2008) respectively. Even Switzerland, which has one of the highest percentage of active commuters, has seen a decrease from 78.4% (1994) to 71.4% (2005) (Grize et al., 2010).

Scotland also follows this trend. The Scottish National Travel Survey statistics show that the percentage of children walking to school has decreased from 69% in 1985/86 to 47% in 2006/07 (Scotland’s Chief Statistician, 2010). Meanwhile, car use has increased from 6% to 27% over the same period. The most recent survey of Scottish children’s commuting behaviours was carried out by the sustainable transport organisation Sustrans. They questioned 260,505 Scottish primary school children about their travel behaviours and found that 51.6% walked, 25.3% were driven, and 3.4% cycled to school (Sustrans, 2009). Data were collected by school teachers and children were asked to raise their hand in class to indicate how they usually travelled to school. Social desirability may have affected the results however. Social desirability refers to the the notion that participants ‘respond to self-report items in a manner that makes the respondent look good rather than to respond in an accurate and truthful manner' (Holtgraves, 2004, p.161). The actual percentage of children who actively commute to school may, therefore, be slightly lower than that reported. Despite this methodological issue, the survey carried out by Sustrans is the largest and most representative available, and shows that approximately 50% of Scottish school children travel to school actively. This compares favourably with other developed countries such as the U.S. and Australia, where active commuting rates of 13% to 40% have been reported. However, Scotland compares less favourably to other European countries such as Denmark, Belgium, and Switzerland where 60-70% of children travel actively to school. Furthermore, although 50% of Scottish school children travel actively, the other 50% do not, meaning that a considerable number of Scottish children are missing out on the potential benefits of active travel.

Finally, it should be noted that there is ambiguity surrounding the definition of an active commuter and studies have used different criteria to categorise an individual as either an active or inactive commuter (Sirard & Slater, 2008). For example, some studies have used usual mode of transport (Cooper, Page, Foster, & Qahwaji, 2003; Tudor-Locke, Ainsworth, Adair, Du, & Popkin, 2003), while others used criteria such as the number of trips made by certain modes in a week (Abbott, Macdonald, Nambiar, & Davies, 2009; Carver, Timperio, Hesketh, & Crawford, 2010), or used direct observation (Sirard, Riner, et al., 2005). These methodological differences make it difficult to compare findings across studies.

2.3 Correlates of Walking to School

An understanding of the determinants and correlates of active commuting is important to identify strategies for increasing active commuting to school. Most studies that have investigated factors affecting school travel mode have used cross sectional designs. Findings from these studies are therefore concerned with the *correlates* of commuting modes, and are unable to infer causation. Such studies have largely focused on the following four groups of correlates: demographic; physical environment; social environment; and psychological aspects. The following sections of the literature review focus on the correlates of walking to school under these four headings, identifying those factors which appear to be most associated with walking to school and areas that have been under-researched. All information is specific to the primary school age population.

2.3.1 Demographic correlates

Studies reporting demographic differences in active commuting to school have focused primarily on gender, ethnicity, and socio-economic status (SES).

It has been suggested that boys are more likely to actively commute to school than girls (Davison, et al., 2008). However, on examination of published literature it is difficult to be definitive on this. Eleven studies with primary school aged samples provide evidence that boys walk to school more than girls. This has been shown in the U.S. (Evenson, Huston, McMillen, Bors, & Ward, 2003; Fulton, Shisler, Yore, & Caspersen, 2005; McDonald, 2007; Rosenberg, Sallis, Conway, Cain, & McKenzie, 2006), Australia (Abbott, et al., 2009; Harten & Olds, 2004; Leslie, Kremer, Toumbourou, & Williams, 2010; Timperio, Crawford, Telford, & Salmon, 2004), New Zealand (Yelavich, et al., 2008), and the U.K (Black, Collins, & Snell, 2001; Voss & Sandercock, 2010). However, a similar number of studies show that there is no difference between boys and girls in terms of active commuting prevalence. This has been shown in Denmark (Cooper, et al., 2006), China (Tudor-Locke, et al., 2003), Australia (Carlin, et al., 1997; Carver, et al., 2010; Hume, Timperio, et al., 2009; Timperio, et al., 2006), the U.S. (Kerr, et al., 2006; McMillan, Day, Boarnet, Alfonzo, & Anderson, 2006), and the U.K. (van Sluijs, et al., 2009).

It is difficult then to establish whether gender differences exist in commuting trends. It is interesting to note however, that no study has found girls to actively commute more than boys. This may suggest that boys travel actively more than girls, as proposed by Davison et al. (2008), and studies that fail to show this trend may be underpowered, or may not have representative samples. Higher levels of active commuting among boys would reflect similar trends in general physical activity levels (Brunton, et al., 2003). One contributing factor to the lower active travel levels among girls may be due to a societal tendency to protect girls more than boys. The result of this would be an increased freedom for boys to travel actively and a restriction on girl’s opportunities to do likewise (Davison, et al., 2008; McMillan, et al., 2006).

Fewer studies have reported differences in commuting behaviours stratified by ethnicity. This is likely due to homogeneous samples in most studies, making comparison of ethnic groups problematic. Studies reporting ethnic differences typically find that children from non-white backgrounds actively commute more than their white peers. This is the case for African American students (Evenson, et al., 2003; Martin, Lee, & Lowry, 2007; McDonald, 2008b), minority students (McDonald, 2007), Hispanic students (Braza, Shoemaker, & Seeley, 2004; Martin, et al., 2007; McDonald, 2008b), and Maori and Pacific Island children (Yelavich, et al., 2008).

Few studies have found no differences between ethnic groups. In Georgia (the U.S.), non-Hispanic Black children walked to school more than children of other ethnicities, but not significantly so (Bricker, Kanny, Mellinger-Birdsong, Powell, & Shisler, 2002). In a U.S. national survey, ethnicity was not found to be a significant variable in an adjusted multivariate logistic regression model used to predict active school transport (Fulton, et al., 2005).

Regarding socioeconomic status (SES) and active school travel, children from lower socioeconomic backgrounds (i.e. children from more deprived backgrounds) are more likely to actively commute than children from more advantaged backgrounds. This has been shown using different indicators of socioeconomic status including household income (Ewing, et al., 2004; Martin, et al., 2007; McMillan, 2007; McMillan, et al., 2006; Pabayo & Gauvin, 2008; Spallek, Turner, Spinks, Bain, & McClure, 2006), car ownership (Carlin, et al., 1997; DiGuiseppi, et al., 1998; Ewing, et al., 2004; Grize, et al., 2010; Panter, Jones, van Sluijs, & Griffin, 2010a; Roberts, 1996), school level SES (Yelavich, et al., 2008), home area SES (Harten & Olds, 2004), parent education level (Martin, et al., 2007; Spallek, et al., 2006), parent level occupational prestige (Carlin, et al., 1997), national SES classification statistics (Metcalf, Voss, Jeffery, Perkins, & Wilkin, 2004), and students receiving public welfare (Braza, et al., 2004).

Only two studies found no association between socioeconomic status and travel mode. One of these studies used the Australian Bureau of Statistics Socioeconomic Indices of Area (Timperio, et al., 2006), and the other used number of vehicles in the household (Merom, Tudor-Locke, Bauman, & Rissel, 2006) to measure socioeconomic status. Both studies were based on Australian samples.

School type is closely linked with socioeconomic status. Children from state/government schools actively commute more than children from private/independent schools (Carlin, et al., 1997; DiGuiseppi, et al., 1998; Merom, et al., 2006). A national survey in Scotland found that 54.4% of primary 5-7 children from state primary schools walked to school, and 21.5% were driven. This compared to 20.8% who walked and 50.9% who were driven at private/independent schools (Sustrans, 2009). This is not surprising given that children who attend private/independent schools likely come from families with abundant resources and possibly have more car access than children from deprived backgrounds. Furthermore, children who attend private/independent schools rarely live within walking distance of their school (Davison, et al., 2008) and so being driven is often a necessity.

2.3.2 Physical environment correlates

This section of the literature review identifies aspects of the physical environment that influence children's walking to school. Attributes of the physical environment are classed as having either a negative (discouraging) or positive (encouraging) effect on travel choice.

Findings from published studies suggest that distance from home to school, busy roads/heavy traffic, and living in a rural area are the three main factors that negatively impact walking to school.

Distance from home to school has been found to be the strongest predictor and most frequently reported barrier to walking to school. The farther a child lives from their school the less likely they are to walk (McMillan, 2007; Merom, et al., 2006; Page, Cooper, Griew, & Jago, 2010; Timperio, et al., 2006). Furthermore, distance has been reported as being a barrier to walking to school by parents (Dellinger & Staunton, 2002) as well as children (Ahlport, Linnan, Vaughn, Evenson, & Ward, 2008; Kirby & Inchley, 2009). These findings are supported in older studies (Black, et al., 2001; DiGuiseppi, et al., 1998) as well as studies conducted more recently (Grize, et al., 2010; Panter, et al., 2010a); in studies using large samples (McDonald, 2007, 2008a) and small samples (Timperio, et al., 2006); and in studies that have been conducted in various countries (Bringolf-Isler, et al., 2008; Ewing, et al., 2004; Panter, et al., 2010a; Yeung, Wearing, & Hills, 2008).

Busy roads is the second most frequently identified factor to negatively impact walking to school. These findings are supported particularly when parent/caregiver perceptions of the environment are used to predict commuting behaviour (Bringolf-Isler, et al., 2008; McMillan, 2007; Merom, et al., 2006; Panter, et al., 2010a; Timperio, et al., 2006), although similar findings have been found using child reported data (Ahlport, et al., 2008; Kirby & Inchley, 2009). Furthermore, busy roads appear to be negatively associated with walking to school regardless of country. This is evident from study findings conducted in several countries, including Australia (Cole, Leslie, Donald, Cerin, & Owen, 2007; Merom, et al., 2006; Timperio, et al., 2006), Canada (Faulkner, Richichi, Buliung, Fusco, & Moola, 2010), the U.S. (Ahlport, et al., 2008; Centres for Disease Control and Prevention, 2002; McMillan, 2007), Switzerland (Bringolf-Isler, et al., 2008), and the U.K. (Panter, et al., 2010a).

Finally, four studies have found that children who live in rural areas are less likely to walk to school than children living in urban areas (Fulton, et al., 2005; Martin, et al., 2007; McDonald, 2007; Yarlagadda & Srinivasan, 2008). This is most likely a product of the greater distance from home to school (Sjolie & Thuen, 2002), making it impractical if not impossible to walk.

Having identified factors that are negatively associated with walking to school the following section discusses factors that are positively associated with walking to school. Evidence suggests that living in high-walkable urban areas with high population density is strongly associated with walking to school. It has been reported that a higher percentage of children who lived in urban areas walked to school compared to their counterparts from rural areas (Martin, et al., 2007; Pabayo & Gauvin, 2008). Furthermore, U.S. children who lived in the city centre were 2.2 times more likely to walk or cycle to school than their peers from rural areas (Fulton et al., 2005). These findings are somewhat intuitive in light of the previously reported evidence that living in rural areas is negatively associated with active school travel.

Regarding high population density, in the U.S. (Braza, et al., 2004; McDonald, 2008a) population density was found to be positively associated with walking or biking to school, i.e. as population density increased so did the percentage or likelihood of walking to school. Other U.S. based researchers found that residential density was highly associated with active school travel (Kerr, et al., 2006). This is presumably because children living in high population density areas generally live close to their schools.

Evidence indicates that area-level walkability and the presence of pavements may also positively influence walking to school. Three U.S. based studies showed such findings. Kerr et al. (2006) concluded that individual and neighbourhood walkability (measured with a walkability index) were significantly related to walking and cycling to and from school. Two studies have shown that the presence of pavements has a significant impact on walking behaviour as a commuting mode. Fulton et al. (2005) found that the odds of walking to school for children who lived in areas with pavements were 3.4 times higher than those who lived in areas without pavements. Another study showed that arterials and collectors (types of roads) with pavements alongside were the most influential physical environmental factors with regard to walking behaviour (Ewing, et al., 2004). This finding is probably related to the fact that these types of roads are located within well-connected urban areas that are conducive to walking. Similar results have been reported by researchers from the U.K. and Australia. Panter et al. (2010) reported that parental perceptions of neighbourhood walkability were positively associated with child active commuting. Leslie et al. (2010) found that children who perceived there to be recreational facilities close to their home and who perceived their local area to be safe for walking had increased odds of walking to and from school.

There is equivocal evidence and mixed findings for the association between various other physical environmental factors and commuting mode among children, making it unclear whether these factors have any impact on mode choice. Examples include street/intersection density and mixed land use (Braza, et al., 2004; Ewing, et al., 2004; Kerr, et al., 2006).

2.3.3 Social environment correlates

In addition to the physical environment, the social environment in which a child has grown up in and lives can influence their school travel decisions. Aspects of the social environment may positively or negatively influence a child's travel choices.

A wealth of evidence is available for the social factors positively associated with walking to school. Children who walk to school tend to come from supportive families (Kirby & Inchley, 2009; McMillan, 2007; McMillan, et al., 2006; Panter, et al., 2010a) where walking is perceived to be healthy (Ahlport, et al., 2008; Kirby & Inchley, 2009; Merom, et al., 2006). Moreover, children who have social support from friends are more likely to walk to school. In a study measuring children's travel behaviour at two time points (2004 and 2006), children who had many friends in their local area were found to be twice as likely to increase their walking to school than other children (Hume, Timperio, et al., 2009). This finding is supported by others that show strong associations between walking to school and social support from friends (Leslie, et al., 2010; Panter, et al., 2010a).

Several social factors have been found to be negatively associated with walking to school. Perhaps the most prominent of these is perceptions of safety in the local area. Several studies indicate that increased parent and child safety concerns are negatively associated with walking to school (Merom, et al., 2006; Panter, et al., 2010a; Timperio, et al., 2006), and children who perceive their local area to be safe are more likely to walk to school (Leslie, et al., 2010). These findings are further supported by qualitative research which has investigated child and parent barriers to and facilitators of walking to school (Ahlport, et al., 2008; Faulkner, et al., 2010; Kirby & Inchley, 2009; Mitchell, Kearns, & Collins, 2007). The bulk of evidence supports a negative association between perceptions of safety and walking to school, however there are conflicting results from studies of objectively measured safety variables. In the U.S., children who lived in areas with above average (median) incivilities were almost 3.53 (95% CI: 1.68 to 7.39) times more likely to walk to school than children who lived in areas with below average incivilities (Rossen, et al., 2011). Neighbourhood incivility was measured objectively using an inventory called the Neighborhood Inventory of Environmental Typology. The findings of

Rossen et al (2011), in comparison to the findings from previous studies, suggest that there may be underlying over-riding factors independent of neighbourhood safety in areas that are truly unsafe. For example, parents of children in these areas may not own a car, or may be unwilling to drive their child if they do own a car.

Another factor negatively associated with walking to school is perceptions of time constraints in the morning (Salmon, Salmon, Crawford, Hume, & Timperio, 2007). Three qualitative studies found that parents report this to be a barrier to allowing their child to walk to school (Ahlport, et al., 2008; Faulkner, et al., 2010; Kirby & Inchley, 2009). These findings link closely with results from studies that indicate a strong association between parents' work situation and child travel behaviour. It has been shown that children whose parents work are less likely to walk to school and are more likely to be driven (Carlin, et al., 1997; Ziviani, Scott, & Wadley, 2004), often en route to a parent's place of work. This is particularly evident when the mother works (DiGuiseppi, et al., 1998; McDonald, 2008c; Yarlagadda & Srinivasan, 2008). Finally, children of parents who believe that it is more convenient to drive their child to school (McMillan, et al., 2006; Panter, et al., 2010a) and who do not allow their child out unsupervised (DiGuiseppi, et al., 1998; Fulton, et al., 2005) are less likely to walk to school and more likely to use motorised transport than other children.

Finally, a particularly interesting finding from the literature is that stranger danger (i.e. the perceived danger presented to children by strangers) has little bearing on school travel choices. This is evidenced by several studies (DiGuiseppi, et al., 1998; Evenson, et al., 2006; Kerr, et al., 2006; Timperio, et al., 2006) which show no influence of perceived stranger danger on children's travel behaviour. These findings challenge the intuitive or anecdotal view that parents believe their children to be at risk from strangers, when it has been shown that perceived stranger danger does not influence travel behaviour.

2.3.4 Psychological correlates

There is a dearth of evidence in the published literature regarding the influence of psychological variables on school travel behaviour. Furthermore, few studies have used strong theory-driven rationales to select potential psychological predictor variables when investigating child travel behaviours (Davison, et al., 2008). To the author's knowledge only two such studies have been conducted.

Mendoza et al. (2010) used social cognitive theory to investigate the role of parent and child self-efficacy and outcome expectations on 4th grade children's school travel behaviours (N = 149, age 9.7 ± 0.7). Commuting mode was self-reported. Self-efficacy and outcome expectations were measured using a 17 and 14 item scale respectively. Child self-efficacy and parent outcome expectations were not significantly related to walking to school. However, higher parents' self-efficacy was significantly associated with higher levels of active commuting to school (std. beta = 0.18, $p = 0.018$). This finding helps to strengthen the argument that parents enforce significant influence on their children's school travel behaviours.

Martin et al. (2007) investigated the association between outcome expectancies and active school travel in 7,433 American school children. Outcome expectancies were measured using a 4-point Likert-scale response (1 = really agree to 4 = really disagree), and were specific to general physical activity, for example: If I did physical activities on most days it would be fun. Outcome expectancies were not significantly associated with active school travel (OR (95%CI) = 1.01 (0.98–1.05), $p > .05$), (Martin, et al., 2007). A weakness of this study is that the outcome expectancies items were related to general physical activity rather than active travel.

The paucity of robustly conceptualized and theory-driven psychological studies presents a gap in the school travel literature that requires attention. It has been suggested that because psychological variables have been shown to influence general physical activity behaviours, analogous constructs must be developed and explored in the school travel context (Sirard & Slater, 2008).

2.3.5 Summary of correlates

In summary, factors strongly associated with walking to school include being non-Caucasian, living in a deprived area, having supportive friends and family, living close to school in a densely populated urban area, and having parents who have low perceptions of dangers for the journey to school. Conversely, factors negatively associated with walking to school include being white, coming from an affluent background with two working parents, attending private school, living far from school, and having parents who have high perceptions of danger for the journey to school and perceptions of time constraints. There is a gap in the literature regarding the role of psychological variables in commuting behaviour.

Additionally, it appears that there may be a lot of confounding in the research literature between variables such as SES, distance to school, school type, and car ownership. For example, crime rates are higher in lower SES areas, in which there is lower car ownership, and which is more likely to be urban. These factors will also likely coincide with areas of higher population density and shorter distance to school. Conversely, children of affluent parents most likely live in suburban areas with low crime rates, have parents who own cars, and attend schools farther from their homes.

2.4 Health Benefits of Walking to School

Travelling actively to and from school has several benefits. These include reduced financial costs, reduced vehicle traffic, and the chance for children to socialise with their parents and peers. Furthermore, no preparation or special equipment is required to walk to school (Mackett, et al., 2005). In addition to these practical, environmental, and social benefits, children who travel actively to school may achieve certain health benefits. Several studies have been conducted to investigate the association between active travel to school and health-related outcomes, and have focused on the following three outcomes: (a) physical activity, (b) cardiovascular fitness, and (c) body composition.

2.4.1 Physical activity.

Several researchers have investigated the association between school travel and physical activity levels in primary-school aged children. They have conducted studies using both objective (accelerometer and pedometer) and subjective (self-report and parent proxy) measures, and have studied children in several countries, including England, the U.S., Australia, Denmark, Estonia, Sweden, and Russia. Study samples ranged from n = 114 (Cooper, et al., 2003) to n = 6,085 (Voss & Sandercock, 2010). Physical activity was usually defined as activity of at least moderate intensity (MVPA), the intensity at which health benefits can be achieved (Warburton, Nicol, & Bredin, 2006). Studies using objectively measured physical activity, the most reliable measurement method, have shown a strong association between active commuting to school and increased levels of physical activity during the period of travel (Cooper, et al., 2003; Cooper et al., 2006; Cooper, Page, Wheeler, Griew, et al., 2010).

Cooper and colleagues have found this association in several studies. In two samples of English primary school children, those who walked to school were significantly more active between the hours of 8 a.m. and 9 a.m. than those who travelled by car (Cooper, et al., 2003; Cooper, Page, Wheeler, Griew, et al., 2010). In addition, boys who walked to and from school were found to be significantly more active between the hours of 3 p.m. and 8 p.m. than those who travelled by car (Cooper, et al., 2003). Similarly, in two Danish samples, children who walked to school were significantly more active during the school commute than their driven peers (Cooper, Andersen, Wedderkopp, Page, & Froberg, 2005; Cooper, et al., 2006). This was found for both boys and girls.

Similar findings have been reported by researchers that conducted studies using accelerometer measured physical activity. Three studies conducted in England investigating children's travel behaviours showed that children who walked to school were more active during the commute than children who travelled by car (Ford, et al., 2007; Metcalf, et al., 2004); and compared to car travellers, children who walked to school achieved more minutes of MVPA on weekdays (van Sluijs, et al., 2009). Another study based in England indicated that those who walked to school expended twice as many Kcals per minute during the trip to school than those who travelled by car (Mackett, et al., 2005), as derived from the RT3 motion sensor (Stayhealthy Inc., Monrovia, CA).

One study conducted in the U.S. showed that regular active commuters achieved approximately 15% more accelerometer counts per minute than irregular, and non-active commuters (Sirard, Riner, et al., 2005). However, researchers that conducted another U.S.-based study found that boys who travelled actively had only marginally higher levels of activity compared to their counterparts who travelled inactively, and no differences were found between active and non-active commuting girls (Rosenberg, et al., 2006).

A study conducted in Estonia (*n* = 1,172) and Sweden (*n* = 1,099) showed that boys who actively commuted to school achieved significantly more MVPA (mean difference = 14 min/day, $p < .05$) across the whole day than their non-active commuting counterparts (Chillon, et al., 2010). Furthermore, active commuters were twice as likely to achieve the daily physical activity recommendations of 60 minutes per day.

In a sample of 1,513 girls (aged 5-16) from schools in Auckland, New Zealand, those who travelled to school actively averaged 1,052 more weekday steps than those who travelled using inactive modes (Duncan, Duncan, & Schofield, 2008). Steps were measured using sealed New Lifestyles NL-2000 (Lee's Summit, MO) pedometers.

Finally, among 2,076 Australian children, there were no differences for daily pedometer-measured step counts between active and inactive commuters in year 1 children (age 6). However, year 5 males and females (age 10), and year 10 females (age 15) who actively commuted took significantly more steps during the school day than inactive commuters (Abbott, et al., 2009). Furthermore, children who actively commuted to school were more likely to meet daily step target recommendations than those who travelled inactively.

In most of the studies mentioned (*n* = 8), the Actigraph (Actigraph, Pensacola, FL) accelerometer was used to measure physical activity. In one study the RT3 (Stayhealthy Inc., Monrovia, CA) accelerometer was used (Mackett, et al., 2005) and the Caltrac motion sensor (Hemokinetics, Madison, WI) was used in another (Rosenberg, et al., 2006). Pedometers were used in only two studies to quantify commuting activity (Abbott, et al., 2009; Duncan, et al., 2008).

The association between active commuting and physical activity levels using self-reported physical activity as the outcome measure has been investigated in three studies (Heelan, et al., 2005; Tudor-Locke, et al., 2002; Voss & Sandercock, 2010). It should be noted that self-reported physical activity measures have certain limitations, such as increased susceptibility to social desirability (Sallis & Saelens, 2000). Findings using self-reported measures should, therefore, be interpreted with caution.

Using the Self-Administered Physical Activity Checklist (SAPAC) in a sample of 320 U.S. children, Heelan et al. (2005) observed that children who travelled actively to school spent significantly more time in physical activity and in moderate activity than those who travelled by car. A study using data from the Russian Longitudinal Monitoring Study used parent-proxy reported activity to assess the impact of omitting active commuting on meeting health-related activity recommendations. The authors concluded that omitting active commuting activity from children's daily accumulated physical activity resulted in a decrease of 12-20% in the prevalence of those meeting the health-related activity recommendations (Tudor-Locke, et al., 2002). In a large study of English school children (n = 6085), boys and girls who cycled to school scored significantly higher in the Physical Activity Questionnaire (PAQ) than both walkers and non-active commuters – indicating higher activity levels. Boys who walked to school scored higher in the PAQ than passive commuters (Voss & Sandercock, 2010).

It is clear from the findings presented that children who commute actively to and from school achieve higher levels of activity during the journey (measured both objectively and subjectively); only two studies were equivocal in their findings (Abbott, et al., 2009; Rosenberg, et al., 2006). However, the literature is not definitive on whether active travellers achieve greater daily and weekly overall activity than passive commuters. There are mixed results in this regard. Researchers that conducted two studies found that higher levels of physical activity between modes was restricted to commuting times (i.e. 8-9 a.m. and 3-4 p.m.), with no difference between active commuters and non-active commuters for daily and weekly physical activity levels (Ford, et al., 2007; Metcalf, et al., 2004). This suggests that there may be some kind of compensation effect, whereby children who travel inactively to school make-up for this lost activity through the rest of the day. Likewise, children who travel to school actively may be less active at other times of the day. There is no support for this theory in literature however (Dale, Corbin, & Dale, 2000; Sirard & Slater, 2008). Dale and colleagues demonstrated that children do not compensate for missed physical activity during the school day by increasing their activity at other times of the day. It is not known, however, whether children restrict activity at certain points in the day if they have engaged in extra activity at another point during that day. This may have important implications for intervention effectiveness. I.e. if activity levels are increased at a given point via intervention (the trips to and from school for example), children may be less active at other points (e.g. break time) by means of some kind of built-in homeostatic bodily function that maintains a given level of daily activity, as has been suggested (Wilkin, 2010). Other studies have shown that active commuters are more active at other times of the day (Cooper, et al., 2003; Heelan, et al., 2005; Mackett, et al., 2005), during weekdays (Abbott, et al., 2009; Chillon, et al., 2010; Cooper, Page, Wheeler, Griew, et al., 2010; van Sluijs, et al., 2009), and across the whole week (van Sluijs, et al., 2009). The weight of evidence suggests that active commuters generally achieve higher levels of activity in a day than passive commuters. However, it is not clear whether this additional activity is enough to merit a concerted effort to promote active forms of school travel. Several authors have quantified the contribution that active commuting makes to time spent in MVPA. Findings show that active commuters engage in between 2 (Cooper et al., 2010) and 14 (Chillon et al., 2010) additional minutes of daily MVPA compared to children who travel by inactive modes. Considering that a relatively large number of children (especially in Britain and Europe) currently actively commute to school, and a number of children live too far from school to actively commute even if they wanted, the value of promoting active commuting based on its ability to contribute to MVPA is questionable. This said, it could be argued that any contribution to daily MVPA time is valuable, regardless of quantity, and therefore any effort to promote daily MVPA is worthwhile.

Cross-sectional designs were used in most of the previously cited studies, and it is therefore not possible to establish causation. It is not clear whether children are more active because they travel actively to school, or if children who are generally more active choose to travel actively. It has been suggested that differences in activity levels by mode can not be explained by the theory that children who are generally more active choose to travel actively (Davison, et al., 2008). This is because differences in activity levels by mode are limited to weekdays and similar differences in activity are not observed at weekends (Cooper, et al., 2005; Cooper, et al., 2003; Sirard, Riner, et al., 2005). A tentative conclusion, therefore, may be that weekday differences in activity levels can be attributed to mode of school travel.

One final observation is that in several of the studies described, school travel time was arbitrarily classified as being between 8 a.m. and 9 a.m., and between 3 p.m. and 4 p.m. It should be noted that primary school aged children typically live in close proximity to their school, and so these 1-hour periods will inevitably include non-travel-related activity as well as travel-related activity. For example, a child may walk to school for 20 minutes and then stand idle in the playground for 10 minutes before the bell rings for the start of school. Another child may be driven to school, but on arrival play football before the bell rings. Both children may achieve similar levels of activity in the hour prior to school; however the latter child has achieved his activity through playground-related games and not through active commuting. More precise measures of travel time are warranted to accurately identify the contribution of active commuting to daily activity levels.

2.4.2 Cardiovascular fitness.

Low cardiovascular (or cardio respiratory) fitness levels have been associated with various metabolic risk factors in children (Andersen, Wedderkopp, Hansen, Cooper, & Froberg, 2003; Bovet, Auguste, & Burdette, 2007). These risk factors are associated with future cardiovascular diseases and will likely track through adolescence into adulthood (Bao, Srinivasan, Wattigney, & Berenson, 1994). Improving cardiovascular fitness in children will therefore help to mitigate against future health problems.

Four studies have been conducted to investigate the relationship between mode of travel to school and cardiovascular fitness in children. One study has been conducted to determine the difference between cardiovascular response to stress in active and non-active commuters. Two of these studies have been carried out with samples of Danish school children (Cooper, et al., 2008; Cooper, et al., 2006). One of these showed that children who cycled to school had significantly higher cardiovascular fitness levels (between 5.4 and 12.7% higher) than passive commuters (Cooper, et al., 2006). The other concluded that higher cardio respiratory fitness was significantly associated with cycling to school in both males and females. Furthermore, longitudinal regression models indicated that a change in mode from non-cycling to cycling was a significant predictor of higher cardio respiratory fitness at follow-up (Cooper, et al., 2008). Maximal cycle ergometer tests were used to assess cardio respiratory fitness.

In a study of 2,271 Estonian and Swedish children, those who cycled to school had significantly higher VO_2max than children who passively commuted or walked to school (VO_2max = 44.0 ml/min/kg vs. 40.9/40.7 ml/min/kg, respectively) (Chillon, et al., 2010). A study of 6,085 English children was the first to show an association between walking to school and higher levels of fitness (Voss & Sandercock, 2010). The previously described studies have only found associations between cycling to school and improved fitness. Voss and Sandercock (2010) found that boys and girls who walked or cycled to school scored higher in a 20-m shuttle run test than passive commuters, and were more likely to be classified as 'fit' according to a logistic regression model.

Finally, a novel experimental approach was used by Lambiase et al. (2010) to compare cardiovascular reactivity to stress in children who walked to school and children who were driven on a simulated journey. Forty children were randomly assigned to a walking group or a driven group. Children in the walking group completed a 1.6 km treadmill walk whilst watching images of a real school commute. Children in the driven group sat on a chair watching the same journey. Following their journeys, each child completed various stress-related tasks and measures of their cardiovascular reactivity to stress were taken. Results showed that children in the walking group had lower heart rate, systolic blood pressure, pulse pressure, and perceived stress reactions to cognitive stress than the control group.

There is compelling evidence for a strong association between cycling to school and higher cardiovascular fitness in children, and some evidence for an association between walking to school and higher cardiovascular fitness. Furthermore, there is some evidence to suggest a dampening of cardiovascular responses to stress among children who walk to school.

2.4.3 Weight status.

Fifteen studies have been conducted that have investigated the association between body composition and commuting modes in primary aged children. Most used body mass index (BMI = weight kg/height m^2) as the measure of body composition. Some used other measures in addition to BMI such as skinfold thickness (Cooper, et al., 2006; Heelan, Abbey, Donnelly, Mayo, & Welk, 2009) and body fat percentage (Ford, et al., 2007; Metcalf, et al., 2004). Sample sizes ranged from 114 (Cooper, et al., 2003) to 6,826 (Li, et al., 2007) and were conducted in six countries. Nine found no association between commuting mode and body composition, five studies found that active commuting was associated with lower BMI, and one found that active commuting was associated with a higher BMI.

Five studies have been carried out in the U.S. to investigate school travel and body composition. Two of these showed that commuting actively to school was not associated with being overweight in children (Rosenberg, et al., 2006), and that BMI was not a significant factor in predicting mode choice (Fulton, et al., 2005). In another study, researchers compared BMI scores between non-active, irregular, and active commuters, and found that there were no differences between the groups (Sirard, Riner, et al., 2005). Heelan et al. (2009) found that frequent walkers had a significantly lower increase in sum of skinfolds and percent body fat over two years than infrequent walkers and passive commuters (Heelan, et al., 2009). Surprisingly, one study of 320 elementary school children in the U.S. showed a significant positive association between active commuting and BMI (partial $r = 0.03$, $p < 0.05$), i.e. children who actively commuted were found to have higher BMI scores than inactive commuters (Heelan, et al., 2005). This is surprising given that an inverse relationship between physical activity level and weight status is typically found in children (Ness, et al., 2007).

Four studies conducted in the U.K. showed no association between active commuting and lower BMI. Body composition values were compared between children who walked to school and children who travelled inactively. No differences were found between these groups for BMI (Cooper, et al., 2003; Voss & Sandercock, 2010) or body fat percentage (Ford, et al., 2007; Metcalf, et al., 2004). In another study Cooper et al. (2006) found no differences for BMI or skinfold measurements between Danish children who used different travel modes (Cooper, et al., 2006).

Five studies have found associations between commuting mode and body composition. Interestingly, most of these were conducted outside of the U.K or the U.S. A large Chinese based study of 6,826 school children identified that overweight children spent less time in active transportation than their normal weight counterparts (Li, et al., 2007). Similarly, a study carried out in Brazil showed that excess weight and excess body fat were more prevalent among passive commuters than active commuters (30% and 33.2% vs. 15.8% and 19.1%, respectively) (Silva & Lopes, 2008). In a previously described study, frequent walkers had a significantly lower increase in sum of skinfolds and percent body fat over two years than infrequent walkers and passive commuters (Heelan, et al., 2009). In the U.K. a study of 2,012 children found that children with a higher BMI were less likely to walk to school than normal weight children (Panter, et al., 2010a). Finally, active commuting to school was predictive of lower BMI *z*-scores in a sample of 1,170 children in Quebec (Pabayo, Gauvin, Barnett, Nikiema, & Seguin, 2010).

There is a little evidence to indicate an association between active commuting and healthy body composition. However, on balance, it appears that active commuting to school is not associated with healthy body composition. This is evidenced by several small, medium, and large scale studies conducted in the U.S., Denmark, and the U.K. It should be noted that body mass index was used as a surrogate measure of body composition in the majority of the studies cited above. The limitations of this technique, particularly in children, have been well documented (Garn, Leonard, & Hawthorne, 1983; Obarzanek, 1993). Depending sex, maturational status, and race, BMI may be an indicator of muscularity rather than fatness. A clearer relationship between commuting mode and body composition may be detected, if one exists, by using more accurate measures of body composition e.g. body fat percentage.

2.4.4 Summary of health benefits of walking to school

Four recent review articles corroborate what is reported in this section. Namely, (a) children who walk or cycle to school are more physically active than those who travel by inactive modes, (b) children who walk or cycle to school have higher levels of cardiovascular fitness than inactive travellers, and (c) active school travel has little impact on weight status or BMI (Davison, et al., 2008; Faulkner, Buliung, Flora, & Fusco, 2009; Lee, Orenstein, & Richardson, 2008; Sirard & Slater, 2008). There is little evidence to support an association between active commuting to school and BMI/weight status in children. There is, however, compelling evidence to support associations between active commuting to school and increased physical activity levels, and increased cardiovascular fitness; both of which are linked to reduced risk of many diseases, particularly in adulthood. Promotion of active modes of travel to school is therefore supported.

2.5 Measurement of School Travel in Children

Accurate measurements are important for understanding the basic characteristics of school travel and for the effective evaluation of interventions. Furthermore, a movement towards standardised measurement protocols would allow for comparisons between studies, which are difficult at present due to the variety of data collection and processing techniques used. The following sections provide a comprehensive breakdown of the various methods used to measure school travel modes and travel-related behaviour in children. Each method is described along with any strengths or weaknesses. Studies that have used each measure are cited. The various measures can be broadly dichotomised into objective and subjective categories and are dealt with under these headings in the following two sections of the literature review.

2.5.1 Objective measures.

Accelerometers.

Accelerometers are small hip-worn devices that objectively record bodily accelerations (Chen & Bassett, 2005) in one to three planes (depending on the make of device). Uniaxial accelerometers measure vertical movement and triaxial accelerometers measure in vertical and horizontal planes. Data from these devices are counts and steps. Counts are manufacturer specific arbitrary values that increase as acceleration increases. Cut points that correspond to metabolic equivalents (METs) can be applied to the count data (Freedson, Pober, & Janz, 2005) to calculate the period of time a wearer spends in different activity intensity categories (e.g. light, moderate, and vigorous). Counts are summed and stored across pre-selected sampling periods called epochs which range from 1 second to several minutes (Rowlands & Eston, 2007), and are selected based on researcher requirements.

Before use, devices are initialised via connection to a computer, using the relevant manufacturer software. This involves selecting a start date and time, epoch length, and subject name. After use data from the devices are downloaded into a raw data format which can subsequently be converted to different formats, for example Microsoft Excel. The strength of accelerometry is that it allows the user to identify when activity occurred (data are time stamped) and can be used to determine activity intensity. Additionally, the devices are contained in hard plastic cases that are not damaged easily and generally do not have buttons so cannot be tampered with by participants. Furthermore, accelerometers do not have visual displays, reducing the effect of reactivity. The weakness of accelerometry is that no data are provided on activity context (i.e. walking to the shops, playing with friends, in a car, or walking to school) (Matthews, 2005). However, some researchers are making progress in this area using pattern recognition techniques such as artificial neural networks to identify activity type (Staudenmayer, Pober, Crouter, Bassett, & Freedson, 2009). Another limitation of accelerometry is that devices can be relatively expensive (≈ £200 - £300).

Several school travel studies have used accelerometers as an outcome measure. Because accelerometer data can be processed and treated using different techniques, each of these studies has used accelerometer data slightly differently. Some studies used the accelerometer output to calculate daily physical activity (e.g. min/day of MVPA) to compare values between those who travelled to school by active modes and those who travelled by inactive modes (Chillon, et al., 2010; Cooper, et al., 2008; Cooper, et al., 2006; Rosenberg, et al., 2006). The most frequently used approach is to analyse data for segments of time across the day (Cooper, et al., 2005; Cooper, et al., 2003; Cooper, Page, Wheeler, Griew, et al., 2010; Ford, et al., 2007; Metcalf, et al., 2004; Sirard, Riner, et al., 2005; van Sluijs, et al., 2009). This provides an indication of the periods of the day during which children are most active (e.g. from 8-9 a.m. and 3-4 p.m. when children are travelling to and from school), which allows for specific comparisons to be made between active and inactive commuters with regard to activity volume and intensity. One study calculated activity (activity calories) for different modes of transport to and from school (Mackett, et al., 2005). Self-reported activity diaries were used to identify the time points between which the travel occurred, and may therefore be subject to a degree of error due to difficulty recalling exactly when events occurred. The Actigraph (Actigraph, Pensacola, FL) accelerometer was used in most of the cited studies. The RT3 (Stayhealthy Inc., Monrovia, CA) was used in one study (Mackett, et al., 2005) and the Caltrac (Hemokinetics, Madison, WI) was used in another (Rosenberg, 2006). Some of the studies used the total accelerometer counts or counts/min to describe activity, while others applied cutpoints to the count data to determine time spent in different intensities. Due to the different techniques used to process accelerometer data it is difficult to compare findings between studies. A consensus on one technique would help to overcome this problem.

Accelerometers are widely used in general physical activity research and also in school travel research (as indicated above). A more in-depth discussion of the issues surrounding accelerometry is therefore warranted. The following sections provide a comprehensive breakdown of these issues under relevant headings.

Choice of monitor.

Accelerometers generally fall under two headings: uniaxial and triaxial. Uniaxial accelerometers measure movement in the vertical plane only, whereas triaxial accelerometers measure in the vertical, anteroposterior, and mediolateral directions. Triaxial accelerometers also calculate a summary variable known as the vector magnitude, using data from the three planes combined. It has been shown that triaxial accelerometers provide a more accurate estimation of activity than uniaxial devices (Eston, Rowlands, & Ingledew 1998; Welk, 2005). However, differences are small and data from both types of device are highly correlated, indicating that they measure the same thing (Ott, Pate, Trost, Ward, & Saunders, 2000). Several device makes and models are available, including the Actigraph (GT1M, GT3X, GT3X+; ActiGraph Inc., Pensacola, FL), Actical and Actiwatch (Mini Mitter Co., Inc., Bend, OR), BioTrainer (IM Systems, Baltimore, MD), and the RT3 (Stayhealthy, Inc., Monrovia, CA). Actigraph models are the most widely used in research (Rowlands & Eston, 2007). Device selection may depend on personal preference/past experience, available reliability and validity evidence, cost of unit and resources available, and required output (e.g. counts, steps, estimated energy expenditure etc.).

Placement.

The bodily position on which an accelerometer is placed may affect the resultant estimation of physical activity. Most studies require participants to place the device on the left or right hip; however previous studies have required participants to place devices on the lower back, ankle, and the wrist. Studies have been carried out to determine which position provides the most accurate estimation of physical activity. In a study conducted under free living conditions, estimates of moderate and vigorous physical activity were not affected by placement when accelerometers were simultaneously placed on the hip and back (Yngve, Nilsson, Sjostrom, & Ekelund, 2003). Bouten et al. (1997) investigated the effect of device placement on accelerometer output and the prediction of energy expenditure during walking between six different locations (lower back, lower leg/foot, upper leg, head and trunk, lower arm/hand, and upper arm). Placement at the lower back produced the strongest prediction of energy expenditure, however data from all locations produced moderate to high associations with measured energy expenditure. In another study, no differences were found between total activity counts from monitors placed at the hip and lower back among 7 year old children during free-living conditions (Nilsson, Ekelund, Yngve, & Sjostrom, 2002). Finally, Welk and colleagues (2000) investigated the effect of placing 3 makes of accelerometer at three different hip locations (anterior-axillary line, mid-axillary line, and the posterior-axillary line) during walking in adults. No differences were observed between locations for two of the devices (BioTrainer and TriTrac-R3D). Significant but small differences were observed between locations for the Actigraph.

Evidence therefore supports the placement of monitors on the hip or lower back to obtain the most accurate estimation of physical activity behaviour (Trost, Mciver, & Pate, 2005). Interestingly, the large-scale NHANES study based in the United States recently moved to a wrist-mounted protocol, despite evidence to suggest that placement around the trunk area provides the most accurate estimation of activity. This decision was likely taken to increase protocol adherence in an effort to reduce data loss.

Epochs.

Data generated by accelerometers are summed and stored across user-specified time periods known as epochs. These typically range from anything between 1 second and 1 minute. Epoch selection is usually dictated by the memory size of the device being used; shorter epochs collect data more frequently and therefore more memory is used. This said, modern accelerometers tend to have relatively large memory capacities and so memory size does not determine epoch selection as much as it did with older devices.

It has been shown that using different epoch lengths affects the estimation of physical activity intensity. Edwardson and Gorely (2010) collected accelerometer data from 311 children and adolescents using 5 second epochs. Downloaded data were re-integrated in epochs of 15-, 30-, and 60-seconds. A significant epoch effect was found for time spent in vigorous physical activity, light physical activity, and rest in the child and adolescent samples, and for MVPA and moderate activity in the child sample. The authors concluded that shorter epochs should be used in child samples to obtain an accurate picture of their physical activity behaviour. Using longer epochs may result in a smoothing effect on the data, whereby sporadic peaks in activity are averaged across a period of time. In another study conducted by McClain and colleagues (2008) accelerometer data were collected using 5-second epochs in 32 fifth-grade children during a 30-minute physical education lesson. Resultant data were re-integrated into epochs of 10-, 15-, 20-, 30-, and 60-seconds. Direct observation of time spent in MVPA was used as a criterion reference. Data collected at 5-second epochs provided the most accurate estimation of time spent in MVPA. The authors concluded that shorter epochs (i.e. 5-second epochs) should be used in children, and that the use of longer epochs results in an underestimation of time spent in MVPA.

As an alternative to using epochs, some devices (e.g. Actigraph GT3X and GT3X+) allow for data to be collected in a ‘raw’ data format, using a pre-selected hertz sampling rate (i.e. 30Hz up to 100Hz in 10Hz increments for the GT3X+ device). Collecting data using this approach allows for data to be retrospectively processed using a variety of different epoch lengths, thus making the data more flexible.

Choice of cut-points.

Cut-points refer to the accelerometer count values that correspond to different thresholds of activity intensity; for example, sedentary, light, moderate, and vigorous. These thresholds help to interpret accelerometer output and can be used to determine time that individuals spend in different intensity categories. The threshold values are determined via calibration studies, whereby objectively measured energy expenditure (e.g. VO_2 or Kcals) is used to determine count values that correspond to the different activity categories.

The selection of cut-points for a study is problematic due to the number available. The choice is complicated further by the differing values of these cut-points. For example, available 1-minute cut-points for MVPA in children, equating to activity of 3 METs, range from 615 to 3200 counts/min (Metallinos-Katsaras, Freedson, Fulton, & Sherry, 2007; Puyau, Adolph, Vohra, & Butte, 2002). This difference in minimum and maximum cut-points will consequently result in either an under- or over-estimation of time spent in moderate to vigorous physical activity.

Until recently there has been no consensus on which accelerometer cut-points are most suitable for use in children. Trost and colleagues (2011) conducted a study in which they investigated the ability of five widely-used cut-points to correctly classify activity as sedentary, light, moderate, and vigorous. Using area under the receiver operating characteristic curve analysis, cut-points developed by Evenson et al. (2008) exhibited the best classification accuracy for all activity categories compared to the other cut-points. The authors concluded that the Evenson cut-points are the most appropriate for use among children. This equates to a threshold of 2296 counts per minute for MVPA.

Wear time and number of monitoring days.

Another important issue related to physical activity monitoring via accelerometer is the number of monitoring hours required to constitute a 'day' of monitoring, and the number of days of monitoring needed to provide reliable data. A criterion of 10 hours of monitoring is widely used to define a day of activity. This approach was suggested by Troiano et al (2008), and is calculated by subtracting non-wear time from 24 hours. Non-wear time is defined as 'an interval of at least 60 consecutive minutes of zero activity intensity counts, with allowance for 1–2 min of counts between 0 and 100' (Troiano et al., 2008, p. 182).

In relation to the number of days of monitoring required to provide a stable estimate of habitual physical activity, the evidence is varied. After reviewing studies that provided reliability estimates of activity monitoring across days, Trost and colleagues (2005) reported that the number of monitoring days needed to achieve a reliability of 0.80 ranges from 4 to 9 days. Additionally, after reviewing more recent literature, Basterfield et al. (2011) reported that the number of days required to obtain stable activity data from children ranges from 3 to 7. In their study of 291 6- to 8-year olds, Basterfield et al. (2011) found that 3 days of monitoring provided reliable physical activity data. These inconsistencies suggest that the number of monitoring days required for stable physical activity data in children may differ depending on age. However, as a general guide, it appears that monitoring across approximately 5 days would provide reliable activity data in children.

Processing technique.

The approach taken to process accelerometer data will depend on whether an individual's data are being treated individually or as part of a group. Individual data processing is used when supplementary data from that individual are used to inform data processing e.g. to process data between given time periods based on the individual's movements during the day, or using age-specific cut-points to define activity intensity. This will most likely be carried out manually having exported the raw accelerometer file into Microsoft Excel, and is very labour and time intensive. Mass/batch data processing is used when data for a group of participants are treated in the same way e.g. across the same periods of time, or using the same cut-points. Data processing software is available for this type of batch analysis. Programmes include MAHUffe software, GENEA suite, MeterPlus software, and ActiLife 5 software. These programmes allow the user to specify various parameters by which the accelerometer data are processed. These include stipulations regarding wear-time, cut-points, and time periods for analysis; making the job of data screening, cleaning, and processing much less onerous than doing so manually.

Missing data.

Missing data can be a threat to study validity through the loss of important information, reduced sample size, and the resultant loss of statistical power (Kang et al., 2009). It is therefore important to replace missing data where possible. Two well-used replacement techniques for physical activity data include the group information (GI) approach and the individual information centred (IIC) approach. The GI approach involves using a summary score (e.g. the mean) from the wider group to which the individual belongs to replace a missing value for the individual. This approach may not be suitable however, particularly for replacing physical activity data collected across repeated days. This is because inter-individual variability is higher than intra-individual variability (Tudor-Locke et al., 2005). A more suitable approach therefore, is to use the remaining data for a given individual to replace their own missing data (for example, when a participant is missing one of four measurement days). This IIC approach uses the remaining data for an individual to replace a missing value (or values), and has been shown to be a more accurate approach to replacing missing data than GI techniques (Kang et al., 2005; Kang et al., 2009).

Limitations.

Although accelerometry is seen as a relatively accurate and practical measure of physical activity, it does have limitations. Possibly the biggest limitation is that no information is provided on activity context. Therefore, although information regarding volume and intensity of activity is available, it is not possible to determine the type of activity that has been undertaken. Additionally, accelerometers cannot accurately measure energy expenditure during certain activities. Specifically, inaccurate data will be provided after measurement during cycling, swimming, or weightlifting. Inaccuracy in the measurement of cycling is particularly problematic in the context of active school travel, where the result is an underestimation of activity for children who cycle to school. Finally, accelerometers struggle to accurately record during very low and very high intensity activities. It has been shown that inaccurate recordings are taken during slow/shuffling walking (Storti et al., 2008) and at high running speed - where activity counts begin to plateaux or even drop off (Brage et al., 2003a; 2003b; Rowlands et al., 2007).

Pedometers.

Pedometers are small hip-worn devices that measure ambulatory physical activity in the form of steps. Older-style pedometers measure steps via a sprung lever arm mechanism that closes an electrical circuit following vertical bodily movements (Melanson, et al., 2004). Developments in device design have led to sophisticated piezoelectric mechanisms being incorporated into pedometers. These devices produce sine waves that are interpreted as steps and also activity intensity (Tudor-Locke & Lutes, 2009). Several brands of pedometer are available, although commonly used research-grade makes include Omron, Yamax, New Lifestyles, Walk4Life, and Kenz Lifecorder. Not all brands of pedometer count steps accurately and variation exists between device output under the same conditions (McClain, Hart, Getz, & Tudor-Locke, 2010; Schneider, Crouter, Lukajic, & Bassett, 2003). Additionally, greater variation exists under certain conditions e.g. slow walking speeds, fast walking speeds, or when being used by individuals with obesity. Validity and reliability evidence should therefore be established for a device before use in a research setting.

The strengths of pedometers for large scale physical activity observation include their low cost (between £5 and £50 depending on brand and mechanism), simplicity of use, instant feedback, and memory function. Pedometers do have weaknesses however, including provision of steps but not activity intensity (other than expensive piezoelectric devices), absence of context specific data, and their inability to measure non-ambulatory physical activity (e.g. cycling or swimming).

Pedometers have only been used once to measure school travel-related physical activity. Abbott et al. (2009) used the Yamax Digi-Walker SW700 to determine if Australian children (*n* = 2076, aged 5-17 years) who walked to school were more likely to meet daily step guidelines than their counterparts who took inactive modes. The proportion of children who met the daily step guidelines was higher among those who walked to school.

Global Positioning System.

The Global Positioning System (GPS) comprises of 24 satellites that orbit the earth (Maddison & Ni Mhurchu, 2009). These satellites emit signals that are picked up by GPS receivers. Using triangulation and trigonometry the location of GPS receivers on the Earth's surface can be tracked relatively accurately. GPS technology has recently been used in physical activity and transportation research to generate useful spatial data regarding routes taken and the location of individuals' activity. Furthermore, GPS data can be merged with accelerometer data and global information systems (GIS) to provide a rich picture of activity intensity in different environments. Using GPS in this way is relatively novel however (within the past 5-6 years), and only a few studies have used this approach (Cooper, Page, Wheeler, Hillsdon, et al., 2010; Maddison, et al., 2010; Oliver, Badland, Mavoa, Duncan, & Duncan, 2010; Quigg, Gray, Reeder, Holt, & Waters, 2010; Rodriguez, Brown, & Troped, 2005; Seeger, Welk, & Erickson, 2009).

GPS has been used in two studies to investigate school travel behaviours. Duncan and Mummery (2007) compared various characteristics of GIS-estimated routes to school with actual routes taken (measured by GPS) in a sample of 75 Australian primary school children. They found no difference between GIS-estimated distance and actual distance taken. However, GIS-estimated routes crossed significantly more ($p < .05$) busy streets compared with GPS measured actual routes. It was concluded that GPS measures should be used in favour of GIS-estimates of travel routes.

Cooper et al. (2010) combined GPS and accelerometer data to investigate the level and location of physical activity on the journey to school in a sample of 137 English primary school children. Data collected outside the school boundary was classed as travel data, and data inside the boundary of the school was classed as playground data. GPS data mapped onto GIS suggested that children took direct routes between home and school before clustering in the playground prior to the start of school. An additional finding was that activity on the journey to school (outside the playground) was of a significantly higher intensity (2131.3 ± 1170.7 vs 1089.7 ± 938.6 counts/min, $p < .001$) than activity inside the school boundary (playground).

There are a number of strengths and weaknesses to using GPS measures of travel behaviour. The major strength of GPS technology is that data generated provide a context for physical activity, allowing for an investigation of how aspects of the physical environment link with physical activity behaviours. This is enhanced when GPS data are merged with accelerometer data and GIS information, allowing for identification of where the most intense or sedentary behaviours occur. However, this presents a burden in that two measuring devices are required. Due to technological developments, single devices are becoming available that are capable of measuring GPS and accelerometer data simultaneously, thus reducing costs and researcher burden. Limitations of using GPS devices include (a) their cost (≈ £100 - £200), (b) short battery life, (c) inability to measure indoors, under heavy tree cover, and near tall buildings, and (d) an initialisation period of up to 5 minutes when first switched on to establish a satellite lock.

Direct observation.

Direct observation involves the surveillance and recording of individuals' travel behaviours at a certain location (e.g. near the school entrance). As children arrive (or leave) school their mode of travel is recorded by one or more trained observers. This technique has been used in three school travel studies.

Suminski et al. (2006) developed and implemented a direct observation protocol for measuring children's school commuting behaviour. Observers stood outside the school grounds with a view that included the school entrance and a transport route to the school. Children who walked or biked from a distance of at least 50 yards (denoted using flags) from the observation point were counted as active commuters. Similarly, on the journey home, children were counted if they exited from the entrance and walked or biked past the 50-yard point. This procedure achieved a between-observation agreement ranging from 97.0% to 100% for identifying child and adult walkers and cyclists on the journey to and from school (Suminski, Petosa, Poston, Stevens, & Katzenmoyer, 2006). The intraclass reliability coefficient for 2 days of observations exceeded .90 for children and adults walking (children: r = .97; 95% CI .92 to 1.0 and adults: r = .91; 95% CI .72 to .98).

Sirard et al. (2005) used direct observation to establish the prevalence of different commuting modes in eight elementary schools (*n* = 3911) in the Southeast United States. Two to three observers recorded children's commuting modes for 60 minutes before and after school, and recorded the results on a specially designed form.

Boarnet et al. (2005) used observations of traffic flow and pedestrian counts to evaluate 10 safe routes to school (SR2S) projects in California. Measures were taken before and after the SR2S traffic improvement projects. Increases in walking to school were observed in five of the 10 project locations.

Strengths of direct observation over other methods include (a) avoidance of low survey response rates, selection bias, and recall errors, (b) accuracy of data, and (c) no participant burden. A limitation of this method is the inability to discern individual behaviour. Using this technique it is not possible to track the behaviours of an individual or link a certain participant to any other data (e.g. age, ethnicity, social status, or views on the environment) in the same way that can be done with accelerometer or pedometer data. This method would be improved by incorporating some type of identification system that would allow an individual's travel behaviour (e.g. observed commuting mode) to be linked to other relevant data (e.g. social status, self-efficacy, or attitudes about the environment). Another limitation of this technique is that it is relatively researcher intensive; at least one researcher must be present in the school vicinity before the start of school and at the end of the school day.

2.5.2 Subjective measures.

Self-report.

Self-reported measures of commuting behaviour involve participants providing information about how they travel to and from school. This measure has been used in some form in almost every school travel study that has been conducted. In essence, the question "How do you usually travel to school?" is asked of the participant, although the exact wording of the question may vary slightly. Examples of self-report methods used in previous studies include (a) a daily checklist on commuting mode (Baslington, 2010; Heelan, et al., 2005), (b) a computerised mapping system including mode of transport used for journey (McKee, 2007), (c) a Web-based questionnaire (Leslie, et al., 2010), (d) a computerised questionnaire (Page, et al., 2010), (e) a 24-hour recall questionnaire (Abbott, et al., 2009), and (f) a hands-up survey measuring mode of travel used on the same day (Sustrans, 2009).

In terms of strengths, self-reported measures are inexpensive and easy to administer to large numbers of participants. This is particularly useful when budgets and resources are restricted. Furthermore, participants' data can be linked to other data gathered for that individual. The main weakness with self-reported techniques is that they are susceptible to social desirability. Another weakness of self-report, particularly in children, is difficulty in recalling past events accurately and cognitively understanding concepts of time (Rowlands & Eston, 2007). Other weaknesses of self-reported data include low response rates and completion errors. Furthermore, if data are collected via paper and pencil it can be time consuming to enter large numbers of surveys, and this method is also prone to human input error.

Parent-report.

Parent-report (or parent proxy) involves a parent providing data on behalf of their child. In relation to commuting studies this involves a parent being asked how their child usually travels to and from school. Examples of this method in the literature include (a) national household surveys (Tudor-Locke, et al., 2002), (b) paper and pencil questionnaires (Duncan, Duncan, & Schofield, 2008; Yeung, et al., 2008; Ziviani, et al., 2004), and (c) via telephone interview (Fulton, et al., 2005; Salmon, et al., 2007).

Similar to child self-reported measures, this technique is relatively inexpensive compared to other methods. Additionally, this approach may be less susceptible to social desirability compared to child self-report measures (parents are detached from the school location and have less to gain by providing inaccurate information). However, to the author's knowledge there is no evidence to support this viewpoint.

Diaries.

Travel diaries are a means by which data can be generated about the nature of a child's trip to or from school. They take the form of a sheet of paper (or potentially an electronic PDA-type device) with spaces for information such as home/school arrival time, mode of travel, travel companion, and locations visited en route. Travel diaries have been underused in school travel studies, with only two available examples. Mackett et al., (2005) used a travel diary as one of a battery of tests to look at the role of travel as a contributing factor in children's daily physical activity. The diary was used to collect data regarding the child's movements across the day, including arrival time at each location, mode used to get there, activity undertaken at the location, and time of departure. These data were used to inform activity monitor data processing. Baslington (2010) used a slightly less detailed diary to collect data from Monday to Friday on how each child travelled to and from school, and how long each journey took. These data were used to evaluate school travel plans at three schools.

Travel diaries are useful, particularly when matched with accelerometer data, as they provide a context to activity (similar to GPS, but less accurate due to the self-reported nature of the data). This allows a picture to be built that provides in-depth information about school travel behaviours. Additionally, travel diaries are inexpensive and provide a practical, yet less accurate, alternative to GPS devices. Similar to other self-report measures, weaknesses of using diaries include susceptibility to social desirability, inaccurate recording, and low response rates. Furthermore, because diaries have been underutilised there is not a recognised approach to dealing with diary data.

Interviews.

The final method of obtaining commuting-related data covered in this section of the literature is interviewing. This technique involves one person questioning another person on the topic of interest. Interviews can be in various formats. These different formats have been used in school travel studies and include telephone interviews (Beck & Greenspan, 2008; Collins & Kearns, 2010; Fulton, et al., 2005; Salmon, et al., 2007), focus groups (Kirby & Inchley, 2009), and one-to-one interviews (Pabayo, et al., 2010; Spinks, Macpherson, Bain, & McClure, 2006).

Interviews can be helpful to answer questions about why certain behaviours are performed, but are very time-consuming and resource-intensive if collecting data on a large sample. Often interviews are used to generate in-depth data on a small number of people. It is often difficult therefore, to generalise findings obtained from interviews.

2.5.3 Summary of measures

The preceding sections have provided a comprehensive breakdown of the various techniques available for measuring school travel behaviour. A researcher's choice of measure will be informed by several factors such as experience, resources available, time, money, accuracy required, practical issues (e.g. sample size), and scope of the study. Researchers should remember that in general, as the simplicity of assessment increases the precision of the measure decreases. For example, fitting participants with portable indirect calorimetry units would be one of the most accurate methods of measuring children's energy expenditure during the school commute, however, this would not be practical or affordable. A balance must be found between practicality and accuracy.

2.5.4 Reliability and Validity

Reliability and validity are key concepts in measurement theory, and are crucial for obtaining accurate and trustworthy data, with minimal error. This section provides a brief description of reliability and validity, and identifies techniques used to obtain reliability and validity evidence.

Reliability is an important concept in measurement theory, and refers to the consistency, or repeatability, of a measure (Thomas & Nelson, 1996). Reliability is primarily concerned with the degree to which an instrument can obtain measures that are free from measurement error (Litwin, 1995). Reliability may be established using techniques such as internal consistency, test-retest methods, and inter-rater reliability. The technique used is likely to be determined by the measure being investigated and the way in which it will be used. For example, the reliability of a group of questionnaire items for measuring a certain construct may be assessed using internal consistency. This is commonly measured using Cronbach's alpha (Cronbach,

1951) which provides an indication of how well the different items measure the same construct. Test-retest reliability assesses an instrument's ability to reproduce results across a time period, such as a week. For example, a group of participants may complete a questionnaire on two occasions. The correlation between these two trials can then be calculated. A high correlation between trials would indicate good test-retest reliability, suggesting that the measure is stable. Finally, inter-rater reliability investigates the ability of two raters (or judges) to assign the same scores to the same participants. For example, inter-rater reliability could be investigated for two observers counting the frequency of participants arriving at school on foot.

Validity is another important concept in measurement theory and is concerned with the degree to which an instrument measures what it is supposed to measure. It is important to note that validity is a single (or unitary) concept (Sechrest, 1984), and to suggest that different types of validity exist is inaccurate. Furthermore, validity is never achieved as such; rather, evidence may be gathered to support the validity of a given measure and the scores obtained from that measure. There are three generally accepted types of evidence for validity; these are content-related evidence, criterion-related evidence, and construct-related evidence.

Obtaining content-related evidence is a relatively subjective way of assessing the appropriateness of a measure. This usually involves a measure being reviewed by individuals who have a good knowledge of the subject area in which it is to be used. The reviewers check that the measure taps into every aspect of the construct/outcome that it should, and that it does not include anything it should not (Sechrest, 1984). Although statistical tests are not typically used to generate content-related validity evidence, it is possible for judges to rate certain aspects of a measure, making the process more objective. For example, this process is used with the content validity index (CVI), where experts rate items based on their relevance (Polit, Beck, & Owen, 2007). Content-related validity evidence is typically gathered during the test development stage.

Criterion-related validity is concerned with how well a measure compares to another measure that is considered to be a *gold standard* (Litwin, 1995). This is often carried out when a less expensive or more practical measure is being proposed to replace a more expensive or less practical measure. Criterion-related validity evidence is established by correlating two measures. Alternatively, differences between the measures can be investigated. The higher the correlation is, or smaller the difference, the more valid the measure.

Finally, construct validity can be viewed as the degree to which the measure is linked to the theoretical construct it purports to measure, and is viewed as the centre point of validity theory. Construct validity provides evidence to help answer questions such as “What does this test measure?” (Sechrest, 1984) and “What inferences or interpretations can be made from the scores obtained from this measure?” (Mahar & Rowe, 2002). The known difference method is often used to provide construct validity evidence (Rowe & Mahar, 2006). This technique is based on the premise that mean scores obtained by a measure of a given construct should differ if the scores have been obtained from two populations that differ (based on theory) on that construct. For example, construct validity of a pedometer may be established by measuring weekly steps in a group of office workers and a group of postal delivery workers. The group of postal delivery workers would be expected to take many more steps across a week than the office workers. Construct validity evidence for the pedometer would be supported if it differentiated between these two groups.

It is important to note that for an instrument to be valid it must be reliable, however reliability alone does not constitute validity, e.g. an instrument may measure consistently but if it does measure what it is supposed to then it cannot be classed as valid.

In the pilot work for the present study test-retest reliability was determined for a new questionnaire designed to collect data on various aspects of primary school-aged children’s school travel behaviour. In addition to this, validity evidence for the New Lifestyles NL-1000 pedometer was investigated, as well as the validity of a travel diary for measuring home arrival time after school.

2.6 School Travel Interventions

This section of the literature review focuses on the three predominant interventions available in the school travel literature: Safe Routes to School, the Walking Bus, and Travelling Green. A description of each is given and evidence to support the effectiveness of each intervention is also provided. It should be noted that other school travel interventions/programmes exist, however there is a paucity of evidence for the effectiveness of these interventions, hence the reason these mentioned interventions have been selected for this review. Other interventions/programmes not covered in this review include walk to school days/weeks/months (Merom, Rissel, Mahmic, & Bauman, 2005), school travel coordinators (Rowland, DiGuiseppi, Gross, Afolabi, & Roberts, 2003), and multi component programmes (Wen, et al., 2008).

2.6.1 Safe Routes to School.

The Safe Routes to School (SRTS) programme is a federally funded active transport initiative in the U.S. The programme aims to increase active commuting to school, make walking and cycling to school safer, and reduce traffic in the school vicinity via infrastructure and non-infrastructure strategies. Infrastructure strategies include implementing bicycle lanes, trails, pathways, pavements, infrastructure improvements, and traffic calming measures (Hubsmith, 2006). Non-infrastructure strategies include education, encouragement, and enforcement. To finance these strategies each state in the U.S. is provided with $5 million across 5 years ($1 million per year), of which 70-90% must be spent on infrastructure-related projects and 10-30% allocated to non-infrastructure approaches. Interventions (projects or strategies) delivered at the state level must fall under one of the “5 E’s” associated with SRTS. These are *Engineering, Education, Encouragement, Enforcement, and Evaluation* (Martin, Moeti, & Pullen-Seufert, 2009). Engineering encompasses the infrastructure-related strategies that have been mentioned. Education, encouragement, and enforcement are concerned with non-infrastructure approaches including public awareness campaigns, outreach to the media and community leaders, traffic education at schools, bicycle and pedestrian safety education for children, and funding for training, volunteers, and managers of SRTS programs (Martin, et al., 2009). Evaluation overarches the other four elements and ensures that any project or strategy is appraised to see how effective it has been. The rest of this section focuses on evaluations of SRTS projects that have been published in peer reviewed journals.

Considering the scale of the SRTS scheme, few quality studies have evaluated the programme. In Marin County, California, researchers investigated the effect of a multi-pronged approach to increase active school travel and reduce car use. Participants were 1743 students from 6 elementary (primary) schools. The intervention was labelled the Marin County Safe Routes to School Program. The approaches used in this programme were: mapping safe routes to school; walk and bike to school days; frequent rider miles contest (points for walking and biking to school, and for car pooling or using the bus); classroom education (including safety and education on travel mode choice decisions); implementation of walking buses and bike trains; and presentations at the state and national level by SRTS staff (Staunton, et al., 2003). A measure of school travel mode (simple show of hands student survey) was taken before the programme was implemented in 2000 and two years after the programme began 2002 (the programme continues to run and receive funding). During this timeframe there was an increase in walking (64%), biking (114%), and carpooling (91%), and a reduction in car use where only one child was in the car (39%). The study is limited by the subjective measure of commuting mode. Untrained researchers asked students to raise their hands to indicate which mode of travel they used to get to school on the morning of the survey. This technique is open to social desirability. The study would benefit from the use of control schools and more robust measures of commuting behaviour.

Boarnet et al. conducted two studies in 2005 investigating the impact of California's SRTS construction (infrastructure) programme. One of the studies examined cross-sectional associations between passing completed SRTS construction projects on the way to school and travel mode (Boarnet, Anderson, et al., 2005). Three infrastructure improvements at 10 schools were investigated in this study (crossing, sidewalk, and traffic control improvements). Participants were 862 parents of 3rd to 5th grade students (ages 8-11 years). Travel surveys were distributed to the parents at schools that had a completed SRTS project nearby. Children who passed the completed SRTS projects on their usual route to school increased their active commuting more (by 15.4%) than children who did not pass a completed SRTS project on their usual route to school (4.3% increase). This difference in proportions was significant (t statistic for difference in proportions = 5.71, $p < .01$).

The other study conducted by Boarnet et al. used multiple case studies at the same 10 schools. Measures were taken before and after completion of the SRTS construction projects. These were related to: perceived pedestrian and bicycle safety; behaviours that impact actual safety (e.g. traffic speeds); and children's commuting behaviour (Boarnet, Day, Anderson, McMillan, & Alfonzo, 2005). Surveys were provided by 1,778 parents before and 1,243 after construction completion. Of the 10 construction projects evaluated, five were deemed to have been successful. All five were either sidewalk improvements or traffic signal improvements. At those sites on which sidewalk improvements were made there was an increase in observed walking (direct observation). Furthermore, children who had sidewalk improvements on their usual route to school were more likely to increase walking than children who did not have the sidewalk improvements. Two of the ten projects were based on improvements to traffic signalling. At these two schools pedestrian counts (observed and survey response) increased post-construction, and traffic speed (observed) decreased at these two schools.

These three studies provide positive results in support of the SRTS programme. The findings should, however, be viewed in light of the study limitations. Two of the studies that measured travel outcomes at pre- and post-intervention did not use control groups (Boarnet, Day, et al., 2005; Staunton, et al., 2003). Any observed effect on travel behaviour may be attributed to some other phenomenon other than the intervention (for example maturation effects, or weather effects). These two studies would therefore be strengthened by the use of control schools. The other study used a cross-sectional design (Boarnet, Anderson, et al., 2005) and findings are therefore concerned with associations and not causation. Furthermore, the primary outcome of travel behaviour (or mode) in each study was self- or parent-reported, measures associated with well-known problems such as social desirability and low response rates. Again, these studies would be strengthened by objective measures of travel behaviour.

2.6.2 Walking Buses.

Walking Buses involve groups of children that walk to and from school along a pre-defined route at a set time. The route passes stops where children may join or leave the bus. Walking Buses are supervised by two or more adults, one who leads the bus (driver) and the other who follows at the back (conductor). Adults are generally parents of the children, and their job is to guide the bus safely between the start of the route and the school (Collins & Kearns, 2005). The concept was conceived in the early 1990s by David Engwicht, an Australian transport activist (Neuwelt & Kearns, 2006) and the first Walking Bus in Britain was established in St Albans, England, in 1998 (CAST, 2000). Since their introduction, Walking Buses have grown in popularity. This is because they are cheap, can be implemented quickly, and are a visible sign that something is being done to curb the widespread decrease in active school travel (Mackett, Lucas, Paskins, & Turbin, 2002). Several studies have investigated the usefulness of Walking Buses. However, only two have been designed to empirically assess their impact on children's commuting behaviour (Heelan, et al., 2009; Mendoza, Levinger, & Johnston, 2009). The remaining studies used qualitative approaches to investigate parent and child perceptions of the benefits of the Walking Buses.

Heelan et al. (2009) used a quasi-experimental design with 2 intervention schools (n = 201) and a control school (n = 123) to investigate the effect of a Walking Bus on commuting behaviour in Nebraskan children. The primary outcome measure was self-reported prevalence of walking. Measures were taken at six time points across 2 years (one pre-intervention measure and five post-intervention measures). The prevalence of walking to school at baseline was similar for the intervention and control group. Prevalence of walking to school was significantly higher ($p < .05$) at each post-intervention time point for the intervention group compared to the control group, suggesting that the Walking Bus was effective at increasing walking to school.

The other quantitative evaluation of a Walking Bus scheme was conducted by Mendoza et al. (2009). The study aimed to investigate the effect of Walking Buses in low-income urban areas of Seattle, Washington. This was a quasi-experiment with one intervention (n = 347) and two control (n = 473) schools. The primary outcome was the proportion of participants who walked or were driven to school. Measures were taken by school teachers, who asked children to raise their hand to indicate how they travelled to school on the morning of the survey. Measures were taken at baseline and 1 month, 6 months, and 12 months post-intervention. Baseline prevalence for walking to school did not differ between groups. However, at 1, 6, and 12 months significantly higher proportions of children walked to school at the intervention school than the control schools. At 12 months post-intervention 25% of children walked to the intervention schools compared to 7% who walked to the control schools. Again, the Walking Bus appeared to contribute to a higher prevalence of walking to school.

Several qualitative evaluations of the Walking Bus have been conducted. These studies were all conducted in New Zealand and generally aimed to gather data on child, parent, and stakeholder attitudes towards the scheme. Data collection techniques included formal and informal interviews (Kearns, Collins, & Neuwelt, 2003; Kingham & Ussher, 2005, 2007; Neuwelt & Kearns, 2006), telephone interviews (Collins & Kearns, 2005), and observations of walking buses (Kearns, et al., 2003; Neuwelt & Kearns, 2006). Some of these studies used mixed methods (i.e. qualitative and quantitative techniques).

One study conducted telephone interviews with school principals and Walking Bus coordinators. It was estimated that a cumulative total of 429 vehicle journeys were saved by Walking Bus routes for each day of operation (Collins & Kearns, 2005). Parents and principals in this study felt that Walking Buses helped to promote wellbeing, specifically in relation to socialisation and safety. Additionally, parents found it easier and less stressful in the morning to allow their child to go with the Walking Bus than to get their child in the car and negotiate traffic to get them to school. The most frequently reported challenge with Walking Buses was difficulty recruiting volunteers to act as drivers and conductors.

In another study, people involved in running the Walking Buses (usually parents) were interviewed to assess the perceived benefits of walking buses in Christchurch (Kingham & Ussher, 2007). One of the most frequently reported benefits from parents was the sense of community that was created by the Walking Bus. This resulted in new friendships for children and their parents. The second most commonly reported benefit was concerned with the children’s health. Although not quantifiable, many parents reported seeing improvements in the health of the children on their Walking Bus. Finally, the third most frequently acknowledged benefit of the Walking Bus was related to time. Specifically, parents reported that they had more time to themselves and one parent reported being able to return to part-time work because of the Walking Bus.

Neuwelt and Kearns (2006) conducted a study to investigate the perceived health benefits of Walking Buses in Auckland. Formal and informal interviews were conducted with children (n = 45) and parents (n = 6) who participated in Walking Buses at four primary schools. Children across all schools generally preferred to walk than take motorised transport. The perceived benefits of using the Walking Buses from the children's perspective were summarised as: creating new friendships, the enjoyment of walking, fitness gains, overcoming fears, becoming safer, and the naturalness of walking (Neuwelt & Kearns, 2006). Drivers (parents) of the walking school buses perceived the following benefits: developing new relationships and caring for neighbourhood children, improving children's attitudes towards physical activity, developing safer road users, and other community benefits.

Kearns, Collins, and Neuwelt (2003) conducted a survey of parents to ascertain perceptions about the benefits, limitations, and long term viability of the Walking Bus. Participant observations and conversations with children in Walking Buses were also carried out over a week. The initiative led to an estimated 19.5 fewer cars arriving outside the school at both drop-off and pick-up times on an average day. Parents perceived the following benefits of the Walking Bus: time saved, removal of hassle of driving and parking, and knowing their children were safe. Parents reported that their children benefitted from the healthy aspects of exercise, mixing with other children, and developing independence through walking. Conversations with participants in the Walking Bus revealed that children valued the exercise and social aspects.

Based on findings from the two quantitative studies and the various qualitative studies, it appears that Walking Buses are not only effective at increasing walking to school, but are highly valued by those who facilitate and participate in them. Despite these generally positive findings, a group of authors concluded that attempts to increase active school travel by means of the Walking Bus may be in vain. Examples of this viewpoint include: "they are, at best, an ambivalent response to the hegemony of motorized transport" (Kearns, et al., 2003, p. 285), "the initiative has a limited ability to address public health challenges originating within an inequitable and car-dominated urban political system" (Collins & Kearns, 2005, p. 61), and "supervised walking is neither the sole answer to children's mobility needs, nor a panacea for the ills of auto-dominated environments" (Collins & Kearns, 2010, p. 7).

Although there may be some merit in their viewpoint, Collins and Kearns may be a little narrow-minded in their conclusions. It is doubtful that the designer of the Walking Bus intended to be a cure-all for the *ills of auto-dominated environments* or to banish the car from daily life. Instead, the Walking Bus provides a helpful alternative to car use, particularly for working parents. Short of solving the public health woes created by our car-dominated culture, the Walking Bus has been shown to increase walking to school and may make a small dent in the rising trend in motorised school travel.

2.6.3 Travelling Green.

The Travelling Green resource is described only briefly here as a more detailed description is provided later (chapter 2, section 2.8). Travelling Green is a 6-week school based active commuting resource, with the primary aim of bringing about a modal shift from motorised transportation to walking. Walking to school is promoted via a set of 13 curricular lessons delivered by the class teacher and goal-setting exercises whereby children aim to walk to school more on each day of the project. The curricular lessons cover road safety, a healthy lifestyle, human anatomy (heart and lungs), environmental issues, and the Highway Code. The resource consists of a Teacher's Handbook and Pupil Packs. The Teacher's Handbook contains the 13 curricular lessons. The Pupil Packs contain wall charts so children can record how they travel to and from school each day. Sheets are also available to set walking goals that can be signed by the parents and teacher. Scottish Government funding has made the resource available to every school in Scotland.

Only one study has evaluated the effectiveness of Travelling Green. McKee et al. (2007) used a quasi-experimental design to investigate the effect of Travelling Green on school travel behaviour in a small sample of Scottish school children. The main outcome measure was self-reported distance travelled by mode. Two schools participated in the study, one intervention (*n* = 31) and one control (*n* = 29). Following the intervention, children increased the self-reported distance walked to school by an average of 602 metres (389%) whereas the control school increased by only 47 metres (17%). Furthermore, distance travelled to school by inactive mode decreased by an average of 900 metres (57.5%) in the intervention school and increased by 50 metres (1.5%) in the control school. Based on these findings it appears that Travelling Green can successfully bring about a change in commuting behaviour in children.

Compared to other walk to school interventions (e.g., SRTS and Walking Bus) there is a lack of research to support the efficacy of Travelling Green. Furthermore, the study conducted by McKee et al. was limited by a small sample and lacked objectively measured physical activity as an outcome. A more robust evaluation of the Travelling Green resource is therefore warranted.

*2.*7 Intervention Evaluation

Considering the cost and resources required to implement school travel interventions, it is important that interventions are evaluated effectively. If an intervention does not successfully bring about an increase in children's active travel to school, questions must be asked about the wisdom of investing time and money to implement the intervention.

Intervention evaluation studies should incorporate features that ensure trustworthy inferences may be made about the intervention's impact. First, evaluation studies should be well designed. Ideally, this means using an experimental design whereby participants are randomised into either the intervention or control group. This controls for potential effects of selection bias i.e. those who receive the intervention are systematically different to those in the control group. Cluster randomised controlled trials are sometimes viewed as unethical because they deprive a group of individuals from something that is hypothesised to be beneficial for them. However, depending on the intervention, it is often possible to administer a delayed intervention to the initial control group, thus all study participants receive the intervention by study completion. If an experimental design is unsuitable or deemed unethical alternative designs may be used, such as clustered randomised trials or stepped wedge designs (Craig, et al., 2008). Second, the study should be powered such that any effects of the intervention can be detected i.e. the sample size is large enough to detect effects of a pre-determined size for a given significance level. Third, valid and reliable outcome measures should be used to capture the behaviour targeted by the intervention. If unreliable or invalid measures are used it will be impossible to determine if the intervention has had an effect. Fourth, maintenance (or follow-up) measures should be taken to determine the lasting impact of the intervention (Stone, McKenzie, Welk, & Booth, 1998). This may involve taking post-intervention measures at 6 and 12 months, for example, and will help to establish if behaviour change is temporary or more long-lasting. Finally, evaluations should include process and cost evaluations to establish if the intervention has been implemented as intended, and to determine the relative and absolute cost of implementing the intervention (e.g. training and material costs).

School travel intervention evaluations to date have lacked these marks of quality. In particular, they have used weak outcome measures, lacked control groups, and failed to take maintenance measures. One of the aims of the present study was to conduct an evaluation of the Travelling Green resource incorporating some of the features identified above.

2.8 Travelling Green

Travelling Green is a six week active travel resource designed for use with primary 5 aged Scottish school children (age 8-9 years). It aims to increase walking to school through educational lessons and goal-setting activities. The resource was conceived by a student at the University of Strathclyde, who subsequently evaluated the project using a quasi-experimental design. Children who took part in the project increased the self-reported distance travelled actively to school and reduced the self-reported distance travelled inactively (McKee, et al., 2007). Following these promising results the project was further developed and refined by West Dunbartonshire Council in collaboration with NHS Greater Glasgow and NHS Argyll and Clyde. The resource was made more compact by reducing some content from the original resource so it could be easily implemented across many schools. In 2003 West Dunbartonshire Council won the National Transport Award for Road

Safety for the Travelling Green project. The resource was subsequently funded by the Scottish Government to be made available to every primary school in Scotland. Distribution of the resource is coordinated by the sustainable transport organisation Sustrans.

The resource has two components – a Teacher's Handbook and a Pupil Pack. The Teacher's Handbook explains the resource for the class teacher including (a) how the project links with the Curriculum for Excellence (Scottish National Curriculum), and (b) how using Travelling Green can contribute towards Health Promoting Schools and Eco Schools accreditation (Scottish Government initiatives encouraging schools to be healthy and environmentally aware). The Teacher's Handbook also contains some introductory activities for the pupils, and 13 lesson plans that can be used at the teacher's discretion during the 6-week intervention. Lessons can be linked to other topics and themes that the class is covering. There are also sheets in the Teacher's Handbook that can be photocopied for use during these lessons. Table 2.3 provides the names and aims of the available lessons.

Table 2.3 Lessons in the Travelling Green Teacher's Handbook

No.	Lesson Name	Aim
1	Understanding the Local Environment	To develop an informed knowledge of the local area.
2	Walking the Route	To develop an awareness of the dangers of traffic.
3.1	Devising Questionnaires	To devise a questionnaire that will measure school travel modes.
3.2	Interpreting Questionnaires	To display, interpret, and discuss data that has been collected.
4	Mapping Skills	To locate and identify information from maps i.e. identifying hazards and walking routes.
5.1	The Heart	To develop a simple understanding of how the heart, lungs, and muscles work.
5.2	The Heart	To understand the relationship between fitness, pulse rate and physical activities.
6	The Lungs	To develop an understanding of the importance of the lungs.
7	Healthy Food/ Lifestyle	To be aware of the relationship between food, energy, and activity.
8	Responsibilities, Rules and Friendships	To demonstrate strategies for keeping safe as a pedestrian.
9	The Green Cross Code	To develop a sound knowledge of road safety in order to become independent road users.
10	The Highway Code	To develop an understanding of the meaning and use of road signs.
11	Fluorescent/ Reflective Clothing	To show an awareness of the need to wear appropriate clothing as a pedestrian to be seen by others.
12	Letter to local authority	To demonstrate ways of responding to risks to safety while travelling as a pedestrian.
13	Poetry	To show an awareness of safety/environmental issues related to walking to school.

As part of the intervention each child receives a Pupil Pack. This is a small folder containing various components to encourage the children to walk to school. The folder contains two wall charts; one to put up at home, to record travel mode from school to home on each day of the project and one for school, to record travel mode from home to school on each day of the intervention. On the reverse side of the home wall chart there is information for parents about the Travelling Green intervention, why walking to school is good for their child, some of the barriers to walking to school, and some information about how they can help their child walk to school. The Pupil Pack also contains two other short booklets. One of these is an information guide for the child telling them about the Travelling Green resource. The other booklet is labelled *My Travel Challenge.* This is the goal-setting element to Travelling Green, where the child sets targets to walk a little more on each week of the intervention. There are spaces in the booklet for the parent and the teacher of the child to sign, in acknowledgement that the goal has been set. There are also two yellow Travelling Green logo reflective stickers for children to attach to their bag or clothes.

2.9 Theoretical frameworks

Most school travel studies have not been guided by a theoretical framework (McMillan, 2005; Mendoza, et al., 2010). Furthermore, most previously developed travel models have been designed primarily for adults and are more concerned with developing equations to predict travel outcomes than with investigating the behavioural aspects involved in mode choice (McMillan, 2005). Four models have been developed relatively recently to investigate variables that influence children's school travel behaviours. These are (a) McMillan's (2005) conceptual framework for the relationship between urban form and a child's trip to school, (b) the Ecological and Active Commuting (ECAC) framework (Sirard & Slater, 2008), (c) Pont's (2010) Model of Children's Active Travel (M-CAT), and (d) Panter's (2008) conceptual framework for the environmental determinants of children's active travel behaviours. The following section describes the main focus and features of each of these conceptual frameworks and then identifies aspects of Panter's (2008) model that will be further investigated in this thesis.

McMillan (2005) was the first to propose a conceptual framework to explain the decision making process regarding a child’s travel choice. This framework (Figure 2.2) challenges the notion that urban form (the built environment) directly influences a child’s travel behaviour. Instead, according to the framework, urban form influences travel choice by a more complex route via mediating and moderating factors that subsequently influence parental decision making. This framework assumes that up to a certain age, the final decision on how the child travels to school is made by the parent. Further, McMillan suggests that parental decision making is ‘a variable on the hypothesised causal pathway between urban form and a child’s trip to school’ (McMillan, 2005, p. 448). Factors suggested to affect the parent’s decision include perceptions of neighbourhood and traffic safety, available household transport options, social norms, parental attitudes, and socio-demographics. This framework is an important contribution to the literature. However, it does not take into account other aspects of the physical and social environment that have been shown to influence school travel behaviour (e.g. distance, school policy, and support from friends). Furthermore, the framework is limited by excluding the child from the decision-making process. Little is known about the interactions between parent and child in the decision-making process, and it may be that children exert a degree of persuasion regarding the mode of travel that is used. This can be viewed as being similar to the way in which children influence their parents when it comes to purchasing decisions in retail situations (McDermott, O’Sullivan, Stead, & Hastings, 2006).

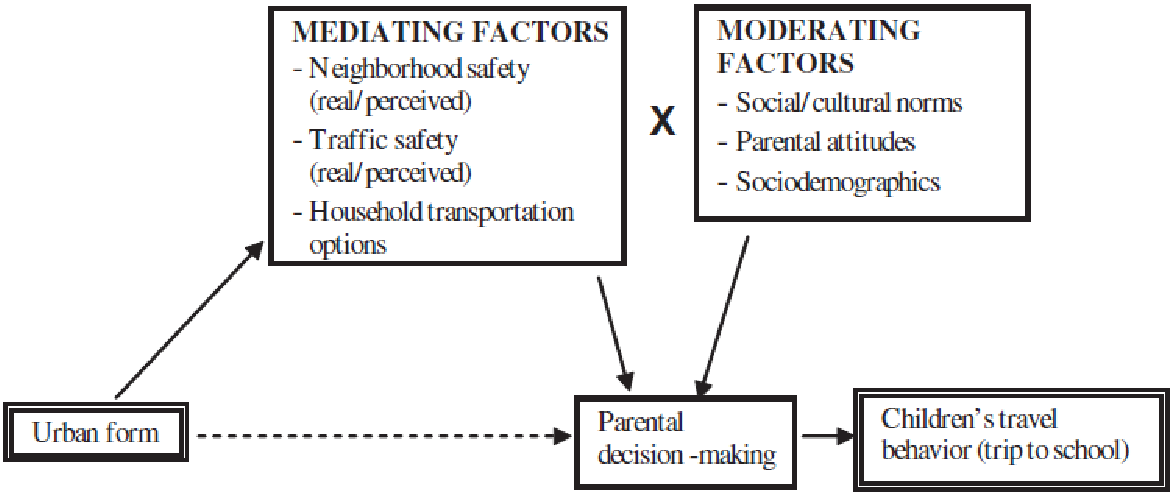

Figure 2.2. McMillan's (2005) conceptual framework of an elementary child's travel behaviour

The ecological and cognitive active commuting (ECAC) framework was developed by urban planners, transportation experts, and researchers from the field of physical activity (Figure 2.3). It is a relatively comprehensive model that acknowledges the complex nature of the decision making process. The model is headed by the constructs of policy and physical and social environmental factors, under which lie perceptions, psychosocial mediators, resources, and the child's perceptions. Direct relationships are represented by solid arrows and dashed arrows indicate variables that are less important or have yet to be studied. The framework was developed primarily as a means by which researchers could organise their studies (Sirard and Slater, 2008) and the authors who presented it conceded that elements of the model may need to be altered or removed as a result of new knowledge (the model contains a section labelled 'other' for variables not yet studied). In this respect, the ECAC framework may be viewed as a work in progress, and does not claim to be a definitive summary of the factors affecting school travel behaviour. Similar to the McMillan framework, the ECAC framework views the parent as making the final decision regarding how their child travels to school.

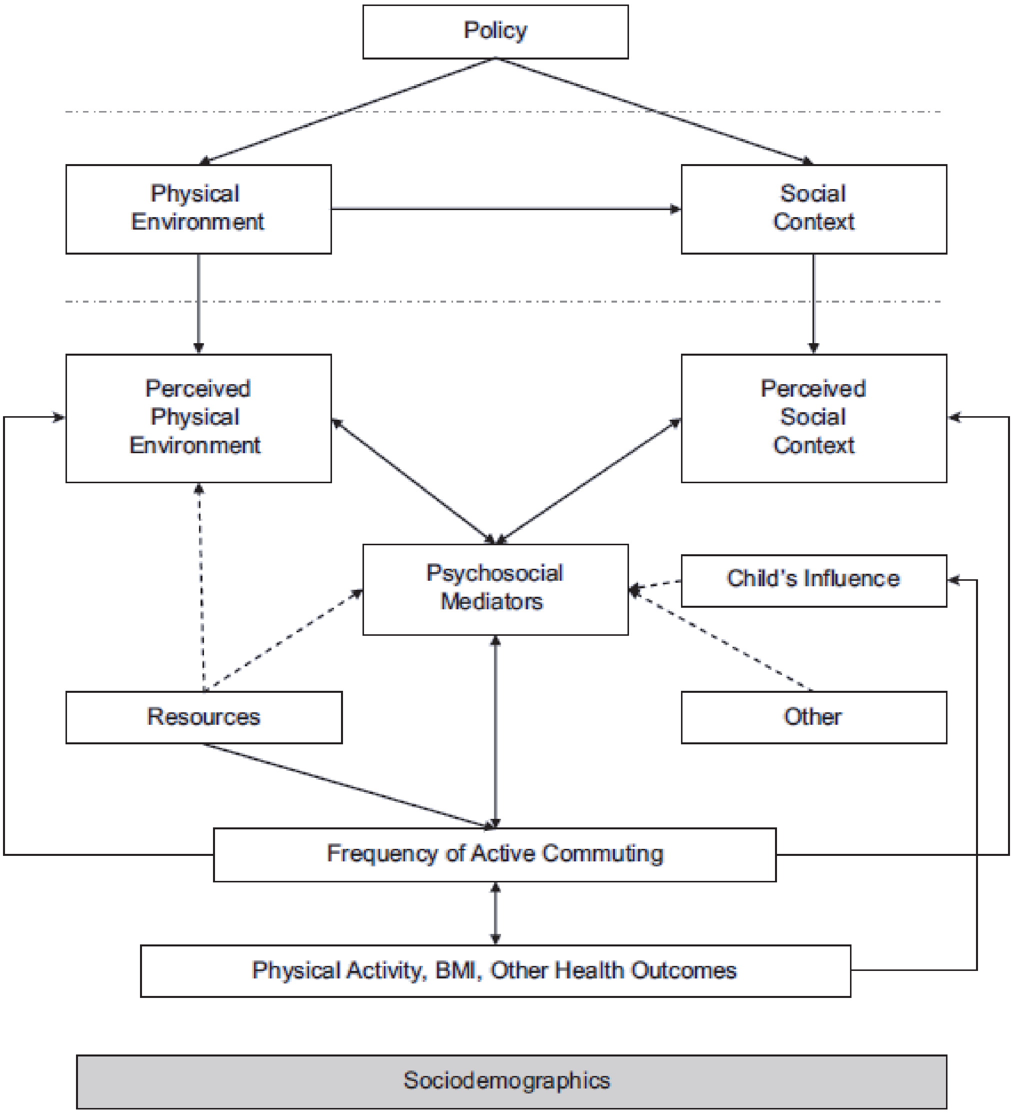

Figure 2.3. The Ecological and Cognitive Active Commuting (ECAC) framework

Pont et al. (2010) developed the most recent framework called the Model of Children's Active Travel (M-CAT). This model (Figure 2.4) has been developed from an occupational therapy perspective and is underpinned by various theories including the International Classification of Functioning, Disability and Health (World Health Organisation, 2008), Bonfenbrenner's (1989) Ecological Systems Theory, and the Person-Environment-Occupational Model (Law, 1996). The model therefore acknowledges the influence of the family context on a child's behaviour, as well as the influence of objective and subjective environmental factors and parent and child perceptions (Pont, Ziviani, Wadley, & Abbott, 2010). Again, this model is a useful contribution to the school travel literature; however it has limitations. The M-CAT model takes a somewhat simplistic view of the process by which a decision regarding travel mode is reached. More specifically, it does not acknowledge the bi-directional nature of the relationship between variables. For example, the model proposes that parent attitudes and perceptions will influence the child, but does not allow for the child to have the same influence on their parent. The model does acknowledge the importance of the child's own perceptions, particularly as he or she gets older. This is an improvement on previous models such as McMillan's (2005); however the parent is still viewed as making the final decision.

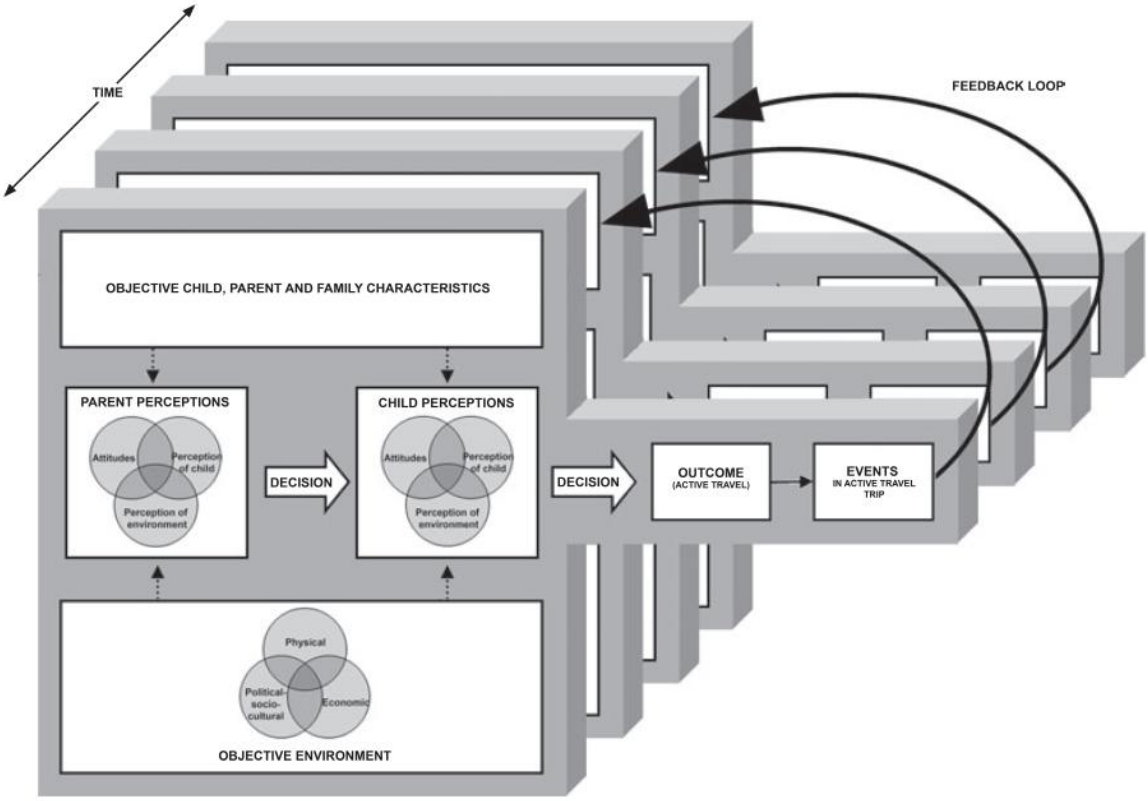

Figure 2.4. Pont's (2010) model of children's active travel

The final model described here was developed by Panter et al. (2008) and is arguably the most comprehensive of those mentioned previously. The Panter framework (Figure 2.5) addresses some of the weaknesses that have been identified among the other frameworks and improves on them in three ways. First, it identifies moderators that alter the relationship between the physical/social environment and school travel behaviour (e.g. age, gender, and distance). Second, it includes a more comprehensive collection of physical environmental factors, individual factors, external factors, and moderators. Third, this is the only model to acknowledge that the child may have the same decision-making power as the parent. Panter et al (2008) suggested that before the mode of travel for the school journey is decided 'children and their parents will enter into a dialogue during the decision making process' (Panter, et al., 2008, p. 10). Additionally, Panter et al. (2008) state that children may use tactics such as '*pester power*' to persuade their parent to allow them to travel using their desired mode. This may have either a positive or negative outcome. For example, the child may want to travel actively and so nag their parent to allow them to cycle or walk when it may be more convenient for the parent to transport their child to school en route to work. Conversely, the child may want to be driven to school when the parent feels that it would be better to walk.

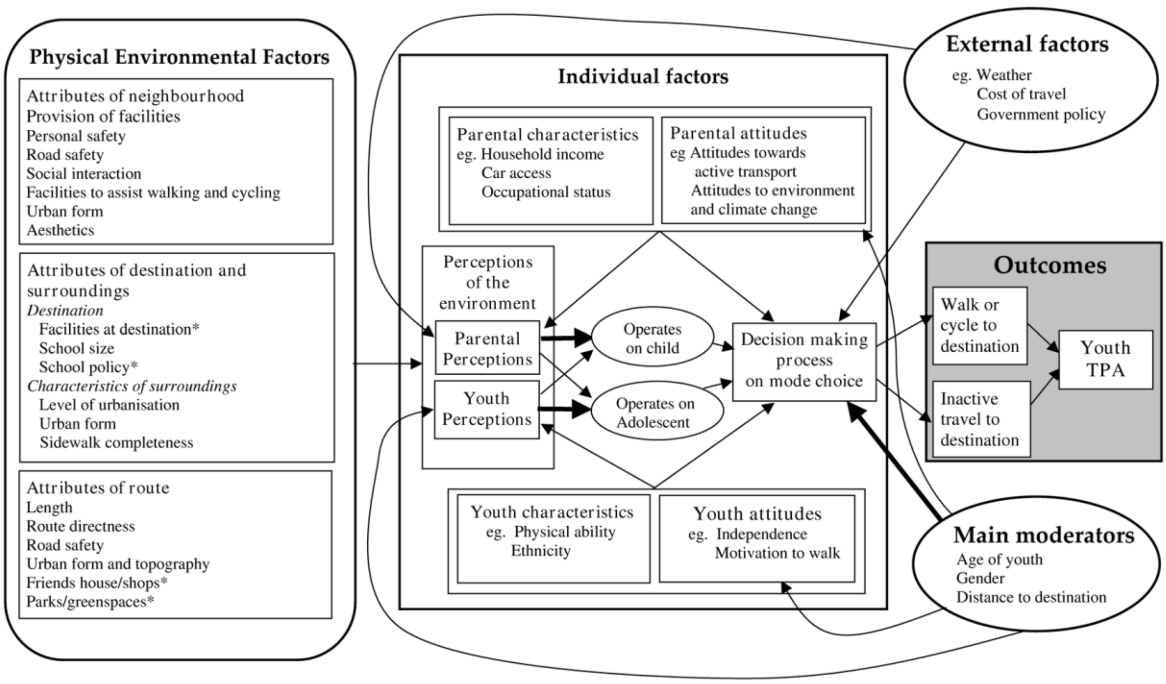

Figure 2.5. Panter's (2008) conceptual framework for the environmental determinants of active travel in children

The authors who developed the above model have conducted two studies which tested certain elements of the model. One of these studies tested the physical environmental elements of the model. In doing so, they assessed whether characteristics of the neighbourhood, route, and school environment were associated with children's active travel, and whether distance was a moderator of this relationship. They found that children who lived in more deprived areas were less likely to walk and children who had a higher density of roads in their neighbourhood were more likely to walk. Distance was not found to moderate these relationships (Panter, Jones, van Sluijs, & Griffin, 2010b). The other study tested variables that broadly fall under the heading of individual factors. This study investigated whether attitudes, social support, and environmental perceptions were associated with children's active school travel, and whether distance moderated these relationships (Panter, et al., 2010a). Various factors including parental and peer support, parental attitudes, and perceived neighbourhood walkability were associated with walking to school. There was a marginal moderating effect of distance on these relationships.

Due to the comprehensiveness of the model developed by Panter and colleagues there are aspects which are untested to date. It was identified previously in this thesis that there is a lack of evidence for the psychological correlates of children's school travel behaviour. Psychological factors may be viewed as falling under the headings of *youth characteristics and attitudes* and *parental characteristics and attitudes* within the *individual factors* box of Panter's. One of the aims of this thesis therefore was to investigate whether psychological variables identified within the social cognitive theory are associated with children's active commuting. In doing so, this will test the parent and child characteristics section in Panter's model and begin to fill the knowledge gap regarding the role of psychological variables in children's school travel. Additionally, the link between Panter's model and the Travelling Green intervention should be noted. One of the processes by which Travelling Green aims to bring about a change in travel mode is through imparting new knowledge to children via educational lessons. This links to the model developed by Panter and colleagues, in that, by imparting new knowledge to children, their attitudes towards walking to school may be changed, resulting in a more positive attitude towards walking to school- which may in turn translate into changed behaviour.

2.10 Gaps in the Literature and Thesis Aims

Following the review of literature two distinct gaps have emerged. First, there is a need for well-designed studies that investigate the effect of school travel interventions on children's commuting behaviour, using objective measures of school travel as the outcome. Previously conducted studies have generally not included control groups or have used self-reported outcome measures. Additionally, researchers that have used objective measures of activity to assess intervention effectiveness have processed activity data across the full day or during blocks of time before and after school rather than during commuting time. Furthermore, most evaluation studies have been conducted in the U.S., Australia, and New Zealand.

The second gap in the literature is concerned with the role of psychological variables in predicting children's school travel behaviours. Most studies have focused on the role of physical and social environmental factors in school travel behaviour. There is a need for studies guided by theory that investigate how psychological variables influence children's school travel. Furthermore, it is unknown whether parent or child psychological variables are more important in determining how the child travels to school.

This thesis aimed to address these gaps in the literature in two ways. First, the effects of Travelling Green on objectively measured school travel behaviours was investigated in a sample of Scottish school children using a quasi-experimental design. Second, this study investigated the psychological predictors of active school travel from a social cognitive perspective, with a specific focus on the constructs of self-efficacy and outcome expectations. In doing so, this tested the parent and child characteristics section of the conceptual framework developed by Panter et al. (2008).

2.11 Research Questions and Thesis Structure

In fulfilling the above aims, this thesis provided answers to the following research questions:

1. Is the NL-1000 accelerometer a valid measure of steps and MVPA during the school commute?

2. Is a newly designed travel questionnaire reliable for use in a primary school setting?
3. Is a self-report travel diary a valid measure of home time arrival for primary school aged children?
4. Does Travelling Green result in participants increasing their physical activity levels on the journey to and from school?
5. In relation to the child and parent attitude sections of Panter's (2008) conceptual model: Can self-efficacy and outcome expectations predict commuting-related physical activity?
6. Is the parent or child the main decision maker regarding school travel mode?

These Research Questions are addressed in three separate papers that make up this thesis. Research Questions 1, 2, and 3 constitute the pilot testing of the measures used in the evaluation of Travelling Green. The pilot work is reported in Paper 1, which describes the rationale and methods for the main evaluation study (see note below). Paper 2 addresses Research Question 4 and is concerned with the effect of Travelling Green on commuting-related physical activity and daily physical activity. Finally, Research Questions 5 and 6 are answered in Paper 3, which investigated the psychological predictors of children's active commuting as identified in Panter's (2008) conceptual framework for the environmental determinants of children's commuting behaviour. The paper titles are outlined below.

Paper 1

An evaluation of Travelling Green: Study rationale and methods.

Paper 2

The effect of a school-based active commuting intervention on children's commuting physical activity and daily physical activity.

Paper 3

Children's school travel: Investigating the role of self-efficacy and outcome expectations.

Note.

It should be noted that Paper 1 describes the rationale and methods for a wider evaluation of Travelling Green within which this thesis is embedded. Consequently, it contains details of methods that are not directly relevant to the research questions posed in this thesis. The wider study investigated the long term effects of Travelling Green including 5- and 12-month maintenance measures and also included the measurement of additional variables associated with the Theory of Planned Behaviour and the construct of Habit. Although Paper 1 of this thesis includes details on these methods, Paper 2 used only data from pre- and post-intervention (not including 5- and 12-month data), and Paper 3 is concerned only with baseline (cross-sectional) data. The full methods are included in Paper 1 as this paper will subsequently be published as a methods paper for the wider Travelling Green study, and so papers associated with the wider study will refer to this paper.

Chapter 3

Paper 1

An evaluation of Travelling Green: Study rationale and methods

Abstract

Background: The journey to and from school has been identified as a prime opportunity to increase physical activity levels in children. However, rates of active commuting to school across the western world have steadily decreased over the past forty years. Strategies that increase walking to school are therefore needed. Travelling Green (TG) is a school based active travel resource aimed at increasing children's walking to school. The resource consists of a curriculum-based program of lessons and goal setting activities. A previous study found that children who received the TG intervention increased self-reported distance travelled to school by active modes and reduced the distance travelled by inactive modes. This study was limited by self-reported outcome measures, a small sample, and no follow-up measures. A more robust evaluation of TG is required to address these limitations. This paper describes the rationale and methods for such an evaluation of Travelling Green, and describes the piloting of various active commuting measures in primary school children.

Methods: Measures of active commuting were piloted in a sample of 26 children (aged 8-9 years) over one school week. These measures were subsequently used in a quasi-experimental design to evaluate the effect of TG on commuting behaviour. Participants were 166 Scottish children (60% male) aged 8-9 years from 5 primary schools, sampled from either end of the Scottish Index of Multiple Deprivation (SIMD). Two schools (*n* = 79 children) received TG in September/October 2009. Three schools (*n* = 87 children) acted as a comparison group. The comparison schools received TG at a later date so they did not miss out on any potential benefits of the intervention. Physical activity was measured using accelerometers (GT1M and NL-1000). Personal and environmental determinants of active commuting were measured via parent and child questionnaire, as were factors related to the Theory of Planned Behaviour and the construct of Habit. Measures were taken pre- and post-intervention and at 5 and 12 months follow-up.

Discussion: The piloted protocol was practical and feasible and piloted measures generally performed well. All study data, including 5 and 12 month follow-up, have been collected and processed. Data analysis is ongoing. Results will indicate whether TG successfully increases active commuting in a sample of Scottish school children and will inform future efforts in school active travel promotion.

Background

Knowledge of the immediate and future health benefits of regular physical activity in children is well established (U.S. Department of Health and Human Services, 2008), and it is known that even relatively small amounts of physical activity can have dramatic health benefits for children in high risk categories (e.g. obese, hypertensive) (Janssen & LeBlanc, 2010). Physical activity promotion in child populations is therefore an important endeavour.

The journey to and from school has been identified as a prime opportunity to increase physical activity levels (Tudor-Locke, et al., 2001), and it has been shown that children who travel actively to school engage in more physical activity during the school commute than their inactive counterparts (Ford, et al., 2007; Metcalf, et al., 2004). It has also been shown that children who actively commute are more active at other times of the day (Cooper, et al., 2003; Mendoza, et al., 2010). Furthermore, children who walk (Voss & Sandercock, 2010) and cycle (Cooper, et al., 2008; Cooper, et al., 2006) to school have higher levels of cardiovascular fitness than inactive travellers.

Despite the benefits associated with active school travel, rates of active commuting to school across the western world have steadily decreased over the past forty years (Buliung, Mitra, & Faulkner, 2009; McDonald, 2007; van der Ploeg, et al., 2008). Reasons for these declining trends are unclear, however contributing factors may include increased pressure on parents' time in the morning (McDonald, 2008c), perceived dangers on the route to school (Kirby & Inchley, 2009), and the convenience of using motorised transportation (Faulkner, et al., 2010).

Several interventions have been designed to promote active school travel. Two examples of these are the Safe Routes to School (SRTS) programme and the Walking School Bus (WSB). The Safe Routes to School programme is a legislation-backed initiative in the United States whereby funding is provided to each state in order to address some of the barriers to walking and cycling to school. The majority of these funds are allocated to infrastructure changes such as traffic calming measures, street lighting, and cycle paths (Martin, et al., 2009). Funds are also used for non-infrastructure activities such as education and special events like walk and cycle to school days (Hubsmith, 2006). Studies that have been conducted to evaluate

SRTS programmes have shown that children at schools taking part in the intervention increased walking, biking, and car-pooling (Staunton, et al., 2003), and that children who passed SRTS projects on their way to school were more likely to increase their walking or cycling (Boarnet, Anderson, et al., 2005).

A Walking School Bus is a group of supervised children that walks to school and picks up other children while travelling a predefined route. The WSB has become popular in many countries, particularly in New Zealand and Australia where it originated, and has been shown to successfully bring about increases in walking to school (Heelan, et al., 2009; Mendoza, et al., 2009). Moreover, the WSB is valued by those who coordinate and participate in them (Kingham & Ussher, 2007; Neuwelt & Kearns, 2006). Although they have been shown to increase walking to school, several problems have been highlighted with the WSB, e.g. the need for parents or other volunteers to act as 'drivers', fading enthusiasm for the programme, and diminishing support from schools and councils (Kingham & Ussher, 2005).

Another intervention designed to promote walking to school is Travelling Green. This resource was designed in Scotland and takes the form of a 6-week project during which the class teacher delivers a series of curriculum-based lessons that cover various commuting and health-related topics. Children also set goals to walk to school on more days of the week by the end of the project. A small-scale evaluation of this intervention found that children who took part in the project increased the distance travelled actively to school following the intervention, and decreased the distance travelled inactively compared with a control school (McKee, et al., 2007). Although the study showed positive results, there were several limitations. No objective measures of commuting behaviour or physical activity were used (results were based on self-reported distance travelled by mode). The sample used was relatively small (one intervention school class, $n = 31$, and one control school class, $n = 29$), and there were no follow-up measures taken to determine if the intervention had any long term effects.

These limitations are not unique to the study conducted by McKee et al (2007). Previous studies that have evaluated school travel interventions have had similar limitations, such as self-reported outcome measure (Mendoza, et al., 2009; Wen, et al., 2008), absence of control groups (Staunton, et al., 2003), and no follow-up measures (Hinckson, Schofield, & Badland, 2006). There is therefore a need to conduct a robust evaluation of the Travelling Green resource that addresses the weaknesses of the study carried out by McKee et al. (2007), and that also addresses the limitations of previous active school travel studies. The study described in this paper aimed to achieve this by:

- Using objective commuting outcome measures
- Using a larger sample
- Taking follow-up measures to assess any long term effect of the intervention

This paper outlines the study rationale, aims, methods, and pilot work for the evaluation of Travelling Green.

Travelling Green Method

Aim

This study was designed to investigate the effect of Travelling Green on commuting behaviour in a sample of primary school children in Scotland (*n* = 166 children). In addition, this study aimed to pilot test several measures of active commuting in a sample of Scottish school children (*n* = 26).

Ethical Approval

Ethical approval for all pilot (Appendix A) and main evaluation (Appendix B) procedures was granted by the University of Strathclyde ethics committee and all data collection was carried out in accordance with the Helsinki Declaration.

Recruitment process

Recruitment for the pilot study was carried out in December 2008. Main study recruitment was carried out between February and June 2009. Permission to contact potential study schools was granted by all relevant local education authorities (Appendix C, D, and E).

Study schools were sought from either end of the socioeconomic continuum, as defined by the Scottish Index of Multiple Deprivation (SIMD;

www.scotland.gov.uk/Topics/Statistics/SIMD). The SIMD provides a relative measure of area level deprivation across 6,505 geographic data zones in Scotland. Area level deprivation is calculated using 38 indicators from the following 7 domains: Income, employment, health, education, housing, geographic access, and crime. This sampling method allows for investigation of how school-level deprivation may influence commuting behaviour. Individual-level (home) SIMD was available by obtaining participants' home postcodes.

A purposive sampling approach was used to identify schools from the upper (most deprived areas) and lower (least deprived areas) quartiles of the SIMD. All potential study schools were located in urban areas, according to the Scottish Neighbourhood Statistics Urban Rural classification (www.sns.gov.uk). Relevant council workers such as school travel coordinators, active schools coordinator, and road safety officers were contacted and asked to suggest potential study schools. Based on recommendations from these sources 11 schools were contacted to establish whether they would be interested in taking part in the study.

Study population

Five schools agreed to participate in the study. Two schools were from areas in the low deprivation SIMD quartile; one intervention school (Int-LoDep) and one comparison school (Comp-LoDep). Three schools were from areas in the high deprivation quartile; one intervention school (Int-HiDep) and two comparison schools (Comp-HiDep: due to small numbers data from these two schools were combined to form one comparison group). It was not possible to randomly assign participants to the intervention or comparison group because schools had already scheduled the delivery of Travelling Green into their curriculum before agreeing to participate in the study, and so the intervention and comparison groups were somewhat pre-defined.

Participants were from primary 5 (ages 8-10 years) because this is the age group for which Travelling Green was designed. Descriptive characteristics of the study schools are displayed in Table 3.1. Study information sheets (Appendix F, G, H, and I) and consent forms (Appendix J) were given to 232 children and their parents. Signed parent and child informed consent were obtained for 167 participants

(72% response rate). Prior to the start of data collection one participant withdrew from the study, leaving a final sample of 166 participants. Children who did not provide consent took part in the intervention, however no outcome measures were taken from these children.

Table 3.1

Study school characteristics

School	*n*	Deprivation level	% Employment deprived*	% of homes owned*	% Free school meals**
Int-LoDep	48	Low	2	97	2
Comp-LoDep	47	Low	3	98	5
Int-HiDep	31	High	19	39	37
Comp-HiDep	19	High	23	43	30
Comp-HiDep	21	High	14	52	26

Notes

*Scottish Neighbourhood Statistics, 2010 (http://www.sns.gov.uk)

**Free School Meals survey, 2009 (http://www.scotland.gov.uk/Resource/Doc/920/0083583.xls)

% Employment deprivation is the percentage of the working age population (16-64 for men and 16-59 for women) who are on the unemployment claimant count, are in receipt of Incapacity Benefit or Severe Disablement Allowance.

Study Design

A quasi-experimental design was used. Two schools (Int-LoDep and Int-HiDep) received the Travelling Green intervention between August and October 2009. Measures of commuting behaviour (questionnaires, travel diary, and objective measures) were taken during 5 consecutive school days prior to starting the intervention and during 5 consecutive school days post-intervention. Three schools acted as comparisons during this period (Comp-LoDep and the two Comp-HiDep schools). The same measures were taken at these schools. The three original comparison schools received the intervention between April and June 2010, allowing for investigation of the effects of seasonality on the intervention. Furthermore, providing the intervention to the comparison schools meant that they would not miss out on any potential benefits of Travelling Green. Follow-up measures were taken at 5 and 12 months post-intervention at all schools to assess any lasting effect of the intervention on travel behaviour. Figure 3.1 shows the study design and timeline.

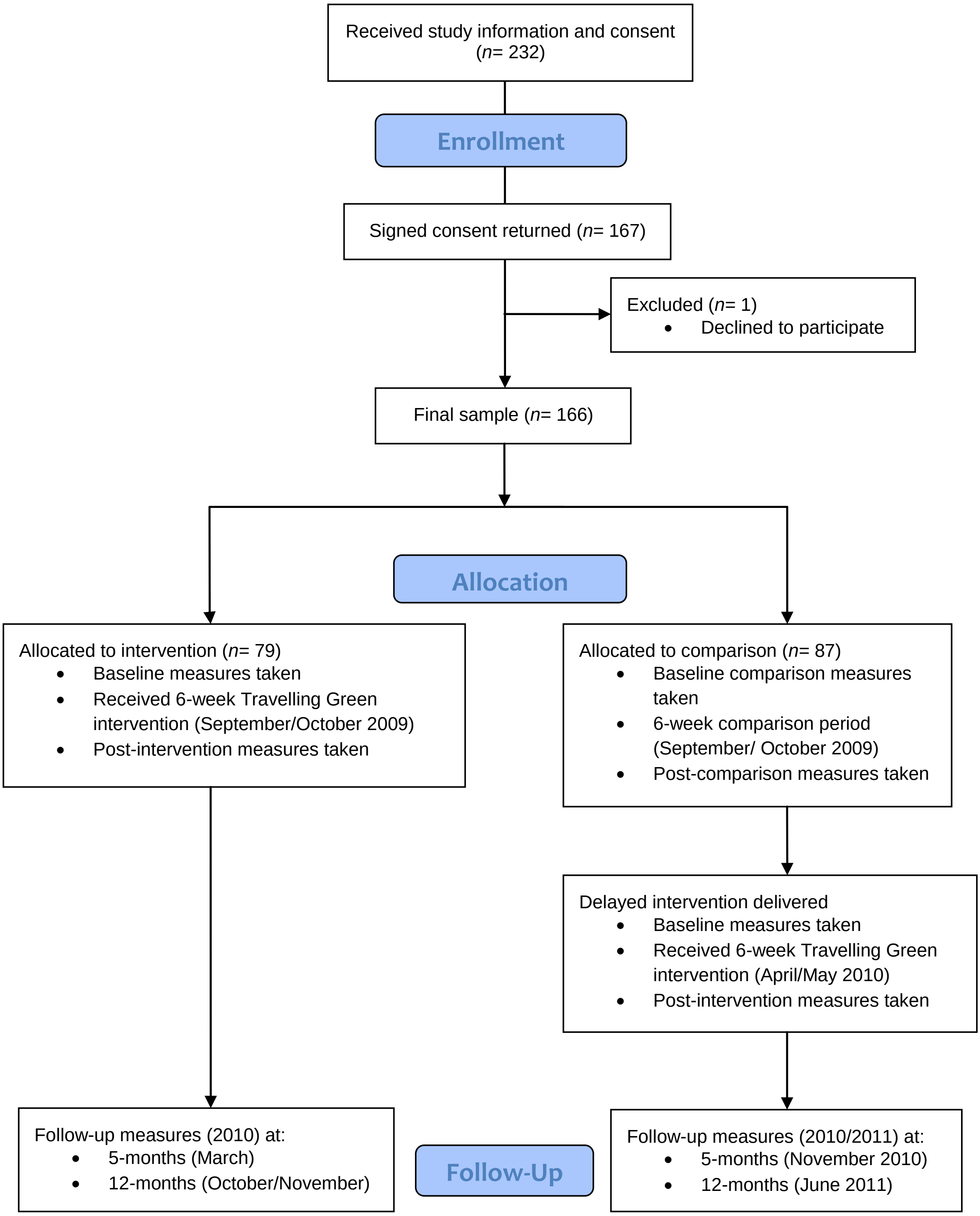

Figure 3.1
Flowchart of study design and timeline

The intervention

Travelling Green is a 6-week active commuting project that aims to increase children's walking to and from school. The project was designed for children aged 8-10 years, on the premise that children of this age are independent enough to travel to school alone, yet young enough to be enthused by a school-based project. The project is comprised of two components: A Teacher's Handbook and individual Pupil Packs for each child.

Teacher's Handbook.

The Teacher's Handbook contains introductory activities. These require children to consider their current school travel behaviours and think about the characteristics of a healthy journey to school. The main component of the Teacher's Handbook is a series of 13 lesson plans that cover a number of health-related and commuting topics. Topics include road safety, the heart and lungs, a healthy lifestyle, the Green Cross Code, and understanding the local environment. The lessons have been designed to link with the 'Curriculum for Excellence' (the Scottish national curriculum), and encompass key subject areas such as Health and Wellbeing, Social Studies, Expressive Arts, Technologies, and Languages. Lessons are used at the teacher's discretion and can therefore be chosen to link with other topics being covered in the curriculum.

Pupil Pack.

The Pupil Pack contains the following elements: (a) a pupil information guide describing the project; (b) a *My Travel Challenge* booklet in which children set goals to travel actively on more days as the project progresses; (c) two wall charts on which children record how they travel to school each day, and how they travel home each day; and (d) two high visibility reflective stickers that can be attached to school bags or clothing.

Travelling Green was designed by West Dunbartonshire council in collaboration with NHS Greater Glasgow, and has been funded by the Scottish Government to be provided to every school in Scotland. Distribution of the resource is being coordinated by the sustainable transport organisation Sustrans. A member of the research team trained the teachers at each school so that they were able to deliver the project.

Measures

Actigraph GT1M.

The Actigraph GT1M (ActiGraph, Pensacola, FL) physical activity monitor contains a uni-axial accelerometer measuring 3.8 × 3.7 × 1.8 cm. Devices in this study were attached to an elastic belt and worn on each participant's right hip. Vertical bodily accelerations are converted into activity counts, which are monotonically related to magnitude of acceleration i.e. as activity intensity increases, so do activity count values. Counts are recorded over a pre-selected period of time (epoch), ranging from 1 sec to 1 min. At the end of each epoch activity counts and steps are summed and stored. Validated cutpoints can be applied to the activity count data to determine time spent in different activity intensities. The GT1M is a widely used measure of physical activity in the research community, and has been validated for use in children against indirect calorimetry in both laboratory (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008) and free-living (Mattocks, et al., 2007) conditions.

The GT1M devices were initialized, and data were downloaded using Actilife data analysis software (version 3.2.2; ActiGraph, Pensacola, Florida, USA). Initialization involves setting the time, date, epoch length, and assigning a file name. In this study, 5-sec epochs were used (this is the shortest epoch length that allows data storage over 5 days). Prior to initializing the devices, the computer used for initialisation was time synchronized with a digital watch to allow for accurate recording of participants' morning arrival times at school. This was important for subsequent data processing.

New Lifestyles NL-1000.

The NL-1000 (New Lifestyles, Inc., Lee's Summit, MO) is a new type of pedometer that uses a piezoelectric mechanism similar to an accelerometer. The NL-1000 costs considerably less than an accelerometer and does not require initialisation or downloading. The device measures 6.4 × 3.8 × 2 cm, and in this study was attached to the elastic belt alongside the GT1M. The NL-1000 records steps and time spent in different activity intensities, and these data are read from a digital display. The device also features an automatic 7-day memory function, whereby daily activity (steps and MVPA time) are stored in the middle of the night and the display is reset for the following day.

The NL-1000 can be set to record time spent in different activity intensities. There are 9 discrete thresholds available, each corresponding to one of three activity intensities (1-3 light, 4-6 moderate, and 7-9 vigorous). Each threshold corresponds to a metabolic equivalent (MET) value, ranging from 1.8 to >8.3 METs (see Table 3.2). The lower and upper bounds of the intensity level can be changed to suit research needs. For example, if a researcher is concerned only with vigorous activity then the threshold can be set at a higher level. The default setting is 4-9, i.e. moderate-to-vigorous physical activity (MVPA). Any activity performed at or between these bounds will be added to the activity time. For the pilot study the MVPA threshold was set at level 3.0 (equating to 2.9 METs), which allowed for comparison to Actigraph data which was analysed in such a way that the MVPA threshold was 3 METs. The threshold was later changed to 4.0 (3.6 METs) for the main evaluation study, to reflect the higher resting energy expenditure in children. The cut-points used to calculate MVPA time from Actigraph data were also increased for the main evaluation study.

Table 3.2

NL-1000 activity level and estimated MET level equivalents

	Activity Level	Estimated MET
Light Intensity	1.0	1.8
	2.0	2.3
	3.0	2.9
Moderate Intensity	4.0	3.6
	5.0	4.3
	6.0	5.2
Vigorous Intensity	7.0	6.1
	8.0	7.1
	9.0	> 8.3

Child questionnaire.

A child school travel questionnaire (Appendix K) was designed specifically for this study. The questionnaire gathered information about children's: (a) demographics; (b) usual mode of travel to and from school; (c) stage of behavioural change related to walking to school; (d) perceived barriers, facilitators, and benefits to walking to school; (e) preferred mode of travel to school; (f) self-efficacy for various commuting-related tasks; (g) perceptions of the local area; and (h) commuting behaviour in relation to the Theory of Planned Behaviour (TPB) and the construct of habit.

Most items in the questionnaire were taken from a pupil questionnaire located in the introductory activities of the Teacher's Handbook in the Travelling Green resource. A question related to perceptions of the local area was adapted from an item in the Traffic and Health in Glasgow Questionnaire (Medical Research Council, 2005). TPB items concerned with attitude, subjective norm, perceived behavioral control, and intention were adapted from previously used items (Rhodes, Macdonald, & McKay, 2006). The Self-report Habit Index (Verplanken & Orbel, 2003) was used to measure habit in relation to walking, and car and bus use as school commuting modes. One question investigating participants' self-efficacy for certain active commuting tasks was developed specifically for this study. Questionnaire item response formats were a mix of tick box and Likert scale. Validity and reliability evidence for the child questionnaire was established during the pilot study, results of which are presented later.

Parent questionnaire.

The parent questionnaire (Appendix L) elicited similar information to the child questionnaire, but answered from the parent's perspective. In addition, the parent questionnaire gathered data on: (a) the child's health status and ethnicity; (b) parent's age and various socioeconomic indicators such as car ownership and employment status; and (c) street connectivity in their area. Validity and reliability evidence for the parent questionnaire was not investigated, however the questionnaire was compiled using items from the following existing questionnaires: (a) Pupil questionnaire in the Travelling Green resource; (b) the Traffic and Health in

Glasgow Questionnaire (Medical Research Council, 2005); and (c) the 'Active Where' Parent-Child Survey 1 (Forman, et al., 2008; Kerr, et al., 2006). Items investigating factors related to the TPB and habit were not included in the parent questionnaire.

Travel diary.

Travel diaries (Appendix M) were used to gather information about the trip home from school. Diaries asked participants what time they arrived home, how they travelled home, and if they went anywhere else on the way home. Participants were asked to complete the diaries retrospectively (i.e. the next morning when they arrived at school) to achieve a higher response rate. Home times reported on the diaries were later used to inform Actigraph GT1M data processing. Validity evidence for the travel diary is reported in the pilot study results.

Pilot Study

Aims.

The pilot study had two aims. Firstly, to assess the practicality and feasibility of using the previously described procedures and measures in a school setting. Secondly, to establish validity and reliability evidence for (a) the NL-1000, (b) the child questionnaire, and (c) the travel diary, for use in school travel research, with a view to using these measures to evaluate Travelling Green.

Method.

A cross sectional design was used, with a sample of 26 primary 5 pupils (8-9 years) from a school in the west of Scotland. These participants were different to those who received the Travelling Green intervention. Ethical approval was granted from the university ethics committee and informed parent and child consent was obtained for each participant.

Pilot data collection was conducted over one school week (Monday to Friday). On the Monday participants completed the child questionnaire under the guidance and supervision of the research team. Participants were then shown how to wear the belt (with attached activity monitors) correctly and were asked to put their belt on at 3pm before travelling home. Travel diaries were also administered.

Participants were asked to wear the belt when travelling to and from school for the duration of the week. On arrival at school each morning a member of the research team recorded each participant's arrival time and NL-1000 steps and time spent in MVPA (minutes and seconds). Participants removed their belts and one of the researchers reset the NL-1000s and stored the belts with attached monitors in the classroom throughout the day. This was done so that when the belts were worn on the trip home from school data collected would be relevant to the commute only, and this data would later be saved to the NL-1000 device memory (allowing home commute data to be recorded the following morning from the device memory). Immediately before travelling home from school participants put their belt back on. Participants had been asked to remove their belts as soon as they arrived home, this resulted in the GT1M output displaying a consecutive sequence of zeros when downloaded, thus providing an accurate record of home arrival time. The following morning one of the researchers recorded the home trip data from the NL-1000 memory. This protocol was repeated on each day of data collection. Activity monitors and travel diaries were collected on the Friday. A second (retest) child questionnaire was administered one week after the first administration.

Test-retest reliability for the child questionnaire was established by calculating percent agreement between items (nominal level data) and using Spearman's rho (ordinal level data). Reliability of the self-efficacy item designed specifically for this study was investigated using an intraclass correlation coefficient (ICC) from a 1-way ANOVA model, adjusted for a single measure.

Validity evidence for the travel diary was established by comparing known home arrival times (determined using the GT1M data) to diary reported home arrival times using Wilcoxon signed ranks test (to assess differences) and Spearman's rho (to assess correlations).

Validity of the NL-1000 was investigated by comparing step and MVPA data to data recorded by the GT1M (criterion measure) during the school commute. GT1M steps and time spent in MVPA were calculated for the journeys to and from school using Microsoft Excel 2007 (Microsoft Corp, Redmond, WA). Activity at or above a threshold of 3 METs was considered to be of moderate intensity. Age specific cut-points based on a previously developed (Freedson, et al., 1997) and published (Trost, et al., 2002) MET prediction equation were used to establish time spent in MVPA. Morning and afternoon commute data were combined to create total commuting steps and total commuting MVPA for each participant for both instruments (NL-1000 and GT1M). Differences between GT1M and NL-1000 data (steps and MVPA) were compared using Wilcoxon signed-rank test, and correlation between instruments was tested using Spearman's rho. Non-parametric tests were used because NL-1000 data were non-normally distributed (see Table 3.3). An alternative approach to investigate agreement between these measures would have been to use Bland Altman plots.

Results.

The majority of questionnaire items had test-retest agreement of above 70%, which was deemed acceptable. The two items on which correlational analysis were carried out demonstrated high correlations, *rho* = .87 and *rho* = .76, and the self-efficacy item had high reliability, ICC = .93, single measures = .86. The Theory of Planned Behaviour item and the Self-Report Habit Index item have been used previously with children of a similar age to the sample in this study (Kremers, Dijkman, de Meij, Jurg, & Brug, 2008; Rhodes, et al., 2006; Wind, Kremers, Thijs, & Brug, 2005).

No significant differences were found between the home arrival times reported on the travel diaries to the known arrival times (mean error = 6 minutes, $z = .56$, $p \geq .05$). Furthermore significant moderate correlations were found between measures (*rho* = .42, $p < .01$). Although the difference between the self-reported and known arrival time was not significant, it should be acknowledged that an error of 6-minutes may be quite substantial in relation to a journey that may take only 10-20 minutes. Furthermore, in this analysis the assumption was made that children removed their activity monitors immediately on arrival home from school. In practice this may not have happened.

Descriptive statistics for NL-1000 and GT1M data are displayed in Table 3.3. The NL-1000 significantly underestimated time spent in MVPA during the school commute compared to the GT1M (mean difference = 99 seconds, $z = -3.08$, $p < .01$), and significantly overestimated steps compared with the GT1M (mean difference = 300 steps, $z = -4.02$, $p < .01$). However, the NL-1000 and GT1M were highly correlated for measuring MVPA (*rho* = .95, $p < .01$) and steps (*rho* = .96, $p < .01$) during the school commute. Furthermore, according to Cohen's D (Cohen, 1988) effect size, the differences between instruments in MVPA and step estimates were small ($d = 0.29$ and $d = 0.42$ respectively).

Table 3.3

NL-1000 and GT1M descriptive statistics

	Mean	SD	Min.	Max.	Skew.	Kurt.
NL-1000 MVPA (Sec)	485	362	80	1720	2.10	6.10
NL-1000 Steps	1302	805	376	3999	2.00	5.60
GT1M MVPA (Sec)	584	328	152	1485	1.20	1.43
GT1M Steps	1002	619	275	2719	1.30	1.71

Conclusions.

Participants generally understood the questions in the child questionnaire, and when a participant did not understand a word or phrase a member of the study team was available to help. No feasibility issues were reported for travel diary or activity monitor protocols, however it was common for participants to forget to put their belt on before leaving for school (18% of data were lost this way).

Results from the pilot study indicate that the child questionnaire and travel diary are valid and reliable tools for use in travel-related research with primary five aged children. Adequate validity evidence was provided for the NL-1000 as a measure of commuting-related physical activity. Although the differences between the NL-1000 and GT1M estimates of MVPA and steps were small, it was decided to continue to use the NL-1000 alongside the GT1M in the main evaluation study in order to generate additional validity evidence for the NL-1000.

Main Evaluation Study

Procedures.

On the Monday of each data collection week members of the research team went to the relevant school to administer the commuting measures. The research team distributed the questionnaires (child and parent) and travel diaries. Participants were asked to store their travel diary in a safe place in the classroom and complete each morning. Parent questionnaires were to be taken home and returned during the course of the week. Participants sat in small groups to complete their questionnaire, and each group was supervised by a member of the research team. Participants were given their belt (with attached activity monitors) on completion of their questionnaire. The time that the activity monitors were distributed was recorded for GT1M data processing purposes. Participants were asked to wear their activity monitors during waking hours, and only to remove them during sleep, swimming, bathing, and contact sports. Participants were also asked to approach one of the research team in the school playground each morning on arrival at school to have their arrival time and NL-1000 steps and MVPA recorded. The protocol for the main evaluation study differed slightly from the pilot study in that participants were asked to wear the activity monitor across the whole day in the main evaluation study, rather than only wearing it during commuting time, as in the pilot study. Participants only wore the monitors during commute time in the pilot study to (a) allow a known home arrival time to be established for comparison with the travel diary reported home time, and (b) to allow the validity of the NL-1000 to be investigated.

On the Friday of data collection participant's activity monitors, parent questionnaires, and travel diaries were collected. This was done after the time of day that the activity monitors had been handed out on the Monday to allow Monday afternoon data to be combined with Friday morning data in order to create a composite day. GT1M data were downloaded on Friday evening and NL-1000 daily MVPA and step totals were retrieved from the device memory and entered into a master data sheet. Questionnaire and travel diary data were entered into the master data sheet. GT1Ms were recharged and initialised over the weekend ready for the next week of data collection (there was not enough equipment or researchers to test schools simultaneously).

Data management.

Electronic data were stored on a password protected computer, and hard copy data (i.e. questionnaires and travel diaries) were kept in a locked filing cabinet. Participants were assigned identification numbers to protect their identity.

Actigraph GT1M data processing.

Non-wear GT1M data were deleted. These were: (a) data before the activity monitors were distributed on the Monday, and after collection on the Friday; (b) data between the hours of 23:30 and 05:30 (i.e. sleeping time); and (c) data on days when the participant was absent or had forgotten to wear their belt (according to written records). Monday afternoon data were then merged with Friday morning data to create a composite day, resulting in 4 full days of data. Steps and time spent in MVPA were then calculated for three distinct time periods: (a) morning commute, (b) afternoon commute, and (c) full day. Morning commute was defined as being from 05:30 to the time the child arrived at school (as recorded by the study team). Afternoon commute data were processed differently depending on the mode of travel reported on the travel diary. If the participant reported walking home, data were analysed from 15:00 (end of school day) to the self-reported home time. If the reported home time was before 15:15 then data were analysed up to 15:15. Data for participants who travelled home inactively were analysed from 15:00 to 15:15. Therefore each participant was credited with a home commute time of at least 15 minutes. The individualised approach used to calculate afternoon commute time for walkers and non-walkers was taken to avoid unfairly biasing walkers, who often take longer to commute than children who travel by car. If travel diary data were unavailable, then afternoon commute activity was deemed as missing and was later replaced. Full day was defined as being between 05:30 and 23:30. Steps were calculated using the 'sum' function in Excel. MVPA was calculated using the 'Count if >' function in Excel. MVPA was defined as any activity at or above 4 METs, derived using a previously published MET prediction equation (Trost, et al., 2002), adjusted for 5-sec epochs. Cutpoints ranged from 136-171 counts/5-secs. Two large studies have previously used this equation to establish cutpoints equivalent to different activity intensities (Riddoch, et al., 2004; Troiano, et al., 2008), and so using these cut-points allows for comparative data to be generated. The MVPA threshold was set at 4 METs because of recent suggestions that a threshold greater than 3 METs is more appropriate for children (Guinhouya & Hubert, 2008), to adjust for their higher resting energy expenditure (Harrell, et al., 2005). Following data processing, step and MVPA data were pasted into a master Excel file ready for missing data replacement. No wear time criterion was used in this study. It was assumed that if participants arrived at school wearing their GT1M there would be at least 8 hours of data collected (6 school-day hours and approximately 1 hour before and 1 hour after school). This is similar to the 10 hours per day wear time criterion used in previous studies with children (Riddoch, et al., 2004; Troiano, et al., 2008).Furthermore, data for days on which participants forgot to wear their belt, or were absent from school, were deleted based on written records.

Data checking and replacement.

Initially, data were checked for inputting errors. A random selection of participants' hardcopy data (i.e. questionnaires and travel diaries) were read aloud by one of the research team while another member of the team visually inspected the data sheet for agreement. 10% of data were checked. Data inputting errors were <5%. Single data entry was used in this study as it has been shown that double data entry considerably increases data inputting time (Reynolds-Haertle & McBride, 1992) and may not materially improve the quality of the final data set (Buchele, Och, Bolte, & Weiland, 2005; Gibson, Harvey, Everett, & Parmar, 1994). Furthermore, range checks on each variable were carried out during and after data entry to identify and correct errors that may have affected the final results and conclusions.

Missing data analyses were then carried out to establish type and percentage of missing data. Written records from a data collection diary were consulted to identify days on which participants had forgotten to wear their belts or had been absent from school. NL-1000 data for such days were deleted (GT1M data for these days had previously been deleted during data processing). Participants with missing questionnaire (both child and parent) and travel diary data were also identified.

Pre-intervention, GT1M and NL-1000 data were missing for 78 of 664 days (11.7%), 12 participants (7.2%) had missing GT1M and NL-1000 data for the whole week , 11 participants (6.6%) had completely missing questionnaire data, 28 parents (17.0%) did not return their questionnaires, and 10 participants (6.0%) lost their travel diary.

Post-intervention, GT1M and NL-1000 data were missing for 169 of 664 days (25.5%), 13 participants (7.8%) had missing GT1M and NL-1000 data for the whole week, 3 participants (1.8%) had completely missing questionnaire data, 58 parents (35.0%) did not return their questionnaires, and 24 participants (14.5%) lost their travel diary. 3 participants (1.8%) had no GT1M and NL-1000 data for both pre- and post-intervention. This information was used to inform data replacement.

Outlying data were identified for daily GT1M steps using previously published guidelines (Rowe, Mahar, Raedeke, & Lore, 2004). Daily steps were classed as outlying if values were <1,000 or >30,000 steps/day. No outlying data were found pre-intervention. Post-intervention, three participants had daily step values < 1,000. These data points were deemed to be unrepresentative of the population in question and were therefore deleted and later replaced, as were corresponding daily MVPA data.

Missing data were replaced before any statistical analyses were performed. Missing data were diverse in nature due to the multiple outcome variables being measured. Various data replacement techniques were therefore used. Team meetings were held to identify and discuss available data replacement techniques. These discussions led to the most appropriate replacement techniques being selected for the different types of missing data.

Individual missing step and MVPA data points were replaced using an individual information centered (IIC) technique (Kang, Zhu, Tudor-Locke, & Ainsworth, 2005). This involved replacing a missing data point with the mean value of remaining data points for a given individual. This technique has been shown to be more accurate than group information based approaches e.g. using a group mean to replace data for an individual (Kang, Rowe, Barreira, Robinson, & Mahar, 2009).

If a single questionnaire item within a scale was missing, IIC was used. If a whole scale was missing, data were replaced using the participant’s corresponding data from the other data collection week. For example, if a participant was missing a whole scale from the post-intervention questionnaire, these data were replaced using their data from the pre-intervention questionnaire. This replacement technique was also used for participants missing a whole week of data (either all of their activity monitor data or questionnaire data). This technique assumed no change from pre- to post-intervention, and protected against committing a type 1 error. This was particularly important for data from participants who received the intervention. Some data were deemed inappropriate to replace and were therefore left missing, for example questions about participant's preferred mode of travel, or preferred travel companion.

Group mean replacement (based on school and gender) was used to replace data for three participants who were missing both pre- and post-intervention GT1M data. This data loss was due to a combination of lost devices and device malfunction.

Following data replacement, data were exported from the Excel spreadsheet into an SPSS 17.0 data file ready for analysis.

Data analysis and sample size calculations.

Descriptive statistics will be used to summarise the sample characteristics. The effect of Travelling Green on children's walking to school will be investigated using a mixed two-way factorial ANOVA, using commuting steps as the primary outcome measure.

G-Power (version 3.1.2) was used to calculate the required sample size for the primary outcome of commuting steps. Statistical test was set at F-test ANOVA, effect size f (Cohen's *f*) was set at 0.15 (medium), Alpha level was set at 0.05, for a power of 80%, using a within-between groups design. There was a high correlation among repeated measures ($r = 0.73$). The total required sample size based on these parameters was 50 (25 in each group). It should be noted that this power calculation does not account for the effect of clustering of variables within groups (i.e. schools).

Data generated through this study will be used to answer several other research questions concerned with: (a) the influence of seasonality on Travelling Green effectiveness; (b) the long term effect of Travelling Green on commuting behaviour; (c) the personal and environmental determinants of active commuting in children; (d) parent's role in children's choice of travel mode; (e) the moderating effect of socioeconomic status and deprivation level on school travel behaviour change; and (f) the role of habit in children's school commuting behaviour. These questions will be dealt with in future papers stemming from the wider Travelling Green study, and are not dealt with in this thesis.

Discussion

This paper set out the study rationale and methods for the Travelling Green study, which had the primary aim of (a) investigating the immediate and long-term effects of Travelling Green on walking to school in a large sample of Scottish children, and (b) pilot testing various measures of active commuting in the school setting. Additional research questions (identified above) will be answered using data generated from this study.

The piloted active commuting measures were found to be reliable and feasible for use in the primary school population, and were therefore used in the main evaluation of Travelling Green. Results from the main study evaluating Travelling Green will help to inform the research community of strategies that may or may not successfully increase children's walking to school.

All data (i.e. pre, post, 5 and 12 month) have been collected and processed. Several data collection issues were encountered. Children regularly forgot to put on their belts before going to school, and equipment loss was common. This posed obvious constraints including data loss and the need to obtain additional equipment. It is interesting to note that children forgot to wear their belts more frequently during post-intervention data collection, and equipment loss was also greater during this time. This suggests that participants may have become less enthused by the study over time, and the novelty of wearing the belts may have worn off as the study progressed. Incentives for children to wear their belts and return them at the end of data collection (small frisbees and wrist bands) were introduced at 5 and 12 month data collection. This approach improved adherence to protocols.

Conducting research in the school environment can present unforeseen challenges, and several difficulties were encountered during this study. These included difficulties contacting and communicating with relevant school staff to set up meetings or to administer testing equipment, for example. It was also challenging to create an atmosphere conducive to conducting controlled research in the school environment, for example one of the study schools had open-plan classrooms where children were easily distracted by activities going on in surrounding classes. These issues were not necessarily the fault of any one individual or group, but are somewhat inherent obstacles of school-based research, and added constraints to conducting the study. Similar issues have previously been reported by other school-based researchers (Harrell, Bradley, Dennis, Frauman, & Criswell, 2000; Thomas & Fleming, 2008). Researchers proposing to conduct a school-based study should ensure that they are well prepared and have efficient protocols in place to fit their study into a busy school schedule. Additionally, researchers should plan for the unexpected and have contingency plans in place.

Methodological issues were encountered that relate specifically to conducting school commuting research, and issues that relate more generally to conducting physical activity research. Previous school travel studies have used a variety of definitions to categorise an individual as either an active or inactive commuter. These include self-reported usual mode of travel (Voss & Sandercock, 2010), parent proxy reported usual mode (Timperio, et al., 2006), mode of travel used on the day of survey (Staunton, et al., 2003), number of trips by mode over the past week (Abbott, et al., 2009), and direct observation (Sirard, Ainsworth, McIver, & Pate, 2005). These methodological differences make it difficult to compare findings between studies, and a consensus on one method of defining commuting mode would be helpful. In the present study, usual mode of travel to and from school was provided by the parent and children. Parent responses may be more accurate as they responded without the presence of researchers (i.e. in their own home) and therefore may be unaffected by social desirability bias.

Another methodological challenge encountered in this study was related to accelerometer use, specifically in choosing one of the many available cut-points to define MVPA. Available 1-minute cutpoints for 3 METs in children range from 615 to 3200 counts/min (Metallinos-Katsaras, Freedson, Fulton, & Sherry, 2007; Puyau, Adolph, Vohra, & Butte, 2002), and no consensus has been reached in the published literature as to which cut-point is most appropriate (Guinhouya & Hubert, 2008;

Wilkin & Voss, 2004). Similar to the issue of defining an active commuter, reaching a consensus on appropriate accelerometer cut-points in children would allow for comparisons to be made between studies. In the present study, age specific MVPA cut-points were calculated for 4 METs using a MET prediction equation developed by the Freedson research group (Freedson et al., 1997) and published by Trost et al. (2002). This equation was developed using data from 80 participants aged 6-18 year olds during treadmill walking and running and has previously been used in two population-based studies with children to determine time spent in MVPA (Riddoch et al., 2004; Troiano et al., 2008). A criticism of this equation is that it was not developed under free-living conditions.

This study has several limitations and strengths. One limitation is the lack of randomisation, however as previously stated randomisation was not possible due to existing school schedules. It is acknowledged that not randomising allocation to intervention and control groups does not protect against any underlying systematic differences between groups. A lack of health-related outcome measures such as BMI, heart rate, or cardiovascular fitness may also be seen as a study limitation. However, it is unlikely that a change in any of these outcome variables would be observed after 6 weeks. Moreover, the desired outcome of Travelling Green is to increase walking as a commuting mode, not to directly change health outcomes. Another limitation is the absence of a control group for the duration of the study i.e. no control for 5 and 12 month follow-up measures. It was felt that it would be unethical to postpone the delivery of Travelling Green longer than necessary; therefore a minimal control period was used. Finally, the study sample is only representative of children from either end of the socio-economic continuum (i.e. high and low deprivation). Study results should therefore only be generalised to children from these populations.

This study has several strengths. Previous studies that have investigated the effect of school commuting interventions have often lacked control groups, have used self-reported outcome measures, and have failed to obtain follow-up measures. The present study addresses each of these limitations by using a quasi-experimental design, by obtaining objectively measured physical activity data, and by taking follow-up measures at 5 and 12 months post-intervention. In addition, to the author's knowledge, this is the first study to accurately establish activity levels during commute time using accelerometry. Previous studies using accelerometry have defined the school commute using segments of time before and after school, for example 08:00-09:00 and 15:00-16:00 (Cooper, et al., 2003; Metcalf, et al., 2004), and thus have inevitably captured activity that was not related to the commute (e.g. when a child was running around the playground with friends before the start of school).

In conclusion, the Travelling Green study will create important evidence for the possibility of increasing walking to and from school using a school-based active travel intervention. This information will contribute to the growing evidence base of strategies used to curb the declining trends in walking to school.

Additionally, the pilot work for the Travelling Green study provides valuable reliability and validity evidence for several active commuting procedures and measures that can now be used with confidence in future commuting related studies.

Chapter 4

Paper 2

The effect of a school based active commuting intervention on children's commuting physical activity and daily physical activity

Abstract

Purpose: Travelling Green (TG) is a school based active travel resource aimed at increasing children's walking to school. The resource consists of a 6-week curriculum-based program of lessons and goal setting activities. This quasi-experimental study aimed to investigate the effect of TG on children's walking to and from school and total daily physical activity.

Methods: Participants were 166 Scottish children (60% male) aged 8-9 years from 5 primary schools. Two schools (n = 79 children) received TG in September/October 2009. Three schools (n = 87 children) acted as a comparison. Steps and moderate to vigorous physical activity (daily, a.m. commute, p.m. commute, and total commute) were measured for 4 days pre-intervention and for 4 days post-intervention using Actigraph GT1M accelerometers. Mixed 2-way factorial ANOVAs were used to evaluate the effect of TG on children's school travel and daily activity.

Results: Mean steps (daily, a.m., p.m., and total commute) decreased from pre- to post-intervention in both groups (TG by 901, 49, 222, and 271 steps/day and comparison by 2,528, 205, 120, and 325 steps/day, respectively). No significant group by time interactions were found for a.m., p.m., and total commuting steps (p > .05). A medium (partial eta squared = .09) and significant (p < .05) group by time interaction was found for total daily steps, indicating that the decrease in total daily steps was significantly less for the intervention schools than the comparison schools. A medium to large main effect for time was found for a.m. steps (eta squared = .06; p < .05), p.m. steps (eta squared = .08; p < .05), and total commuting steps (eta squared = .14; p < .05) There was no significant group main effect (p > .05) for any of the commuting measures. Moderate to vigorous physical activity results were similar to step results.

Conclusion: TG appears to have little effect on children's walking to and from school. It should be noted that pre-intervention measures were taken in early fall when weather conditions were conducive to walking, and post-intervention measures were taken in late fall/early winter when weather conditions were less conducive to

walking. This is reflected in decreased steps across all step categories for both groups from pre- to post-intervention. However, for total daily steps and daily moderate to vigorous physical activity, the TG intervention appeared to result in a smaller decrease than for children in the comparison schools.

Introduction

There are many benefits of physical activity to children that encompass various physical, social, and psychological aspects (Janssen & LeBlanc, 2010). The journey to school is a prime opportunity for children to be physically active (Tudor-Locke, et al., 2001), however recent trends show that children actively commute to school less than they used to (Buliung, et al., 2009; McDonald, 2007; van der Ploeg, et al., 2008). There is a need for interventions that promote active commuting to school so that these negative trends are reversed. Two popular programmes that aim to achieve this are Safe Routes to School and Walking Buses.

Safe Routes to School is a federally funded initiative in the U.S. that aims to increase the prevalence and safety of active school travel. Funding ($1 million to each state per year) is provided for infrastructure and non-infrastructure-related strategies. Infrastructure-related strategies include improved pavements, traffic calming measures, and school-crossings. Non-infrastructure-related strategies include public awareness campaigns, outreach to the media and community leaders, traffic education at schools, and bicycle and pedestrian safety education for children. Safe Routes to School initiatives have been found to successfully increase active school travel and reduce car use (Boarnet, Anderson, et al., 2005; Boarnet, Day, et al., 2005; Staunton, et al., 2003).

Walking Buses involve groups of children that walk to and from school along a pre-defined route at a set time. The route passes stops where children may join or leave the bus. Walking buses are supervised by two or more adults, one who leads the bus (driver) and the other who follows at the back (conductor). Adults are generally parents of the children, and their job is to guide the bus safely between the start of the route and the school (Collins & Kearns, 2005). Walking Buses have grown in popularity because they are inexpensive, can be implemented quickly, and are a visible sign that something is being done to curb the widespread decrease in active school travel (Mackett, et al., 2002). Two studies, each using quasi-experimental designs, have been conducted to assess the impact of Walking Buses on children’s commuting behaviour (Heelan, et al., 2009; Mendoza, et al., 2009). Each of these studies showed that children at schools where Walking Buses were implemented walked significantly more post-intervention compared to children in the control schools. Walking prevalence was measured using a hands-up survey (Mendoza, et al., 2009) and using a self-report logging tool (Heelan et al., 2009).

Travelling Green is another school travel intervention that is implemented in Scotland. This 6-week school-based project aims to increase walking to school via in-class lessons and goal-setting activities. A previously conducted study found that children who received the intervention increased the distance travelled to school by active modes and decreased the distance travelled by inactive modes following the intervention (McKee, et al., 2007). These are positive findings; however the study had limitations. Physical activity was not objectively measured (the outcome measure was self-reported mode and distance) and the study sample was small (one intervention school, *n* = 31, and one control school, *n* =29).

The present study aimed to carry out a more robust evaluation of Travelling Green by using objectively measured physical activity as the outcome variable and by using a larger study sample.

Method

Results presented in this paper are based on data collected as part of a larger study that investigated the long term effects of Travelling Green on the commuting behaviour of primary school aged children. Data were collected pre- and post-intervention, and at 5 and 12 month follow-up. A detailed description of the method used in that study is available in Paper 1 of this thesis. Results presented in this paper are concerned solely with the effect of Travelling Green on commuting behaviour and daily physical activity from pre- to post-intervention; no results are reported from data collected at 5 or 12 month follow-up. University ethical approval was granted for all procedures (Appendix B).

Sample and Design

Participants were 166 children (aged 8-9 years) from 5 primary schools in the west of Scotland. A quasi-experimental design was used to investigate the effect of Travelling Green. Two schools (*n* = 79) received the intervention in September/October 2009. Three schools (*n* = 87) acted as comparisons during this period. Outcome measures were taken during 5 school days pre-intervention and 5 school days post-intervention. These included an objective measure of commuting-related physical activity (Actigraph GT1M accelerometer), a school travel questionnaire, and a travel diary.

The Intervention

Travelling Green was designed by West Dunbartonshire Council in collaboration with NHS Greater Glasgow, and has been funded by the Scottish Government to be provided to every school in Scotland. The resource comprises a Teacher’s Handbook and Pupil Packs for each child. The Teacher’s Handbook contains introductory activities to the project and a series of 13 lesson plans based on topics such as road safety, the importance of a healthy lifestyle, and lessons on how parts of the body function (i.e. the heart and lungs). Teachers can use the lessons at their discretion and can therefore relate the topics to other themes being covered in the curriculum. The Pupil Pack contains materials that allow the pupils to set walking goals (i.e. try to walk to school on more days of the week as the project progresses) and to record how they travel to and from school each day. The programme lasts for 6 weeks. Teachers at each school were trained on how to deliver Travelling Green by a member of the study team. The study team member had previously received instruction on how to train teachers to deliver the resource.

Procedures

Due to restrictions on equipment and personnel it was not possible to collect data in each school simultaneously. Data were therefore collected in one school at a time, from Monday to Friday. Participants completed the child questionnaire on the Monday during school time under the supervision of the study team. On completion of the questionnaire participants were given the elastic belt with attached GT1M and shown how to wear the belt correctly. Instructions were given to put the belt on after waking up in the morning and to take it off before bed. Monitors were not to be worn during bathing, swimming, or contact sports to prevent damage to the devices. On arrival at school each morning participants approached a member of the study team in the school playground who recorded the participant’s arrival time using a digital watch that had been time synchronised with the computer used to initialise the

GT1M. Participants were instructed to complete their travel diary retrospectively (i.e. at the start of the school day when they entered the classroom). This achieved a higher response rate than if the diaries were taken home and returned at the end of the week. GT1Ms and travel diaries were collected on the Friday and data were downloaded the same day. Questionnaire data and travel diary data were entered into an SPSS spreadsheet.

GT1M data were processed in such a way that steps and time spent in MVPA were calculated for morning commute, afternoon commute, total commute, and the full day. Outlying activity data points were deleted and missing activity data were replaced using an individual information centred (IIC) approach (Kang, et al., 2005).

Data analysis

Descriptive statistics were calculated for relevant variables. Mixed two-way factorial analyses of variance (ANOVAs) were used to assess the effect of Travelling Green on steps and MVPA time (total commute, morning commute, afternoon commute, and full day).

Results

Baseline sample characteristics are displayed in table 4.1, and mean step and MVPA values for all commuting conditions are displayed in table 4.2. Across the total sample (intervention and comparison combined) 47% of participants reported walking to school, 26% did no walking, and 27% used mixed modes (including some walking) – these figures were generated via the child questionnaire. MVPA attributed to the school commute (18 mins) accounted for 20% of participants average daily MVPA (91 mins), and accounted for 30% of the daily recommended MVPA for children (60 mins/day, Scottish Executive, 2003). On average participants achieved 31 minutes more than the daily recommendations for children’s MVPA.

Table 4.1
Baseline sample characteristics

	Intervention	**Comparison**
n	79	87
Age (yrs; mean ± SD)	8.7 ± .51	8.6 ± .48
Male (%)	57	62
Walkers (%)*	56	39
Non-walkers (%)	15	36
Mixed modes (%)	29	25

*Commuting mode was derived using the question ‘On a normal day, how do you usually travel to school?’

Table 4.2
Step and MVPA values at pre- and post-intervention, Mean ± SD

	Intervention group		**Comparison group**	
Steps	Pre-Intervention	Post-intervention	Pre-Intervention	Post-intervention
Total commute	2,395 ± 936	2,124 ± 852	2,186 ± 1091	1,861 ± 953
Morning commute	1,168 ± 471	1,119 ± 617	1,167 ± 608	962 ± 579
Afternoon commute	1,227 ± 735	1,005 ± 501	1,019 ± 715	899 ± 588
Total daily	10,766 ± 3370	9,865 ± 3494	12,013 ± 3117	9,485 ± 2600
MVPA time (secs)				
Total commute	1,082 ± 499	924 ± 415	1,016 ± 551	870 ± 470
Morning commute	534 ± 228	501 ± 278	548 ± 286	463 ± 288
Afternoon commute	548 ± 405	423 ± 260	468 ± 381	407 ± 305
Total daily	5,062 ± 1644	4,633 ± 1722	5,827 ± 1664	4,656 ± 1431

Steps decreased from pre- to post-intervention by 271, 49, 222, and 901 for total commute, morning commute, afternoon commute, and total day respectively for the intervention group and by 325, 205, 120, and 2528 for the comparison group. MVPA time (secs) decreased from pre- to post-intervention by 158, 33, 125, and 429 for total commute, morning commute, afternoon commute, and total day respectively for the intervention group and by 146, 85, 61, and 1,171 for the comparison group.

Afternoon commute steps and MVPA data were skewed and kurtotic (> 2.0) and were therefore log transformed before analysis. Analyses were carried out on the untransformed and transformed data. Results using both data were not meaningfully different and so results from the untransformed data are reported.

No significant group by time interactions were found for morning (Figure 4.1), afternoon (Figure 4.2), and total commuting steps (Figure 4.3) ($p > .05$). A large (partial eta squared = .09; Cohen, 1988, p. 283) and significant ($p < .05$) group by time interaction was found for total daily steps, indicating that the decrease in total daily steps was significantly less for the intervention schools than the comparison schools (Figure 4.4). Results indicate a medium to large main effect for time for morning commute steps (eta squared = .06; $p < .05$), afternoon commute steps (eta squared = .08; $p < .05$), and total commute steps (eta squared = .14; $p < .05$). There was no significant group main effect ($p > .05$) for any of the commuting steps measures.

No significant group by time interactions were found for morning (Figure 4.5), afternoon (Figure 4.6), and total commuting MVPA time (Figure 4.7) ($p > .05$). Similar to total daily steps, a large (partial eta squared = .08) and significant ($p < .05$) group by time interaction was found for total daily MVPA time, indicating that the decrease in total daily MVPA time was significantly less for the intervention schools than the comparison schools (Figure 4.8). Medium to large main effects were found for time for morning commute MVPA time (eta squared = .07; $p < .05$), afternoon commute MVPA time (eta squared = .08; $p < .05$), and total commute MVPA time (eta squared = .14; $p < .05$). There was no significant group main effect ($p > .05$) for any of the commuting MVPA time measures.

Objectively measured commuting physical activity decreased from pre- to post-intervention, however the proportion of participants in the intervention group that self-reported walking to school post-intervention increased by 10% (from 56% to 66%) and the proportion of participants who reported no walking or using mixed modes decreased by 1% and 9% respectively. Post-intervention, self-reported walking to school increased by 8% in the comparison group and the proportion of participants reporting that they did no walking or used mixed modes decreased by 7% and 1% respectively.

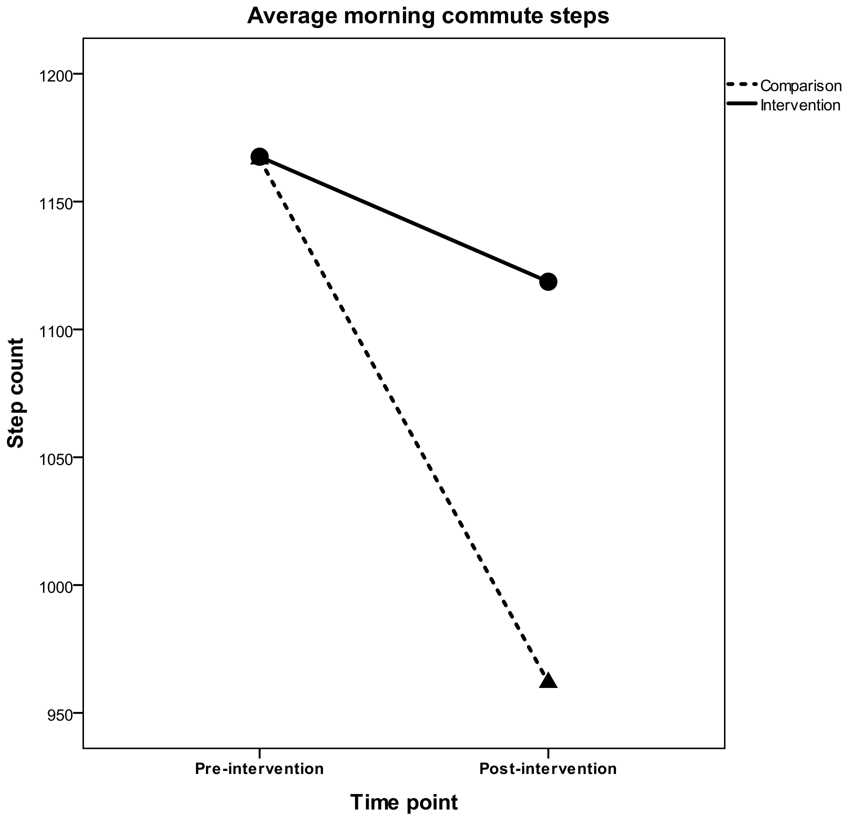

Figure 4.1
Average morning commute steps

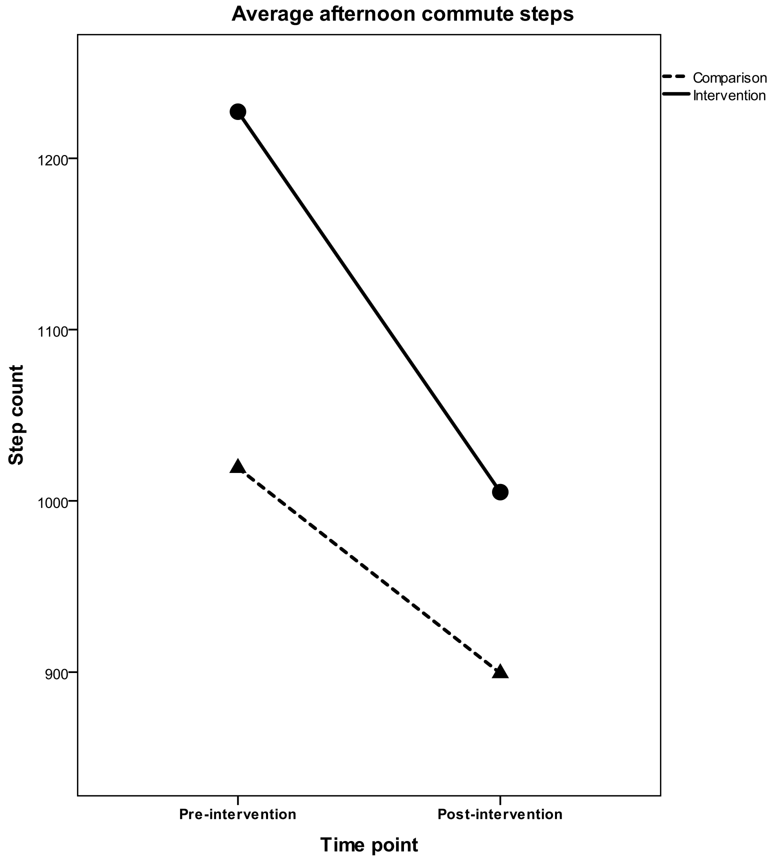

Figure 4.2
Average afternoon commute steps

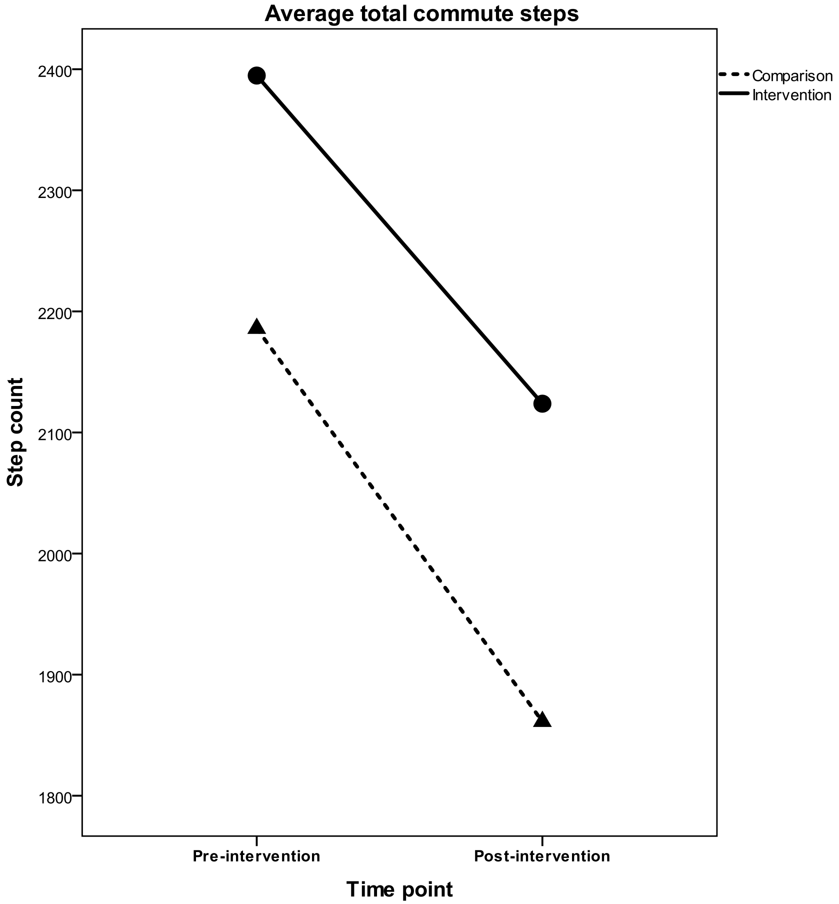

Figure 4.3
Average total commute steps

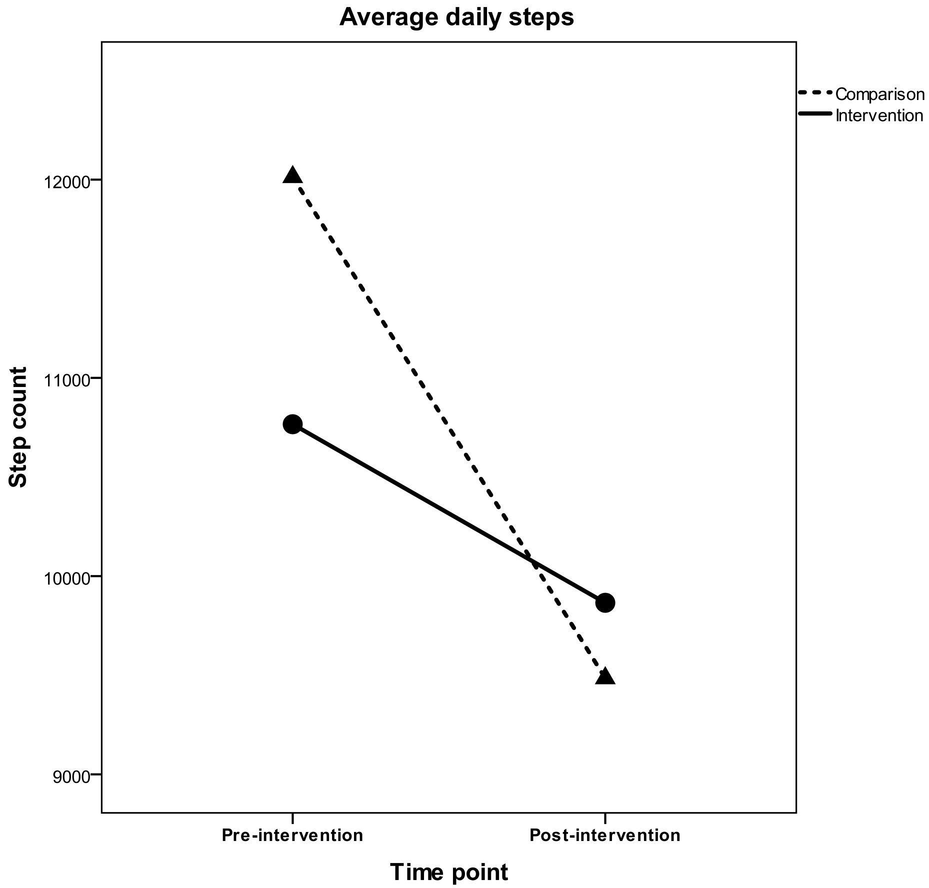

Figure 4.4
Average daily steps

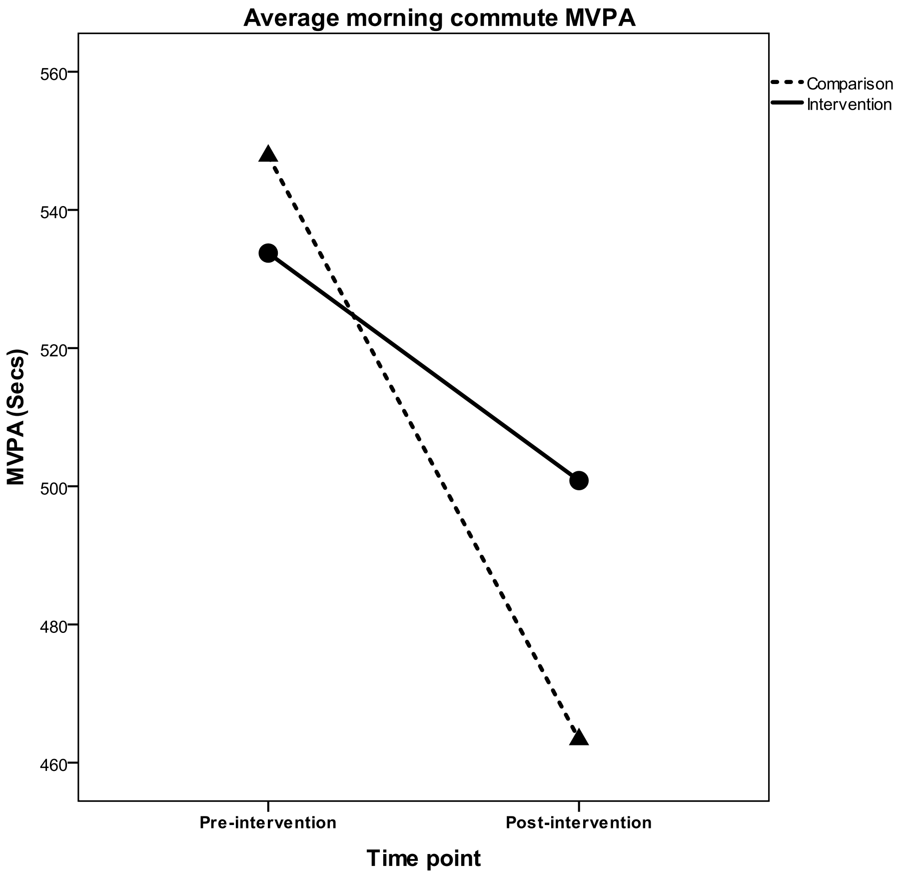

Figure 4.5
Average morning commute MVPA

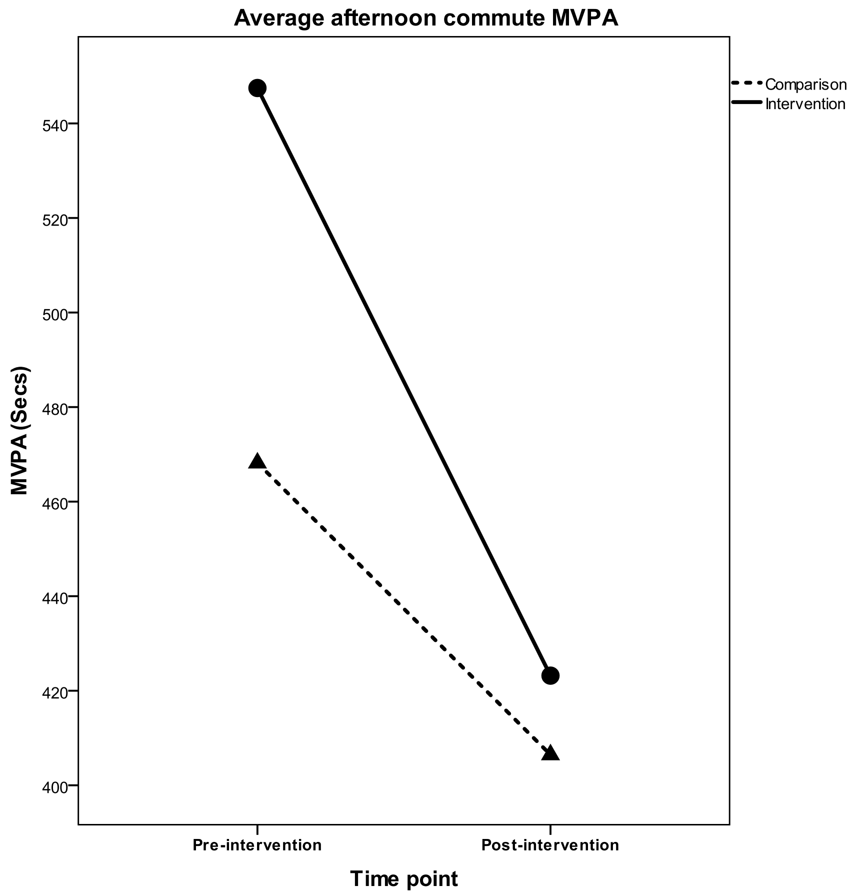

Figure 4.6
Average afternoon commute MVPA

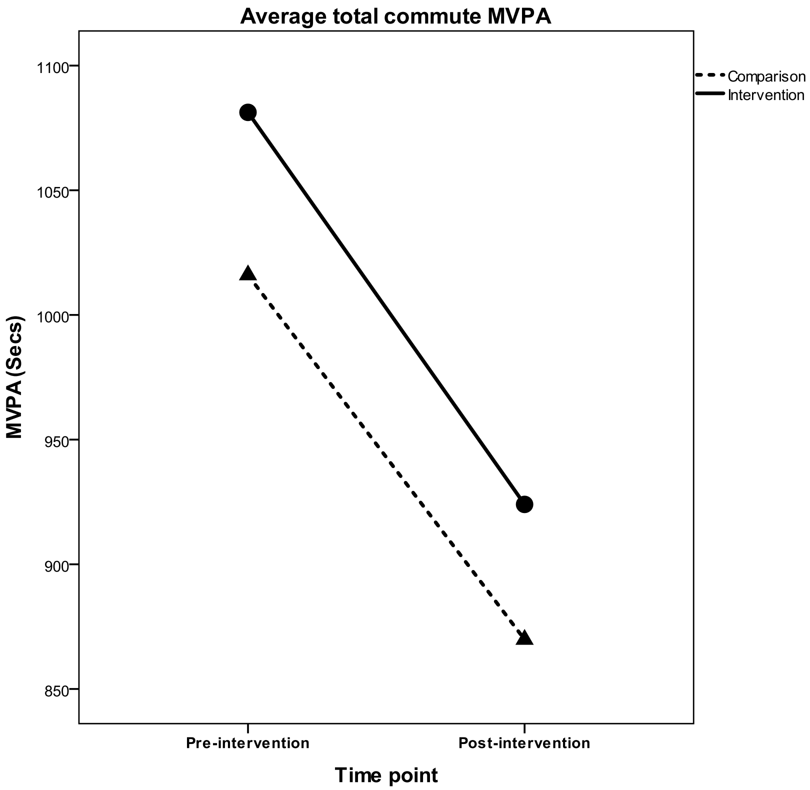

Figure 4.7
Average total commute MVPA

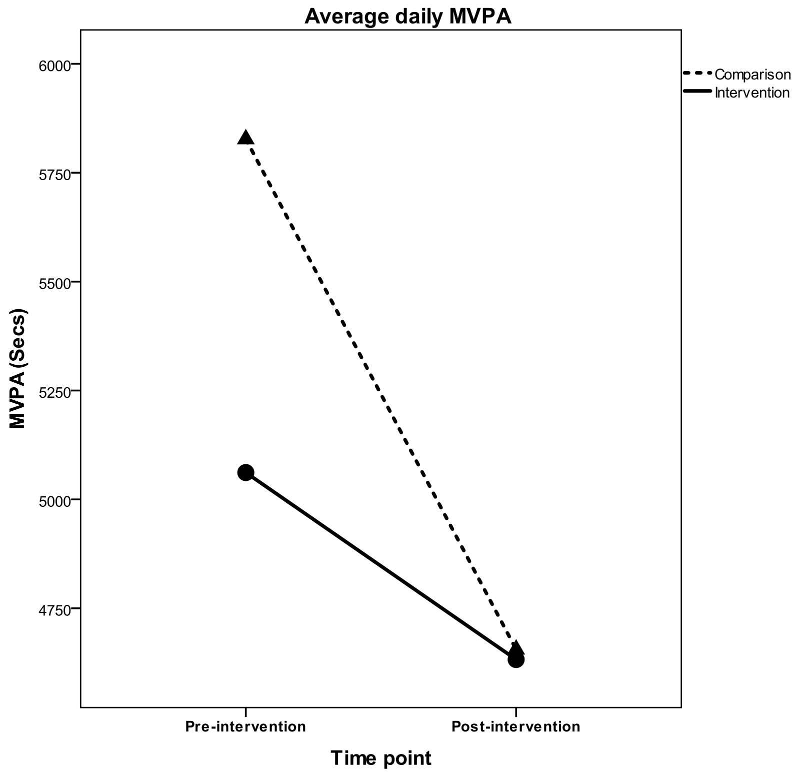

Figure 4.7
Average daily MVPA

Discussion

The purpose of this study was to investigate the effect of Travelling Green on children's objectively measured physical activity and school commuting behaviour. Both the intervention and control group decreased commuting-related steps and MVPA time from pre- to post-intervention. The intervention group decreased daily steps and MVPA less than the control group following the intervention. The intervention therefore appeared to have no effect on objectively measured commuting behaviour but may have attenuated the seasonal decline in daily physical activity from pre- to post-intervention. There was an increase, however, in self-reported walking to school in the intervention group, although the same trend was observed in the comparison group.

These findings are unexpected given that Travelling Green has previously been shown to increase the distance travelled to school by active mode and decrease the distance travelled by inactive mode in children who received the intervention (McKee, et al., 2007). There are two possible contributing factors as to why the intervention appears to be ineffective. First, pre-intervention measures were obtained during late summer/early autumn when weather conditions (i.e. temperature, rainfall, and daylight hours; www.metoffice.gov.uk/weather/) were conducive to walking. However, post-intervention measures were obtained during late autumn/early winter when weather conditions were less conducive to walking. This is supported by previous research that has found a marked decrease in both children's physical activity levels (Carson & Spence, 2010; Riddoch et al., 2007) and active school travel during the winter period (Borrestad, Andersen, & Bere, 2011; Heelan, et al., 2009) and inclement weather (Pooley et al., 2010; Suminski et al., 2006).

Second, the fidelity of intervention implementation is unknown. Because the intervention was delivered by the class teachers, rather than the research team, it may not have been implemented as was intended. Teachers have a busy schedule and a full curriculum, and so an additional initiative or programme to be implemented on top of an already large workload may be viewed as burdensome and therefore poorly delivered. This raises important issues about the nature of effectiveness and efficacy research. The present study may be defined as an effectiveness trial, in that it aims to assess the impact of Travelling Green in a heterogeneous sample, in two variable sites, and when being delivered under non-controlled conditions (Prochaska, Evers, Prochaska, Van Marter, & Johnson, 2007). Efficacy trials are characterised by the delivery of a highly controlled intervention to a homogeneous sample (Glasgow, Lichtenstein, & Marcus, 2003). In this regard, the evaluation study conducted by McKee et al. (2007) is more similar to an efficacy trial than an effectiveness trial. These factors may account somewhat for the different findings between the present study and that of McKee et al. (2007).

A positive finding from this study was an increase in the number of intervention group participants that reported walking to school post-intervention; however this increase in self-reported walking was also observed in the comparison group and was not reflected by the objective physical activity measures. Additionally, it is encouraging to note that, on average, participants in both groups exceeded the daily physical activity guidelines of 60 minutes of MVPA (Scottish Executive, 2003).

Another interesting finding is that total daily steps and MVPA decreased significantly less in the intervention group compared to the control group. It may be that the curricular lessons on topics such as general health and physical activity resulted in children in the intervention group decreasing their activity levels less than the comparison group at times when they had the autonomy to do so e.g. during break time, lunch, and after school. Additionally, parents of the children in the study sample reported overwhelmingly (90%) that they were the main decision maker regarding their child's travel mode. This suggests that even if a child wanted to change their travel behaviours they would be unable to do so, because their parent is the gatekeeper to this behaviour. This is supported by previous research indicating that a child's mode of travel to school is heavily influenced by their home environment, their parent's work situation, and the mode of travel that their parents perceive to be easiest and most convenient (Faulkner, et al., 2010; McDonald, 2008c).

Strengths and Limitations

A major strength of the present study is the more accurate measurement of physical activity during commute time. To our knowledge this is the first study to obtain such data. The few studies to date that have used accelerometry to measure commuting-related physical activity have used relatively arbitrary time periods before and after school to define commuting time, e.g. 08:00-09:00 and 15:00-16:00, or 45 minutes before the start of school (Cooper, et al., 2003; Ford, et al., 2007; Metcalf, et al., 2004; Sirard, Alhassan, Spencer, & Robinson, 2008). Using these approaches non-commuting-related activity is attributed to commuting activity, for example when a child arrives early in the school grounds and plays with friends before the start of school, resulting in an inflated estimation of commuting-related activity and the introduction of random variation. In the present study an individualised approach was taken to determine relatively precise school and home arrival times. Although time consuming, this novel technique provided an accurate time frame during which commuting activity was assessed. One other study has accurately determined commuting-related activity by combining GPS and accelerometry data, and defined the journey to school as any activity occurring outside the school boundary (Cooper, Page, Wheeler, Griew, et al., 2010). However, these data were only concerned with the journey to school, and no similar information was reported for the journey home. Other strengths of the present study include the relatively large sample and the use of comparison schools.

Despite these strengths there are several study limitations. First, participants were not randomised into the intervention or comparison group. This was due to the unit of intervention delivery being at the school level rather than the individual level. Furthermore, some schools had already scheduled the implementation of Travelling Green into their school year before agreeing to participate. Second, results are only generalisable to children from schools in either an area of high deprivation or an area of low deprivation. Third, only four full days of data were available, and results may be strengthened if data were collected over a complete school week, including the journey to school on Monday and the journey home on Friday. Finally, substantial data loss was encountered. Pre-intervention, GT1M data were missing for 78 of 664 days (11.7%) and 12 participants (7.2%) had missing GT1M data for the whole week. Post-intervention, GT1M data were missing for 169 of 664 days (25.5%) and 13 participants (7.8%) had missing GT1M data for the whole week. Data loss was due to participant failure to adhere to study protocol and equipment loss. Better quality data may be achieved by using incentives to increase adherence to protocols and minimise equipment loss.

Conclusion

Travelling Green has no effect on commuting-related physical activity among Primary 5 aged Scottish school children. However, it may mitigate against the detrimental effects of seasonality on daily physical activity levels. This study is the first to objectively measure commuting-related physical activity during accurately-measured commute time, and is one of few studies to use accelerometry in the evaluation of a school travel intervention.

Data collected as part of the wider Travelling Green study (Paper 1 of thesis) will help to fill the knowledge gap in areas such as (a) the effect of Travelling Green during a more favourable time of year (late spring/early summer), (b) commuting behaviour change as children age, (c) the role of psychological variables in commuting-related behaviour change, and (d) the moderating effect of socioeconomic status and deprivation level in commuting-related behaviour change. Future school travel research should (a) investigate the effect of Travelling Green on children from the general population (i.e. not from areas of high or low deprivation) and (b) aim to increase adherence to study protocols by using incentives.

Chapter 5

Paper 3

Children's school travel: Investigating the role of self-efficacy and outcome expectations

Abstract

Background: An understanding of the correlates of school travel behaviour may help in the development of interventions aimed at curbing declining rates of active travel. Most correlational studies have focused on the physical and social environment and little is known about the psychological correlates of children's school travel. Furthermore, the relative importance of parent and child psychological attributes is unknown, and it is unclear who the main decision maker is regarding the child's travel mode.

Aim: The primary aim of the present study was to investigate the ability of parent and child psychological attributes (self-efficacy and outcome expectations) to predict school travel behaviour. Additionally, this study aimed to investigate the relative importance of parent and child psychological attributes, and to determine whether the parent or child is the main decision maker regarding mode choice.

Method: Participants were 166 Scottish school children (mean age 9) and 143 parents (mean age 40). Commuting-related activity (steps) was measured for the journey to and from school using accelerometers. Parent and child questionnaires were used to determine age, gender, distance from home to school, car ownership, deprivation level, usual mode of school travel, main decision maker for commuting mode, self-efficacy for commuting-related tasks, and outcome expectations for walking to school. Psychological attributes (self-efficacy and outcome expectations) that displayed bivariate correlations with commuting steps were included in hierarchical multiple regression models to investigate their ability to predict commuting activity for the journey to and from school while controlling for relevant confounders.

Results: Around half of the participants walked to school. More children walked home from school (57%) than to school (49%). Parent self-efficacy (beta = .26, $p < .01$) was the only psychological attribute to predict commuting behaviour for the journey to school. None of the parent or child psychological attributes significantly predicted commuting behaviour for the journey home. Car ownership was a

significant predictor of commuting behaviour for the journey to (beta = -.24, $p < .01$) and from school (beta = -.25, $p < .05$). Parents reported overwhelmingly (90%) that they were the main decision makers regarding whether their child walked to school.

Conclusion: Parent self-efficacy significantly predicted commuting behaviour on the journey to school. Interventions aimed at increasing walking to school should be targeted to older children who have autonomy to change their behaviour. Alternatively, interventions may focus on parents of younger children as they have the final say regarding how their child travels to school.

Introduction/Rationale

Active commuting to school affords an important opportunity for children to contribute to their daily physical activity levels and reap the potential health benefits (Sothern, Loftin, Suskind, Udall, & Blecker, 1999). Children who walk to school are more active during the commute (Ford, et al., 2007) and at other times of the day (Cooper, et al., 2003), and have higher levels of cardiovascular fitness (Voss & Sandercock, 2010) compared to their peers who travel using inactive modes. In spite of these benefits, active school travel is in decline in many developed countries (Grize, et al., 2010; McDonald, 2007; van der Ploeg, et al., 2008).

An understanding of the correlates of active school travel is an important step in reversing these trends. The term correlate refers to the cross-sectional association between a variable and an outcome. It is important to note that correlation does not infer causation, however the identification of a correlate may warrant grounds for further study (Bauman, Sallis, Dzewaltowski, & Owen, 2002). For example, a correlate may be experimentally manipulated to determine whether it brings about a causal change in the outcome of interest. Two examples of this strategy are available from the school travel literature: the Safe Routes to School initiative and Walking Buses. It has been shown that heavy traffic, busy roads, and other physical environmental features are negatively associated with walking to school (McMillan, 2007; Timperio, et al., 2006). The Safe Routes to School initiative (SR2S) implements changes such as improved pavements, crossings, and traffic calming measures to make the physical environment more conducive to walking (Hubsmith, 2006). This manipulation of the physical environment has been shown to be effective in altering active commuting behaviour (Boarnet, Day, et al., 2005). Walking buses are another example of how a correlate can be manipulated to bring about a causal effect in commuting behaviour. High levels of social support (peer and parental) is associated with an increased likelihood of walking to school (Hume, Jorna, et al., 2009; Panter, et al., 2010a). Walking buses bring adults and children together which facilitates this supportive environment for walking to school. Again, manipulating a correlate in this way has been shown to increase active school travel (Heelan, et al., 2009).

A number of correlates of children's walking to school have been identified. Those for which the strongest evidence exists include distance from home to school (Sirard & Slater, 2008), deprivation level (Ewing, et al., 2004), ethnicity (Evenson, et al., 2003; McDonald, 2007), gender (Davison, et al., 2008), car ownership (Carlin, et al., 1997; Grize, et al., 2010), living in an urban area with a high population density (Fulton, et al., 2005), and perceiving road and traffic danger (Braza, et al., 2004; Bringolf-Isler, et al., 2008).

Studies to date have focused primarily on the demographic and environmental correlates of children's travel behaviours (Sirard & Slater, 2008) and little is known about the role of psychological factors in this area. Various psychological correlates have been shown to be associated with general physical activity behaviours in children. These include motivation (Biddle & Armstrong, 1992), intentions (Sallis, Prochaska, & Taylor, 2000), outcome expectations (Heitzler, Martin, Duke, & Huhman, 2006), and self-efficacy (Strauss, Rodzilsky, Burack, & Colin, 2001). It is reasonable to hypothesise that similar relationships may exist between psychological variables and children's commuting behaviour. A recently developed conceptual framework (Panter, et al., 2008) identified psychological factors (in the form of parent and child attitudes) as possible determinants of children's school travel behaviour. However, to the author's knowledge only two studies have investigated the relationship between psychological factors and children's school travel behaviours (Martin, et al., 2007; Mendoza, et al., 2010).

Mendoza et al. (2010) investigated the influence of self-efficacy and outcome expectations on school travel behaviour in 149 children from low-income backgrounds. Self-efficacy for active commuting was measured in children and one of their parents, and parent outcome expectations for active commuting were also measured. Parents' self-efficacy for allowing their child to actively commute to school was the only variable significantly associated with the percent of weekly trips made by active modes.

Martin et al. (2007) investigated the role of child outcome expectations and parental perceived barriers in relation to school travel behaviour in a nationally representative sample of U.S. children (aged 9-15 years). Child outcome expectations were not associated with active school travel (OR (95% CI) = 1.01 (0.88–1.16), $p > .05$). Parents' perceptions of barriers were found to be significantly associated with active school travel (OR (95% CI) = 1.07 (1.03–1.12), $p < .05$).

The above studies were conducted in the U.S. and the findings may not be generalised to other populations where attitudes and environments differ considerably. Furthermore, these studies used self-reported mode of travel as the outcome, and would be strengthened by using objective measures of commuting-related activity. Self-reported measures are renowned for their lack of accuracy and susceptibility to social desirability, and may therefore taint any true relationships between variables. Studies that investigate the relationship between objectively measured commuting activity and psychological variables are needed.

The present study aims to address the above limitations and in so doing generate new knowledge regarding the role of psychological variables in predicting children's school travel behaviour. Social cognitive theory (SCT) is used as the guiding psychological theory in this study. SCT is a comprehensive theory of human behaviour that has been used extensively in physical activity research (Dishman, et al., 2004; Griffin-Blake & DeJoy, 2006; Ryan, 2005). The theory is founded on the premise that human agency is a product of triadic reciprocality. This involves bi-directional relationships between the person, their environment, and their behaviour, which continuously change and influence each other (Bandura, 2001). There are five determinants of health behaviour within this theory. These are: (a) *knowledge* of benefits and risks of certain behaviours, (b) *self-efficacy* for executing health behaviours, (c) *outcome expectations* for the benefits and costs of carrying out certain behaviours, (d) *goals* for achieving certain health habits and strategies for realizing them, and (e) *perceived facilitators* and *impediments* to changing behaviour (Bandura, 2004).

The present study focuses on two of the central determinants in SCT; self-efficacy and outcome expectations. Self-efficacy refers to a person's belief about their abilities to carry out certain actions (Bandura, 2007). In the school travel context this may relate to a child's confidence in their ability to cross busy roads on the way to school, or a parent's belief that their child is able to walk to school independently. Self-efficacy is a key construct in SCT because it affects the other determinants. An individual's efficacy will determine what type of goals or outcome expectations they have, for example, or will influence the way they think about overcoming barriers and impediments. Outcome expectations is the second construct investigated in this study. These are the perceived positive and negative results of adopting a certain behaviour and are important in determining whether an individual will change their behaviour. For example, a child may be likely to start walking to school if they believe it will make them healthier; however they may be deterred from walking to school if they think they will get wet and cold from the wind and rain while walking.

The preceding sections of this paper have highlighted that little is known about the psychological correlates of children's active school travel. In addition to this, it also remains unclear whether child or parent attitudes are most influential in determining how the child travels to school, and there is no consensus in the literature about who the main decision maker is regarding the child's travel mode (McMillan, 2005; Panter, et al., 2008). Child development literature suggests that a child is not able to plan logically and reason deductively until the age of 11 or 12 (Schaffer, 2004). It is reasonable to suggest therefore, that primary school-aged children (5-11) may not have the cognitive capabilities or autonomy to make decisions regarding their school travel, and perhaps the parent is the gatekeeper to their travel behaviour at this age. It is important, therefore, to investigate the parent's role in this process. The present study aims to determine whether child or parent psychological attributes (i.e. self-efficacy and outcome expectations) are most important in this regard, and whether the parent or child is the primary decision maker.

The present study therefore has two aims: (a) to investigate the role of parent and child psychological attributes in predicting children's school travel behaviour, and (b) to determine the relative importance of parent and child psychological attributes in relation to the child's school travel and to identify the primary decision maker regarding the child's mode of travel.

Methods

Cross-sectional baseline data collected as part of a larger quasi-experimental study were used to answer the research questions. Full methods for the wider study are presented in Paper 1 of this thesis. Only methods relevant to the aims of the present study are reported in this paper. Ethical approval was granted for all procedures by the University of Strathclyde Ethics Committee (Appendix B). Signed informed consent was provided by parent and child participants before data were collected.

Sample

Participants were primary 5 children (n = 166, mean age 9) and one of their parents (n = 143, mean age 40) from 5 urban schools in the west of Scotland. Schools were purposively sampled from areas of either high or low deprivation according to the Scottish Index of Multiple Deprivation (SIMD). Schools were sampled this way to ensure variability in socio-economic-related data. Researchers visited each school to administer child and parent questionnaires, activity monitors (accelerometers), and travel diaries.

Measures

Commuting mode.

Commuting mode for the trip to school in the morning was determined via the parent questionnaire using the question: ‘On a normal day, how does your child usually travel TO school?’ Mode of travel for the trip home from school was determined using the question: ‘On a normal day, how does your child usually travel FROM school?’ Response options included: on foot, by school bus, by public transport, by car, by bicycle, other, or a mixture of two modes. Responses were later recoded into the following three categories: walker, non walker, and mixed-mode (with at least some walking). Parent, rather than child, responses were used to determine mode choice because it was thought that parents would provide a more accurate account of how their child travels to school. Children may be more susceptible to social desirability, thus providing a less accurate account of their travel behaviours. Parents were also asked who makes the decision about their child's travel mode.

Commuting-related activity.

Morning (to school) and afternoon (from school) commuting physical activity was measured using the Actigraph GT1M accelerometer (ActiGraph, Pensacola, FL). This activity monitor has been used widely in physical activity research and has been shown to be a valid measure of activity in children (Evenson et al., 2008: Mattocks, 2007). Data produced by the GT1M are steps and activity counts. Activity counts may be used to determine time spent in moderate to vigorous physical activity (MVPA). The primary outcome for this study was commuting steps and so MVPA data are not reported. Participants had their school arrival time recorded each morning by a member of the study team, and home arrival time was established via travel diaries (as was home commute mode). This information was used in subsequent GT1M data processing.

Demographic variables.

The parent questionnaire was used to gather data on parent gender, age, home postcode, and number of cars in the household. Distance from home to school in meters was calculated using the directions function in Google maps (Google Inc., Mountain View, CA) based on home and school postcodes. Home postcode was also used to determine home deprivation level using the Scottish Index of Multiple Deprivation (SIMD). The SIMD provides a relative measure of area level deprivation across 6,505 geographic data zones in Scotland based on the following 7 indicators: Income, employment, health, education, housing, geographic access, and crime. Child age and gender were determined via the child questionnaire.

Psychological Social Cognitive variables.

Child self-efficacy for various commuting-related tasks was measured using a 14-item scale (How sure are you that you can…?) with a three point Likert scale response (Very Sure, Kind of Sure, Not Sure). This scale has been shown to have high internal consistency (Cronbach's alpha = .80) and test-retest reliability (ICC =

.86) (Rowe, Murtagh, McMinn, Ord, & Nelson, 2010). Child outcome expectations for walking to school were measured using an 11-item scale with a tick response. The question ‘If you walked part or all of the way to school on most days, what benefits would there be?’ was followed by 11 options for perceived positive outcomes. This scale is similar to a previously developed outcome expectations scale used in children (Heitzler, et al., 2006; Saunders, et al., 1997) and has been shown to have high test-retest agreement (thesis Paper 1).

Parent self-efficacy was measured using a 14-item question similar to the child self-efficacy scale. Parents responded to the question ‘How confident are you that your child can…?’ for various commuting-related tasks, and answered using a 5-point Likert response (Very confident, Quite confident, Somewhat confident, Not particularly confident, Not at all confident). This scale has been shown to have high internal consistency (Cronbach’s alpha = .96) (Rowe, Murtagh, McMinn, Ord, & Nelson, 2010). Parent outcome expectations were measured using a similar scale to the child outcome expectations scale. The question ‘If your child walked part or all of the way to school on most days, what benefits would there be?’ was asked, and 11 tick response perceived benefits were available. Wording of the self-efficacy and outcome expectations scales are displayed in Table 5.1.

Table 5.1.
Self-efficacy and outcome expectation question wording

Self-efficacy	
Child stem: How sure are you that you can…?[a]	**Parent stem: How confident are you that your child can…?[b]**
Walk to school	Walk to school
Ask a parent or other adult to walk to school with you	Ask a parent or other adult to walk to school with them
Walk to school even if your friends don't walk	Ask a friend to walk to school with them
Ask your friends to walk to school with you	Walk to school even if their friends don't walk
Walk to school in bad weather	Walk to school in bad weather
Cross difficult roads when walking to school	Cross difficult roads when walking to school
Walk to school even if there are not enough lollipop people	Cope with busy traffic when walking to school
Walk to school even if there are many cars near the school entrance	Walk to school even if there are many cars near the school entrance
Cope with busy traffic when walking to school	Walk to school even if there are not enough lollipop people
Walk to school even if I am frightened of meeting strangers	Walk to school even if they are frightened of meeting strangers
Find a route to walk to school	Walk to school even if they are frightened of being bullied
Walk to school even if there is poor lighting	Walk to school even if there is poor lighting
Walk to school even if it takes a long time	Walk to school even if it takes a long time
Walk to school even if I am frightened of being bullied	Find a route to walk to school

Table 5.1.
Self-efficacy and outcome expectation question wording

Outcome expectations	
Child stem: If you walked part or all of the way to school on most days, what benefits would there be?[c]	**Parent stem: If your child walked part or all of the way to school on most days, what benefits would there be?**
My heart and lungs would be healthier	My child's heart and lungs would be healthier
I would be alert and awake for school	My child would be alert and awake for school
I would be able to talk to my friends on the way	My child would be able to talk to his/her friends on the way
My body would become healthier	My child's body would become healthier
It would be fun	It would be fun
I would be helping the environment	My child would be helping the environment
I would hear and see things that I wouldn't usually	My child would hear and see things that he/she wouldn't usually
I would save money on fares	My child would save money on fares
I would get lots of fresh air	My child would get lots of fresh air
I would be able to talk to my parents on the way	They would be able to talk to me on the way
I would be able to talk to my brother(s) or sister(s) on the way	They would be able to talk to their brother(s) or sister(s) on the way

Note.
[a] Response format: Very Sure, Kind of Sure, Not Sure
[b] Response format: Very confident, Quite confident, Somewhat confident, Not particularly confident, Not at all confident
[c] Tick response format for child and parent outcome expectations

Procedures

Data were collected during one school week at each of the 5 study schools. On the Monday of the data collection week the research team visited the relevant school to administer child and parent questionnaires, travel diaries, and accelerometers. Children were supervised by researchers while completing their questionnaires, so that any queries regarding question wording could be answered.

Children were instructed to take the parent questionnaire home and to return it completed by the end of the week. Participants were instructed to complete their travel diary retrospectively (i.e. in the morning when they arrived at school) to achieve a higher response rate than if the diaries were taken home. After the children had completed their questionnaire they were given a GT1M accelerometer and shown how to wear it correctly. Participants were instructed to wear the monitor during waking hours and only to take it off for contact sports, bathing, and swimming. On immediate arrival at school each morning participants approached a member of the study team who recorded their school arrival time. This information (as well as the travel diary information) was used to determine known commute time to and from school. Parent questionnaires, travel diaries, and activity monitors were collected on the Friday of the data collection week. Data from the GT1M were downloaded that evening.

Data treatment

GT1M data processing.

Commuting steps were calculated for the morning and afternoon commutes, using researcher-recorded school arrival times and participant reported home arrival times to inform data processing.

Psychological social cognitive variables

Self-efficacy data were summed to create a total self-efficacy score for each participant (child and parent data). Data were coded in such a way that a high total self-efficacy score corresponded to greater personal self-efficacy and a lower total score corresponded to lower personal self-efficacy. Outcome expectation scores were also summed for each participant and were again coded in such a way that a high total outcome expectation score corresponded to perceiving many benefits of walking to school, and a low total score corresponded to perceiving few benefits of walking.

Analysis

Sample characteristics.

Relevant descriptive statistics were calculated. Morning commuting steps were normally distributed, however afternoon commuting steps were positively skewed and kurtotic (≥ 2.0), therefore non-parametric tests were used with these data. A one-way ANOVA was used to investigate differences in average morning commuting steps between walkers, non-walkers, and children who used mixed modes. A Kruskal-Wallis test was used to investigate the same question for afternoon commuting data. Differences in morning commuting steps between boys and girls were assessed using an independent *t*-test, and differences between boys and girls for afternoon commuting steps were investigated using a Mann-Whitney test. A one-way ANOVA was used to investigate differences in average morning commuting steps between the 5 schools that constituted the sample, and a Kruskal-Wallis test was used to investigate the same question for the afternoon commuting data.

Basic associations.

Reliability analyses were conducted for the parent and child self-efficacy scales (Cronbach's alpha = .95 and .81 respectively) and for the parent and child outcome expectations scales (Cronbach's alpha = .82 and .78 respectively). Pearson correlations were calculated between the social cognitive variables and morning commuting steps. Spearman's rho was used to investigate associations between afternoon commuting steps and the social cognitive variables. Associations between commuting steps and non-social cognitive variables were also investigated (i.e. distance, car ownership, and SIMD).

Hierarchical multiple regression.

Hierarchical multiple regression was used to determine whether self-efficacy and outcome expectations were able to predict a significant amount of variance in commuting steps, while controlling for distance, deprivation level, car ownership, and school. The correlates of commuting behaviour may theoretically differ for the commute to school and the commute home. To investigate whether this is the case two models were created, one for morning commuting steps and one for afternoon commuting steps. Only variables that were significantly correlated in bivariate analysis or where differences between groups were identified (i.e. gender and schools) were included in the model. All relevant assumptions were investigated and are reported in the results. To allow for multiple regression analysis, afternoon commuting step data were log transformed to correct for the positive skew. The transformed data were checked for normality, which had been achieved.

Results

Sample Characteristics

Children (mean age 9 years) were 60% male and parents (mean age 40 years) were 87% female (Table 5.2). Walking was the most prevalent mode of transport used to travel to school (49%), which is almost identical to recently reported Scottish population statistics (Sustrans, 2009), suggesting a representative sample in this study. More children walked home from school (57%) than to school. Parents reported that they were the primary decision maker regarding whether their child walked to school (90%). Only 3% of parents said that their child made the decision about whether they walked to school, and 7% reported that it was a joint decision.

Table 5.2. Parent and child descriptive statistics

		n*	**Mean**	**SD**	**Min.**	**Max.**	**Skew.**	**Kurt.**
Parents	Age	134	39.8	5.4	27	50	-.41	-.31
	Car ownership	137	1.6	.88	0	5	.31	1.6
	SIMD Rank	140	4105	2243	145	6492	-.52	-1.40
Children	Age	166	8.64	.49	8	10	-.46	-1.41
	Distance (m)	143	1123	745	100	4160	1.66	4.15

Note.
*Sample sizes vary due to missing parent questionnaire data

An omnibus one-way ANOVA indicated significant mean differences for morning commuting steps between modes, $F(2, 135) = 8.02$, $p < .01$ (Table 5.3). Post-hoc tests revealed that walkers took significantly more steps on average than non-walkers (mean difference = 393 steps, $p < .01$). Walkers took more steps than children who travelled by mixed modes (mean difference = 51), but not significantly more ($p > .05$).

Table 5.3. Morning and Afternoon commuting steps by mode

Journey	Mode	*n*	%	Mean	SD	Min	Max	Skew.	Kurt.
Morning	Walkers	68	49	1309	523	636	3010	1.10	1.24
	Non Walkers	41	30	916	462	220	2439	1.20	1.85
	Mixed modes	29	21	1258	538	427	2517	.33	-.46
Afternoon	Walkers	78	57	1245	675	282	4718	2.28	8.63
	Non Walkers	33	24	646	488	261	2903	3.48	14.57
	Mixed modes	27	19	1189	877	330	4250	1.88	4.63

A Kruskal-Wallis test indicated that afternoon commuting steps significantly differed by commuting mode. Post-hoc Mann-Whitney U tests using a Bonferroni correction found that walkers took significantly more steps than non-walkers (median difference = 473, $p < .01$), but not significantly more steps than children who used mixed modes (median difference = 76, $p > .05$). There were no differences between boys and girls for morning commuting steps (mean difference = 31, $p > .05$) or afternoon commuting steps (median difference = 90, $p > .05$). There were no differences between schools for morning commuting steps, $F(4, 161) = .54$, $p > .05$. There were significant differences between schools for afternoon commuting steps, $H(4) = 20.96$, $p < .01$.

Basic associations

Parent self-efficacy and outcome expectations were both significantly positively correlated with morning commuting steps, indicating that as self-efficacy and outcome expectations increase, so do morning commuting steps. Parent self-efficacy was the only social cognitive variable to correlate with afternoon commuting steps. None of the child social cognitive variables correlated with commuting steps (Table 5.4).

Table 5.4. Correlations between Psychological Social Cognitive variables and commuting steps

	Morning steps		**Afternoon steps**	
Psychological variable	***r***	**Sig.**	***rho***	**Sig.**
Parent self-efficacy	.27	<.01	.20	<.05
Parent outcome expectations	.18	<.05	.16	.07
Child self-efficacy	.08	.28	.11	.17
Child outcome expectations	-.06	.44	-.06	.45

Car ownership was negatively correlated with morning commuting steps, indicating that as car ownership increases the number of morning commuting steps decreases. Distance from home to school and car ownership were negatively correlated with afternoon commuting steps. Deprivation level (SIMD) was also negatively correlated with afternoon commuting steps, indicating that as SIMD value increases (corresponding to a reduction in deprivation level) number of commuting steps decreases (Table 5.5).

Table 5.5. Correlations between non Social Cognitive variables and commuting steps

	Morning commute		Afternoon commute	
	r	**Sig.**	***rho***	**Sig.**
Distance	-.02	.82	-.26	<.01
Car Ownership	-.27	<.01	-.26	<.01
SIMD	-.08	.34	-.24	<.01

Hierarchical multiple regression

Morning commute

Hierarchical multiple regression was used to investigate the ability of two psychological variables (parent self-efficacy and parent outcome expectations) to predict children's morning school travel behaviour (steps), after controlling for car ownership. None of the assumptions of multiple regression were violated (i.e. normality, linearity, multicollinearity, and homoscedasticity). Furthermore, the sample size was more than sufficient for the number of predictor variables used, according to previous guidelines that suggest at least 15 participants for every predictor variable (Stevens, 1996). Car ownership was entered in step one, and explained 6% of the variance in morning commuting steps. Parent self-efficacy and parent outcome expectations were entered in step 2. The model as a whole explained 16% of the total variance in morning commuting steps (F (3, 128) = 8.34, p < .001). The two social cognitive variables explained an additional 10% of the variance in commuting behaviour (table 5.6), after controlling for car ownership (R squared change = .10, F change (2, 128) = 7.63, p < .01). In the final model, only parent self-efficacy and car ownership were statistically significant predictors, with self-efficacy recording a higher beta value (beta = .26, p < .01) than car ownership (beta = -.24, p < .01). In real terms, this represents a difference of 562 steps between two children whose parents record the highest or lowest possible self-efficacy scores.

Afternoon commute

Hierarchical multiple regression was used to investigate the ability of parent self-efficacy to predict children's afternoon school travel behaviour (steps), after controlling for distance, car ownership, deprivation level, and school. Afternoon step data were non-normal (Skewness and kurtosis ≥2.0) so these data were log-transformed to achieve a normal distribution. Distance, car ownership, deprivation level, and school (schools were entered using dummy variables) were entered in step one, and explained 18.8% of the variance in afternoon commuting steps. Parent self-efficacy was entered in step 2. The model as a whole explained 19.2% of the variance in afternoon commuting steps (F (8, 119) = 3.54, p < .01). Parent self-efficacy only explained an extra 0.5% of the variance in afternoon commuting steps (Table 5.6, F change (1, 119) = .68, p > .05). In the final model only car ownership (beta = -.25, p < .05) and one of the school dummy variables (beta = .33, p < .01) were statistically significant. Table six displays the results for the morning and afternoon regression analyses.

Table 6. Hierarchical multiple regression analyses predicting morning and afternoon school commuting steps from parent self-efficacy and parent outcome expectations

	Commuting behaviour			
	Morning commute		Afternoon commute	
Predictor	ΔR^2	β	ΔR^2	β
Step 1	.06*		.19*	
Control variables[a, b]				
Step 2	.10*		.01*	
Parent self-efficacy		.26*		.07
Parent outcome expectations[c]		.15		
Total R^2	.16*		.19*	
n	132		128	

Note.
[a] Control variable was car ownership for morning commute analysis
[b] Control variables for afternoon commute include distance, car ownership, deprivation level, and school
[c] Parent outcome expectations only included in the morning commute regression model
* $p < .01$.

Discussion

This study investigated the ability of parent and child psychological attributes to predict children's objectively measured commuting behaviour after controlling for known confounders. Additionally, this study examined the relative importance of parent and child psychological variables on commuting behaviour and established who the main decision maker is regarding school travel mode.

Parent self-efficacy for their child's ability to carry out school travel-related tasks was the only significant psychological predictor of school travel behaviour (morning commute). Neither of the child psychological factors was associated with commuting behaviour to or from school. None of the parent or child psychological factors were associated with afternoon commuting behaviour. Car ownership was a significant predictor of both morning and afternoon commuting behaviour. Parents reported overwhelmingly that they were the main decision maker regarding whether their child walked as a commuting mode.

These are important confirmatory findings in light of previous research conducted with children of a similar age. Mendoza et al. (2010) and Martin et al. (2007) found similar results to this study. In one of these studies parent self-efficacy was the only psychological variable associated with children's active commuting (Mendoza, 2010), and outcome expectations were not associated with commuting behaviour in either study (Martin et al., 2007; Mendoza et al., 2010). Furthermore, children's psychological variables were found to have no association with commuting behaviour. Results from the present study and from the study conducted by Mendoza et al. (2010) suggest that parents' psychological variables (specifically parent self-efficacy) are more important than child variables in relation to the child's commuting behaviour. This hypothesis is strengthened by the finding from the present study that parents are the main decision maker regarding how their child travels to school.

These findings have two important implications. First, they suggest that a fundamental assumption of Panter's (2008) conceptual model may be flawed. Panter (2008) proposed that the decision on travel mode is likely a result of both parent and child perceptions, and that a dialogue will take place between parent and child before a decision is made. Results from the present study suggest that the parent's psychological perceptions are more important than the child's, and that the parent is the outright decision maker regarding their child's travel mode. In turn, this supports assumptions of three previously developed frameworks: (a) McMillan's (2005) conceptual framework for the relationship between urban form and a child's trip to school, (b) the Ecological and Active Commuting (ECAC) framework (Sirard & Slater, 2008), and (c) Pont's (2010) Model of Children's Active Travel (M-CAT). These three models presuppose that the parent is the primary decision maker in the travel decision and is the gatekeeper to their child's behaviour – a presupposition that is supported by the present study.

Second, if parents are the main decision maker regarding their child's school travel mode at this age, it seems illogical to target school travel interventions to children, who may not have the capabilities to change their behaviour. Interventions to promote walking to school should therefore be targeted towards parents and not children, and should focus on building confidence in their child's ability to walk to school. Alternatively, school travel interventions should be targeted at older children who have autonomy to change their travel behaviour.

Several other interesting findings have emerged from this study. It appears that there may be different predictors for the journey to school than for the journey home from school. Certainly, parental self-efficacy did not predict afternoon travel behaviour but did predict morning commute behaviour. Although not immediately clear, this may be related to the nature of these two trips. The trip to school in the morning has a distinct purpose and time constraint (i.e. children must arrive at school for 9am). The trip home is different however. On leaving school children may not necessarily have a defined time that they must arrive home. These differences in trip characteristics will likely be linked to differences in trip predictors - particularly for predictors that can be moderated. For example, parental self-efficacy was found to predict morning but not afternoon travel behaviour. This variable may have been moderated by the different nature of these two trips. It is possible to see how self-efficacy may be a factor when a specific arrival time at school must be met, but may not be a factor when the arrival time home is flexible. Put more simply, a parent may have confidence in their child's ability to arrive home within a general timeframe but not have the same confidence in their child's ability to get ready before school, leave the house on time, and arrive at school for 9am. This theory can also be applied to car-ownership, which was found to be a significant predictor of travel behaviour for both morning and afternoon commutes. However, in this instance the variable is such that it cannot be moderated by the characteristic of the trip - either a person owns a car (or cars) or they do not.

Distance was not a significant predictor of commuting behaviour in this study. This is an unusual finding given that most studies to date have found a negative association between distance to school and walking behaviour. This may be a product of the Scottish primary school system where, particularly in urban areas, children live within relatively small school catchment areas. In our sample 92% of participants lived within 2 km of their school, 54% lived within 1 km, and the mean distance from home to school was 1.1 km. Compared to other published studies, children in this sample live very close to their school. Australian children have been reported to live on average 2.3 km (Timperio et al., 2006) and 3.0 km (Ziviana et al. 2004) from their school. Of 1656 children in an American study only 315 (19%) lived within 1 mile of their school (Bricker et al, 2002) and half of the children in a New Zealand based study lived more than 2 km from their school (Merom et al., 2006).

This study has several strengths. Commuting-related activity was objectively measured using accelerometry during relatively accurately measured commute time, a novel method in this field. The study was guided using an established psychological theory and related variables were measured in both children and their parents. Non-psychological variables such as distance and deprivation were measured robustly.

Study limitations should be mentioned. Data were collected on a relatively small cross-sectional sample, and so inferences regarding causation and generalisability should be made with caution. The study sample was predominantly white; therefore no inferences may be made regarding ethnicity. Additionally, the sample only contains children and parents from backgrounds that are either highly deprived or relatively well-off (i.e. the top and bottom quartiles of the SIMD). The study would be strengthened by including participants from the middle two quartiles of the SIMD. Finally, it is acknowledged that distance from home to school may have an important moderating effect on the predictors of commuting behaviour. Ideally the analysis would be stratified by distance to account for this effect. However, the small sample did not permit this, and instead distance was controlled for in the models.

Future studies should seek to add to the small knowledge base regarding the relationship between psychological variables and commuting behaviour in children. This may involve further cross-sectional testing of psychological variables, or testing the causal nature of these variables experimentally. Researchers should also use theoretical frameworks to guide their studies. Interventions aimed at increasing active travel should focus their attentions on older children who have the autonomy to change their behaviour or target the parents of younger children.

Conclusion

Parental self-efficacy predicts morning school travel behaviour in 9-year old Scottish children. Child psychological variables are not associated with commuting behaviour. Car ownership is a predictor of walking to and from school. Parents are the main decision maker regarding their child's travel mode, and distance is not associated with commuting behaviour. Although parent self-efficacy is weakly associated with walking to school, further studies are warranted to investigate the under-studied topic of psychological variables and children's commuting behaviour. Additionally, future studies should investigate the differing natures of journeys to and from school.

Chapter 6

Review of research questions and contribution to knowledge

6.1 Review of research questions

Six research questions were posed at the beginning of this thesis. The following section addresses these questions, providing answers to each.

1. **Is the NL-1000 accelerometer a valid measure of steps and MVPA during the school commute?**

Validity of the NL-1000 accelerometer was investigated in the pilot study (Paper 1 of this thesis). Steps and MVPA for the school commute (morning and afternoon commutes combined) measured by the NL-1000 were compared to the same data collected by the Actigraph GT1M accelerometer (criterion reference). The NL-1000, on average, underestimated time spent in MVPA by almost 100 seconds and overestimated steps by 300, however these differences were deemed to be small according to Cohen's D. Devices were also highly correlated for both steps and MVPA. These positive results suggest that the NL-1000 is a valid measure of children's commuting related physical activity, although further validity evidence would strengthen this conclusion.

2. **Is a newly designed travel questionnaire reliable for use in a primary school setting?**

The child travel questionnaire used in the Travelling Green study was designed specifically for this study using items from several existing questionnaires. Data generated via the questionnaire include: (a) demographics; (b) usual mode of travel to and from school; (c) perceived barriers, benefits, and facilitators to walking to school; (d) self-efficacy for walking-related tasks; (e) preferred travel mode and companion; (f) feelings about local area; and (g) information related to the Theory of Planned Behaviour and the construct of Habit. Reliability of this newly developed questionnaire was investigated in the pilot study (Thesis Paper 1) using test-retest reliability (there was a period of one week between test administrations). Item reliability was investigated using percent agreement (nominal level data) and correlational analysis (ordinal level data). The reliability of the self-efficacy scale designed specifically for this study was investigated using an intraclass correlation coefficient (*ICC*) from a 1-way ANOVA model, adjusted for a single measure. The majority of nominal questionnaire items had test-retest agreement of above 70% and the two items (barriers and facilitators questions) on which correlational analysis were carried out demonstrated high correlations, *rho* = .87 and *rho* = .76. The self-efficacy scale had high reliability, *ICC* = .93, single measures = .86. These results provide strong reliability evidence for the child travel questionnaire, suggesting that it may be used with confidence in school travel research.

3. **Is a self-report travel diary a valid measure of home time arrival for primary aged children?**

The travel diary was used to establish home arrival time to inform GT1M data processing. Although travel diaries have been used in previous school travel studies (Baslington, 2010; Mackett, et al., 2005), to the author's knowledge no study has provided validity evidence for their use. The pilot work for the Travelling Green study (Thesis Paper 1) aimed to provide such evidence by comparing travel diary reported home time to known home arrival time. Known home arrival time was established by identifying the time at which consecutive zeros appeared in participant's GT1M data. Participants had been instructed to remove their monitors on home arrival and place their monitor somewhere secure until morning. Therefore, the time at which consecutive zeros appeared indicated when the participant arrived home. A Wilcoxon signed ranks test was used to assess differences between measures and Spearman's rho was used to assess correlations. No significant differences were found between the home arrival times reported on the travel diaries and the known arrival times (mean error = 6 minutes, $z = .56$, $p \geq .05$). Furthermore, significant moderate correlations were found between measures (*rho* = .42, $p < .01$). These findings provide strong validity evidence to support the use of travel diaries as a measure of home arrival time in 8 and 9 year old children.

4. **Does Travelling Green result in participants increasing their physical activity levels on the journey to and from school?**

Previous research (McKee et al., 2007) has shown that children who take part in the Travelling Green resource increase the distance travelled to school by active modes and decrease the distance travelled by inactive modes following the intervention. This research was limited, however, by the use of a small sample and self-reported outcome measures. The present study aimed to carry out a more robust evaluation of Travelling Green by using a quasi-experimental design, a larger sample, and objective outcome measures. The study sample consisted of 166 primary 5 aged children, 79 of whom received the Travelling Green intervention, and 87 who acted as a comparison group. The main outcome measure was steps (morning, afternoon and total commute, and daily). Time spent in MVPA was also determined for each of these periods. Steps and time spent in MVPA decreased by a similar amount from pre- to post-intervention in both groups following the intervention. Daily steps and time spent in MVPA decreased significantly less in the intervention group compared to the comparison group (Thesis Paper 2). These results indicate that Travelling Green does not result in an increase in physical activity levels on the journey to and from school, but that it may mitigate against a decrease in daily physical activity levels associated with seasonal change (pre-intervention measures were taking during favourable weather conditions and post-intervention measures were taken during late autumn/early winter when weather conditions were less conducive to walking).

5. **In relation to the child and parent attitude sections of Panter's (2008) conceptual model: Can self-efficacy and outcome expectations predict commuting-related physical activity?**

Panter's (2008) conceptual model for the determinants of children's active travel includes psychological variables in the form of parent and child attitudes. To date, most studies that have investigated correlates of children's commuting behaviour have focused on environmental and social factors. Few studies have investigated psychological correlates/predictors. This thesis (Paper 3) aimed to identify psychological predictors of children's active school travel from a social cognitive perspective, testing the parent and child attitudes section of Panter's (2008) model in the process. Two core constructs within the social cognitive theory were selected for analyses; these were self-efficacy and outcome expectations. Hierarchical multiple regression models were used to identify child and parent psychological predictors of commuting behaviour (steps) while controlling for known confounders (i.e. distance, car ownership, deprivation level, and school). Parent self-efficacy for their child's ability to carry out commuting-related tasks was the only significant psychological predictor of commuting behaviour (morning commute). Child self-efficacy and outcome expectations did not predict commuting behaviour. Car ownership was a significant predictor of morning and afternoon commuting steps. These results indicate that parental self-efficacy for their child's commuting abilities may be more important in determining commuting-related physical activity than child psychological variables, suggesting that parents have the more important role in how children travel to school.

6. **Is the parent or child the main decision maker regarding school travel mode?**

This question was addressed simply (Paper 3) using the parent questionnaire item 'Who decides whether your child walks to school or not?' The majority of parents (90%) responded by saying that they were the main decision maker. Only 3% of parents said that their child made the decision about whether they walked to school, and 7% reported that it was a joint decision. This provides strong evidence that parents are the primary decision makers regarding their child's mode choice at this age, and compliments the findings from Research Question 5 which showed that parent's psychological variables were more important in predicting children's commuting activity than the child's psychological variables. Future research should investigate the way in which decisional balance changes as children become older.

6.2 Contribution to knowledge

The results from the three studies that constitute this thesis provide evidence that advances knowledge in the field of school travel research in three distinct ways.

First, Paper 1 set out to provide, for the first time, validity and reliability evidence for three school travel measurement techniques. These are (a) a newly developed school travel questionnaire for children, (b) a school-to-home travel diary that establishes home arrival time, and (c) the New Lifestyles NL-1000 accelerometer. The newly developed school travel questionnaire was found to have good test-retest reliable and subscales within the questionnaire were internally consistent. This questionnaire is suitable for use in future school travel studies with children aged 8-9 years. Likewise, the travel diary provided valid estimates of home arrival time when compared with known home arrival time and is also therefore a suitable measurement tool for future school travel studies. The New Lifestyles NL-1000 accelerometer provided adequate validity evidence as a measure of commuting-related physical activity.

In addition to providing validity and reliability evidence for the previously mentioned school travel measures, Paper 1 described a novel technique for processing school travel-related accelerometer data. This technique allows physical activity data to be accurately established for commute time by using previously recorded school and home arrival times to inform accelerometer data processing. Although time consuming, this novel technique generates more accurate data than simply using arbitrary blocks of time as a proxy for defining the commutes to and from school. Researchers processing commuting-related accelerometer data should consider the pros and cons of using these techniques, and acknowledge that a balance exists between efficiency and quality of data i.e. using the novel approach in this study provides accurate estimates of commuting activity but takes a long time. Conversely, using a block of time that is applied to every participant provides less accurate data but allows for the use of batch processing techniques which saves a considerable amount of time.

Second, findings from Paper 2 indicate that the Travelling Green intervention does not result in an increase in children's school travel-related physical activity when administered during the autumn term. Travelling Green does however, appear to attenuate a seasonally-related decline in daily physical activity levels. This suggests that children may be able to change their physical activity behaviours at certain times (e.g. break, lunch, and after school), but do not have the autonomy to change their travel behaviours because their parents are the decision maker regarding this behaviour.

Third, Paper 3 of this thesis contributes important knowledge about the psychological predictors of children's school travel behaviour. This is a currently under-studied area. The only psychological predictor of children's objectively measured commuting physical activity was parental self-efficacy for their child's ability to overcome commuting-related tasks. Household car ownership was found to be an important non-psychological predictor of commuting behaviour. Parent outcome expectations did not predict commuting behaviour, nor did child self-efficacy or outcome expectations. Parents reported that they were the main decision makers regarding how their child travelled to school.

These findings may be used to inform the promotion of active school travel. It has been shown in this thesis that parents of children aged 8-9 are the main decision makers regarding their child's school travel behaviours. Furthermore, parental self-efficacy for their child's ability to overcome commuting-related tasks is a predictor of commuting behaviour. Future school travel interventions should therefore be developed for parents of young children or for older children who have the autonomy to determine their travel behaviours. Alternatively, interventions like Walking Buses or Safe Routes to School programmes may be more appropriate for younger children as these interventions foster supervised and safe environments for walking to school.

6.3 Conclusion

This thesis reports the methods (Paper 1) and results (Paper 2) for an investigation of the effect of Travelling Green on children's school travel behaviours, and an investigation of the psychological predictors of children's commuting-related physical activity (Paper 3). Travelling Green did not result in an increase in children's travel-related physical activity, but did appear to mitigate against the detrimental effects of seasonality on daily physical activity. The investigation of the psychological predictors of children's school travel behaviour helps to understand why Travelling Green did not influence travel behaviour. Parental self-efficacy was the only significant predictor of children's travel behaviour, and parents overwhelmingly reported that they were the primary decision maker regarding their child's travel mode. This explains why Travelling Green, an intervention developed for children rather than parents, was not effective. Future travel interventions should be developed for parents of younger children or older children who have the ability to change their travel behaviour.

References

Abbott, R. A., Macdonald, D., Nambiar, S., & Davies, P. S. (2009). The association between walking to school, daily step counts and meeting step targets in 5- to 17-year-old Australian children. *Pediatric Exercise Science, 21*, 520-532.

Ahlport, K. N., Linnan, L., Vaughn, A., Evenson, K. R., & Ward, D. (2008). Barriers to and facilitators of walking and bicycling to school: Formative results from the non-motorized travel study. *Health Education & Behavior, 35*, 221-244.

American College of Sports Medicine. (1975). *Guidelines for Graded Exercise Testing and Exercise Prescription*. Philadelphia: Lea & Febiger.

Andersen, L. B., Wedderkopp, N., Hansen, H. S., Cooper, A. R., & Froberg, K. (2003). Biological cardiovascular risk factors cluster in Danish children and adolescents: The European Youth Heart Study. *Preventive Medicine, 37*, 363-367.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, New Jersey: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: The exercise control*. New York: W.H. Freeman.

Bandura, A. (1998). Health promotion from the perspective of social cognitive theory. *Psychology and Health, 13*, 623-649.

Bandura, A. (2001). Socila Cognitive Theory: An agentic perspective. *Annual Review of Psychology, 52*, 1-26.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Education & Behavior, 31*, 143-164.

Bao, W., Srinivasan, S. R., Wattigney, W. A., & Berenson, G. S. (1994). Persistence of Multiple Cardiovascular Risk Clustering Related to Syndrome X From Childhood to Young Adulthood: The Bogalusa Heart Study. *Archives of Internal Medicine, 154*, 1842-1847.

Baslington, H. (2010). Evaluating school travel initiatives and promoting ‘healthy travel’ through PSHCE. *Education, 38*, 117-135.

Basterfield, L., Adamson, A. J., Pearce, M.S., & Reilly, J. J. (2011). Stability of habitual physical activity and sedentary behavior monitoring by accelerometry in 6- to 8-year-olds. *Journal of Physical Activity and Health, 8*, 543-547.

Bauman, A. E., Sallis, J. F., Dzewaltowski, D. A., & Owen, N. (2002). Toward a better understanding of the influences on physical activity the role of determinants, correlates, causal variables, mediators, moderators, and confounders. *American Journal of Preventitive Medicine, 23*, S5-S14.

Beck, L. F., & Greenspan, A. I. (2008). Why don't more children walk to school? *Journal of Safety Research, 39*, 449-452.

Biddle, S., & Armstrong, N. (1992). Children's physical activity: An exploratory study of psychological correlates. *Social Science & Medicine, 34*, 325-331.

Black, C., Collins, A., & Snell, M. (2001). Encouraging walking: The case of journey-to-school trips in compact urban areas. *Urban Studies, 38*, 1121-1141.

Blair, S., & Brodny, S. (1999). Effects of physical inactivity and obesity on morbidity and mortality: Current evidence and research issues. *Medicine & Science in Sports & Exercise, 31*, S646-S662.

Blair, S., Cheng, Y., & Holder, J. S. (2001). Is physical activity or physical fitness more important in defining health benefits? *Medicine & Science in Sports & Exercise, 33*, S379-S399.

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

Boarnet, M. G., Day, K., Anderson, C. L., McMillan, T., & Alfonzo, M. (2005). California’s Safe Routes to School Program: Impacts on walking, bicycling, and pedestrian safety. *Journal of the American Planning Association, 71*, 301-317.

Bonfenbrenner, U. (1989). Ecological systems theory. *Annals of child development, 6*, 187-249.

Borrestad, L. A., Andersen, L. B., & Bere, E. (2011). Seasonal and socio-demographic determinants of school commuting. *Preventive Medicine, 52*, 133-135.

Bouten, C.V., Sauren, A. A. Verduin, M., & Janssen, J. D. (1997). Effects of placement and orientation of body-fixed accelerometers on the assessment of energy expenditure during walking. *Medical & Biological Engineering & Computing, 35*, 50–56.

Bovet, P., Auguste, R., & Burdette, H. (2007). Strong inverse association between physical fitness and overweight in adolescents: A large school-based survey. *International Journal of Behavioral Nutrition and Physical Activity, 4*.

Brage, S., Wedderrkopp, N., Anderson, L.B. & Froberg, K. (2003a). Influence of step frequency on movement intensity predictions with the CSA accelerometer: A field validation study in children. *Pediatric Exercise Science 15*, 277-287.

Brage, S., Wedderkopp, N., Franks, P.W. Anderson, L.B. & Froberg, K. (2003b). Reexamination of validity and reliability of the CSA monitor in walking and running. *Medicine & Science in Sports & Exercise, 35*, 1447-1454.

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

Bricker, S. K., Kanny, D., Mellinger-Birdsong, A., Powell, K. E., & Shisler, J. L. (2002). School Transportation Modes: Georgia 2000. *Morbidity and Mortality Weekly Report, 51*, 704-705.

Bringolf-Isler, B., Grize, L., Mader, U., Ruch, N., Sennhauser, F. H., & Braun-Fahrlander, C. (2008). Personal and environmental factors associated with active commuting to school in Switzerland. *Preventive Medicine, 46*, 67-73.

Brunton, G., Harden, A., Rees, R., Kavanagh, J., Oliver, S., & Oakley, A. (2003). *Children and physical activity: A systematic review of barriers and facilitators*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Buchele, G., Och, B., Bolte, G., & Weiland, S. K. (2005). Single vs. double data entry. *Epidemiology, 16*, 130-131.

Buliung, R. N., Mitra, R., & Faulkner, G. (2009). Active school transportation in the Greater Toronto Area, Canada: An exploration of trends in space and time (1986-2006). *Preventive Medicine, 48*, 507-512.

Carlin, J. B., Stevenson, M. R., Roberts, I., Bennett, C. M., Gelman, A., & Nolan, T. (1997). Walking to school and traffic exposure in Australian children. *Australian and New Zealand Journal of Public Health, 21,* 286-292.

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

Carver, A., Timperio, A., Hesketh, 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*, 1799-1805.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100,* 126-131.

CAST. (2000). *An Evaluation of the Walking Bus at Pirehill First School: A report for the Staffordshire Walking Bus Partnership*: The Centre for Alternative and Sustainable Transport, Staffordshire University.

Centres for Disease Control and Prevention. (2002). Barriers to Children Walking and Biking to School — United States, 1999. *Morbidity and Mortality Weekly Report, 51*, 701-703.

Chen, K. Y., & Bassett, D. R. (2005). The technology of accelerometry-based activity monitors: Current and future. *Medicine & Science in Sports & Exercise, 37,* S490-S500.

Chillon, P., Ortega, F. B., Ruiz, J. R., Veidebaum, T., Oja, L., Maestu, J., et al. (2010). Active commuting to school in children and adolescents: An opportunity to increase physical activity and fitness. *Scandinavian Journal of Public Health, 0*, 1-7.

Cohen, J. (1988). *Statistical power analysis for the behavior sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Cole, R., Leslie, E., Donald, M., Cerin, E., & Owen, N. (2007). Residential proximity to school and the active travel choices of parents. *Health Promotion Journal of Australia, 18,* 1036-1073

Collins, D. C. A., & Kearns, R. A. (2005). Geographies of inequality: Child pedestrian injury and walking school buses in Auckland, New Zealand. *Social Science & Medicine, 60,* 61-69.

Collins, D. C. A., & Kearns, R. A. (2010). Walking school buses in the Auckland region: A longitudinal assessment. *Transport Policy, 17*, 1-8.

Cooper, A. R., Andersen, L. B., Wedderkopp, N., Page, A. S., & Froberg, K. (2005). Physical activity levels of children who walk, cycle, or are driven to school. *American Journal of Preventive Medicine, 29*, 179-184.

Cooper, A. R., Page, A. S., Foster, L. J., & Qahwaji, D. (2003). Commuting to School: Are children who walk more active? *American Journal of Preventive Medicine, 25*, 273-276.

Cooper, A. R., Page, A. S., Wheeler, B. W., Griew, P., Davis, L., Hillsdon, M., et al. (2010). Mapping the walk to school using accelerometry combined with a global positioning system. *American Journal of Preventive Medicine, 38*, 178-183.

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 Behavioral Nutrition and Physical Activity, 7*.

Cooper, A. R., Wedderkopp, N., Jago, R., Kristensen, P. L., Moller, N. C., Froberg, K., et al. (2008). Longitudinal associations of cycling to school with adolescent fitness. *Preventive Medicine, 47*, 324-328.

Cooper, A. R., Wedderkopp, N., Wang, H., Andersen, L. B., Froberg, K., & Page, A. S. (2006). Active travel to school and cardiovascular fitness in Danish children and adolescents. *Medicine & Science in Sports & Exercise, 38*, 1724-1731.

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M. (2008). Developing and evaluating complex interventions: The new Medical Research Council guidance. *British Medical Journal, 337*(7676).

Creswell, J. W. (2003). *Research design : qualitative, quantitative, and mixed method approaches* (2nd ed.). Thousand Oaks: Sage Publications.

Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*, 297-334.

Dale, D., Corbin, C. B., & Dale, K. S. (2000). Restricting opportunities to be active during school time: Do children compensate by increasing physical activity levels after school? *Research Quarterly for Exercise and Sport, 71*, 240-248.

Davies, M. B. (2007). *Doing a successful research project : Using qualitative or quantitative methods* New York: Palgrave Macmillan

Davison, K. K., Werder, J. L., & Lawson, C. T. (2008). Children's active commuting to school: Current knowledge and future directions. *Preventing chronic disease: Public health research, practice, and policy, 5*(3).

Dellinger, A. M., & Staunton, C. E. (2002). Barriers to children walking and bicycling to school—United States, 1999. *Morbidity and Mortality Weekly, 51*, 701-704.

DiGuiseppi, C., Roberts, I., Li, L., & Allen, D. (1998). Determinants of car travel on daily journeys to school: Cross sectional survey of primary school children. *British Medical Journal, 316*, 1426-1428.

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

Dollman, J., & Lewis, N. R. (2007). Active transport to school as part of a broader habit of walking and cycling among South Australian youth. *Pediatric Exercise Science, 19*, 436-434.

Duncan, E. K., Duncan, S. J., & Schofield, G. (2008). Pedometer-determined physical activity and active transport in girls. *International Journal of Behavioral Nutrition and Physical Activity, 5*.

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

Dunn, A. L., Andersen, R. E., & Jakicic, J. M. (1998). Lifestyle physical activity interventions. History, short- and long-term effects, and recommendations. *American Journal of Preventive Medicine., 15*, 398-412.

Edwardson, C. L., & Gorely, T. (2010). Epoch length and its effect on physical activity intensity. *Medicine & Science in Sports & Exercise, 42*, 928-934.

Eston, R.G., Rowlands, A.V. and Ingledew, D.K. (1998) Validity of heart rate, pedometry and accelerometry for predicting the energy cost of children's activities. *Journal of Applied Physiology*, *84*, 362-371.

Evenson, K. R., Birnbaum, A. S., Bedimo-Rung, A. L., Sallis, J., Voorhees, C. C., Ring, K., et al. (2006). Girls' perception of physical environmental factors and transportation: Reliability and association with physical activity and active transport to school. *International Journal of Behavioral Nutrition and Physical Activity*, *3*.

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

Evenson, K. R., Huston, S. L., McMillen, B. J., Bors, P., & Ward, D. S. (2003). Statewide prevalence and correlates of walking and bicycling to school. *Archives of Pediatrics & Adolescent Medicine, 157*, 887-892.

Ewing, R., Schroeer, W., & Greene, W. (2004). School location and student travel: Analyses of factors affecting mode choice. *Transportation Research Record: Journal of the Transportation Research Board*(1895), 55-63.

Faulkner, G. E. J., Buliung, R. N., Flora, P. K., & Fusco, C. (2009). Active school transport, physical activity levels and body weight of children and youth: A systematic review. *Preventive Medicine, 48*, 3-8.

Faulkner, G. E. J., Richichi, V., Buliung, R. N., Fusco, C., & Moola, F. (2010). What's "quickest and easiest?": Parental decision making about school trip mode. *International Journal of Behavioural Nutrition and Physical Activity, 7*, 62.

Feltz, D., Short, S., & Sullivan, P. (2008). *Self Efficacy in sport: Research and strategies for working with athletes, teams and coaches*. Champaign, IL: Human Kinetics.

Ford, P., Bailey, R., Coleman, D., Woolf-May, K., & Swaine, I. (2007). Activity levels, dietary energy intake, and body composition in children who walk to school. *Pediatric Exercise Science, 19*, 393-407.

Forman, H., Kerr, J., Norman, G., J, Saelens, B., E, Durant, N., H, Harris, S., K, et al. (2008). Reliability and validity of destination-specific barriers to walking and cycling for youth. *Preventive Medicine, 46*, 311-316.

Freedson, P., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine & Science in Sports & Exercise, 37,* S523-S530.

Freedson, P. S., Sirard, J., Debold, E. P., Pate, R. R., Dowda, M., Trost, S. G., et al. (1997). Calibration of the Computer Science and Applications, Inc. (CSA) accelerometer. *Medicine & Science in Sports & Exercise, 29,* 45.

Fulton, J. E., Shisler, J. L., Yore, M. M., & Caspersen, C. J. (2005). Active transportation to school: Findings from a national survey. *Research Quarterly for Exercise & Sport, 76,* 352-357.

Garn, S. M., Leonard, W. R., & Hawthorne, V. M. (1983). Three limitations of the body mass index. *American Journal of Clinical Nutrition, 44*, 996-997.

Gibson, D., Harvey, A. J., Everett, V., & Parmar, M. K. (1994). Is double data entry necessary? The CHART trials. *Control Clinical Trials, 15,* 482-488.

Glasgow, R. E., Lichtenstein, E., & Marcus, A. C. (2003). Why don't we see more translation of health promotion research to practice? Rethinking the efficacy-to effectiveness transition. *American Journal of Public Health, 93*, 1261-1267.

Griffin-Blake, S. C., & DeJoy, D. M. (2006). Evaluation of Social-cognitive Versus stage-matched, Self-help physical activity interventions at the workplace. *American Journal of Health Promotion, 20*, 200-209.

Grize, L., Bringolf-Isler, B., Martin, E., & Braun-Fahrlander, C. (2010). Trends in active transportation to school among Swiss school children and its associated factors: Three cross-sectional surveys 1994, 2000 and 2005. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 28.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research In K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks: Sage.

Guinhouya, C. B., & Hubert, H. (2008). Incoherence with studies using actigraph MTI among children age 6-12 yr. *Medicine & Science in Sports & Exercise, 40*, 979.

Ham, S. A., Macera, C., & Lindley, C. (2005). Trends in Walking for Transportation in the United States, 1995 and 2001. *Preventing Chronic Disease, 2*(4).

Harrell, J. S., Bradley, C., Dennis, J., Frauman, A. C., & Criswell, E. S. (2000). School-based research: Problems of access and consent. *Journal of Pediatric Nursing, 15*, 14-21.

Harrell, J. S., McMurray, R. G., Baggett, C. D., Pennell, M. L., Pearce, P. F., & Bangdiwala, S. I. (2005). Energy costs of physical activities in children and adolescents. *Medicine & Science in Sports & Exercise*, *37*, 329-336.

Harten, N., & Olds, T. (2004). Patterns of active transport in 11-12 year old Australian children. *Australian and Newzealand Journal of Public Health, 28*, 167-172.

Heelan, K. A., Abbey, B. M., Donnelly, J. E., Mayo, M. S., & Welk, G. J. (2009). Evaluation of a walking school bus for promoting physical activity in youth. *Journal of Physical Activity & Health, 6*, 560-567.

Heelan, K. A., Donnelly, J. E., Jacobsen, J. A., Mayo, M. S., Washburn, R., & Greene, L. (2005). Active commuting to and from school and BMI in elementary school children - preliminary data. *Child: Care, Health & Development, 31*, 341 - 349.

Heitzler, C. D., Martin, S. L., Duke, J., & Huhman, M. (2006). Correlates of physical activity in a national sample of children aged 9–13 years. *Preventive Medicine*, *42*, 254-260.

Hillman, M., Adams, J., & Whiteclegg, J. (1990). *One false move... A study of children's independent mobility*. London: Policy Studies Institute.

Hinckson, E., Schofield, G., & Badland, H. (2006). The effect of school travel plans in reducing school-related motorised travel: Five case study schools. *Journal of science and medicine in sport, 9*(Supplement 1), 10.

Hubsmith, D. (2006). Safe Routes to School in the United States. *Children, Youth and Environments, 16*, 168-190.

Hume, C., Jorna, M., Arundell, L., Saunders, J., Crawford, D., & Salmon, J. (2009). Are children's perceptions of neighbourhood social environments associated with their walking and physical activity? *J Sci Med Sport, 12*(6), 637-641.

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*, 195-200.

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

Kang, M., Rowe, D. A., Barreira, T. V., Robinson, T. S., & Mahar, M. T. (2009). Individual information-centered approach for handling physical activity missing data. *Research Quarterly for Exercise and Sport, 80*, 131-137.

Kang, M., Zhu, W., Tudor-Locke, C., & Ainsworth, B. (2005). Experimental determination of effectiveness of an individual information-centered approach in recovering step-count missing data. *Measurement in Physical Education and Exercise Science, 9*, 233-250.

Kearns, R. A., Collins, D. C. A., & Neuwelt, P. A. (2003). The walking school bus: Extending children's geographies? *Area, 35*, 285 - 292.

Kelishadi, R., Razaghi, E. M., Gouya, M. M., Ardalan, G., Gheiratmand, R., Delavari, A., et al. (2007). Association of Physical Activity and the Metabolic Syndrome in Children and Adolescents: CASPIAN Study. *Hormone Research in Paediatrics, 67*, 46-52.

Kerr, J., Rosenberg, D., Sallis, J., F, Saelens, B., E, Frank, L. D., & Conway, T. L. (2006). Active commuting to school: Associations with the environment and parental concerns. . *Medicine & Science in Sports & Exercise, 38*, 787-794.

Kingham, S., & Ussher, S. (2005). Ticket to a sustainable future: An evaluation of the long-term durability of the Walking School Bus programme in Christchurch, New Zealand. *Transport Policy, 12*, 314-323.

Kingham, S., & Ussher, S. (2007). An assessment of the benefits of the walking school bus in Christchurch, New Zealand. *Transportation Research Part a-Policy and Practice, 41*, 502-510.

Kirby, J., & Inchley, J. (2009). Active travel to school: Views of 10-13 year old schoolchildren in Scotland. *Health Education, 109*, 169-183.

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *The Qualitative Report, 10*, 758-770.

Kremers, S. P. J., Dijkman, M. A. M., de Meij, J., Jurg, M. E., & Brug, J. (2008). Awareness and habit: Important factors in physical activity in children. *Health Education, 108,* 475-488.

Law, M. (1996). The person-environment-occupation model: A transactive approach to occupational performance. *Canadian Journal of Occupational Therapy, 63*, 9-23.

Lee, M. C., Orenstein, M., & Richardson, M. (2008). Systematic review of active commuting to school and children's physical activity and weight. *Journal of physical activity and health, 5,* 930-949.

Lee, T. (1957). On the relation between the school journey and social and emotional adjustment in rural infant children. *British Journal of Educational Psychology*, *27*, 101-114.

Lee, T., & Rowe, N. (1994). Parents' and children's perceived risks of the journey to school. *Architecture Behaviour, 10*, 379-389.

Leslie, E., Kremer, P., Toumbourou, J. W., & Williams, J. W. (2010). Gender differences in personal, social and environmental influences on active travel to and from school for Australian adolescents. *Journal of Science and Medicine in Sport*, *13*, 597-601.

Li, Y., Zhai, F., Yang, X., Schouten, E. G., Hu, X., He, Y., et al. (2007). Determinants of childhood overweight and obesity in China. *British Journal of Nutrition*, *97*, 210-215.

Litwin, M. S. (1995). *How to measure survey reliability and validity*. London: SAGE Publications.

Mackett, R. L., Lucas, L., Paskins, J., & Turbin, J. (2002). *A methodology for evaluating walking buses as an instrument of urban transport policy*: Paper written for the WCTR Special Interest Group 10 (Urban Transport Policy Instruments) First Annual Conference, held in Leeds, July 2002.

Mackett, R. L., Lucas, L., Paskins, J., & Turbin, J. (2005). The therapeutic value of children's everyday travel. *Transportation Research Part A, 39*, 205-219.

Maddison, R., Jiang, Y., Vander Hoorn, S., Exeter, D., Ni Mhurchu, C., & Dorey, E. (2010). Describing patterns of physical activity in adolescents using global positioning systems and accelerometry. *Pediatric Exercise Science, 22*, 392-407.

Maddison, R., & Ni Mhurchu, C. (2009). Global positioning system: A new opportunity in physical activity measurement. *International Journal of Behavioral Nutrition and Physical Activity, 6*.

Mahar, M. T., & Rowe, D. A. (2002). Construct validity in physical activity research. In G. J. Welk (Ed.), *Physical activity assessments for health-related research* (pp. 51-72). Champaign, IL: Human Kinetics.

Malina, R. (2001). Tracking of physical activity across the lifespan. *President's Council on Physical Fitness and Sports Research Digest, 3*, 3-8.

Martin, S. L., Lee, S., & Lowry, R. (2007). National prevalence and correlates of walking and bicycling to school. *American Journal of Preventitive Medicine, 33*, 98-105.

Martin, S. L., Moeti, R., & Pullen-Seufert, N. (2009). Implementing Safe Routes to School: Application for the Socioecological Model and issues to consider. *Health Promotion Practice, 10*, 606-614.

Matthews, C. E. (2005). Calibration of accelerometer output for adults. *Medicine & Science in Sports & Exercise, 37*, S512-522.

Mattocks, C., Leary, S., Ness, A., Deere, K., Saunders, J., Tilling, K., et al. (2007). Calibration of an accelerometer during free-living activities in children. *International Journal of Pediatric Obesity, 2*, 218-226.

McClain, J. J., Hart, T. L., Getz, R. Z., & Tudor-Locke, C. (2010). Convergent validity of 3 low cost motion sensors with the ActiGraph accelerometer. *Journal of Physical Activity & Health, 7*, 662-670.

McDermott, L., O’Sullivan, T., Stead, M., & Hastings, G. (2006). International food advertising, pester power and its effects. *International Journal of Advertising, 25*, 513-539.

McDonald, N. C. (2007). Active transportation to school: Trends among US school children, 1969 - 2001. *American Journal of Preventive Medicine, 32*, 509-516.

McDonald, N. C. (2008a). Children’s mode choice for the school trip: The role of distance and school location in walking to school. *Transportation, 35*, 23-35.

McDonald, N. C. (2008b). Critical factors for active transportation to school among low-income and minority students: Evidence from the 2001 national household travel survey. *American Journal of Preventitive Medicine, 34*, 341-344.

McDonald, N. C. (2008c). Household interactions and children's school travel: The effect of parental work patterns on walking and biking to school. *Journal of Transport Geography, 16*, 324 - 331.

McDonald, N. C., Deakin, E., & Aalborg, A. E. (2010). Influence of the social environment on children's school travel. *Preventive Medicine, 50,* S65-S68.

McKay, H. A., Petit, M. A., Schutz, R. W., Prior, J. C., Barr, S. I., & Khan, K. M. (2000). Augmented trochanteric bone mineral density after modified physical education classes: A randomized school-based exercise intervention study in prepubescent and early pubescent children. *The Journal of Pediatrics, 136,* 156-162.

McKee, R., Mutrie, N., Crawford, F., & Green, B. (2007). Promoting walking to school: Results of a quasi-experimental trial. *Journal of Epidemiology and Community Health, 61*, 818-823.

McMillan, T. (2005). Urban form and a child's trip to school: The current literature and framework for future research. *Journal of Planning Literature, 19*, 440-456.

McMillan, T. (2007). The relative influence of urban form on a child's travel mode to school. *Transportation Research Part A - Policay and Practice, 41*, 75-89.

McMillan, T., Day, K., Boarnet, M. G., Alfonzo, M., & Anderson, C. (2006). Johnny walks to school—does Jane? Sex differences in children’s active travel to school. *Children, Youth and Environments, 16*, 75-89.

Medical Research Council. (2005). Traffic and health in Glasgow questionnaire. *Version 2*.

Melanson, E. L., Knoll, J. R., Bell, M. L., Donahoo, W. T., Hill, J. O., Nysse, L. J., et al. (2004). Commercially available pedometers: Considerations for accurate step counting. *Preventive Medicine, 39,* 361-368.

Mendoza, J. A., Levinger, D. D., & Johnston, B. D. (2009). Pilot evaluation of a walking school bus program in a low-income, urban community. *BMC Public Health, 9*, 122.

Mendoza, J. A., Watson, K., Baranowski, T., Nicklas, T. A., Uscanga, D. K., Nguyen, N., et al. (2010). Ethnic minority children's active commuting to school and association with physical activity and pedestrian safety behaviors. *The Journal of Applied Research on Children: Informing Policy for Children at Risk, 1*.

Merom, D., Rissel, C., Mahmic, A., & Bauman, A. (2005). Process evaluation of the New South Wales Walk Safely to School Day. *Health Promotion Journal of Australia, 16*, 100-106.

Merom, D., Tudor-Locke, C., Bauman, A., & Rissel, C. (2006). Active commuting to school among NSW primary school children: Implications for public health. *Health place, 12*, 678-687.

Metallinos-Katsaras, E. S., Freedson, P. S., Fulton, J. E., & Sherry, B. (2007). The association between an objective measure of physical activity and weight status in preschoolers. *Obesity, 15*, 686–694.

Metcalf, B., Voss, L., Jeffery, A., Perkins, J., & Wilkin, T. (2004). Physical activity cost of the school run: Impact on schoolchildren of being driven to school (EarlyBird 22). *British Medical Journal, 329*, 832-833.

Meyer, A. A., Kundt, G., Lenschow, U., Schuff-Werner, P., & Kienast, W. (2006). Improvement of early vascular changes and cardiovascular risk factors in obese children after a six-month exercise program. *Journal of the American College of Cardiology, 48*, 1865-1870.

Mitchell, H., Kearns, R. A., & Collins, D. A. (2007). Nuances of neighbourhood: Children’s perceptions of the space between home and school in Auckland, New Zealand. *Geoforum, 38*, 614–627.

Motl, R. W., Dishman, R. K., Trost, S. G., Saunders, R. P., Dowda, M., Felton, G., et al. (2000). Factorial validity and invariance of questionnaires measuring social-cognitive determinants of physical activity among adolescent girls. *Preventive Medicine, 31*, 584-594.

Nelson, N. M., Foley, E., O'Gorman, D. J., Moyna, N. M., & Woods, C. B. (2008). Active commuting to school: How far is too far? *International Journal of Behavioural Nutrition and Physical Activity, 5*(1).

Ness, A., Leary, S. D., Mattocks, C., Blair, S. N., Reilly, J. J., Wells, J., et al. (2007). Objectively measured physical activity and fat mass in a large cohort of children. *PLoS Med, 4*.

Netz, Y., & Raviv, S. (2004). Age differences in motivational orientation toward physical activity: An application of Social-Cognitive theoroy. *The journal of psychology, 138*, 35-48.

Neuman, W. L. (2007). *Basics of social research : Qualitative and quantitative approaches* (2nd ed.). Boston: Pearson/Allyn and Bacon.

Neuwelt, P. A., & Kearns, R. A. (2006). Health benefits of Walking School Buses in Auckland, New Zealand: Perceptions of children and adults. *Children, Youth and Environments, 16*, 104-120.

Nilsson, A., Ekelund, U., Yngve, A., & Sjostrom, M. (2002). Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science, 14*, 87–96.

Obarzanek, E. (1993). Methodological issues in estimating the prevalence of obesity in childhood. *Annals of the New York Academy of Sciences, 699*, 278-279.

Oliver, M., Badland, H., Mavoa, S., Duncan, M. J., & Duncan, S. (2010). Combining GPS, GIS, and accelerometry: Methodological issues in the assessment of location and intensity of travel behaviors. *Journal of Physical Activity and Health, 7*, 102-108.

Ott, A. E., Pate, R. R., Trost, S.G., Ward, D. S., and Saunders, R. (2000). The use of uniaxial and triaxial accelerometers to measure childrens “free play” physical activity. *Pediatric Exercise Science, 12*, 360–370.

Pabayo, R., & Gauvin, L. (2008). Proportions of students who use various modes of transportation to and from school in a representative population-based sample of children and adolescents, 1999. *Preventive Medicine, 46*, 63-66.

Pabayo, R., Gauvin, L., Barnett, T. A., Nikiema, B., & Seguin, L. (2010). Sustained active transportation is associated with a favorable body mass index trajectory across the early school years: Findings from the Quebec

Longitudinal Study of Child Development birth cohort. *Preventive Medicine, 50 Suppl 1*, S59-64.

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 Behavioral Nutrition and Physical Activity, 7*, 17.

Panter, J. R., Jones, A. P., & van Sluijs, E. M. F. (2008). Environmental determinants of active travel in youth: A review and framework for future research. *International Journal of Behavioral Nutrition and Physical Activity, 5*(34).

Panter, J. R., Jones, A. P., van Sluijs, E. M. F., & Griffin, S. J. (2010a). Attitudes, social support and environmental perceptions as predictors of active commuting behaviour in school children. *Journal of Epidemiology and Community Health, 64*, 41-48.

Panter, J. R., Jones, A. P., van Sluijs, E. M. F., & Griffin, S. J. (2010b). Neighborhood, route, and school environments and children’s active commuting. *American Journal of Preventive Medicine, 38,* 268-278.

Petosa, R. L., Suminski, R., & Hortz, B. (2003). Predicting vigorous physical activity using social cognitive theory. *American Journal of Health Behaiour, 27*, 301-310.

Polit, D. F., Beck, C. T., & Owen, S. V. (2007). Is the CVI an acceptable indicator of content validity? Appraisal and recommendations. *Research in Nursing & Health, 30*, 459-467.

Pont, K., Ziviani, J., Wadley, D., & Abbott, R. (2010). The model of children’s active travel: A conceptual framework for examining factors influencing children’s active travel. *Australian Occupational Therapy Journal*.

Pooley, C., Whyatt, D., Walker, M., Davies, G., Coulton, P., & Bamford, W. (2010). Understanding the school journey: Integrating data on travel and environment. *Environment and Planning A, 42,* 948-965.

Prochaska, J., Evers, K., Prochaska, J. M., Van Marter, D., & Johnson, J. L. (2007). Efficacy and effectiveness trials examples from smoking cessation and bullying prevention. *Journal of Health Psychology, 12,* 170-178.

Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: Toward an integrative model of change. *Journal of Consulting and Clinical Psychology, 51*, 390-395.

Puyau, M. R., Adolph, A. L., Vohra, F. A., & Butte, N. F. (2002). Validation and calibration of physical activity monitors in children. *Obesity research, 10*, 150-157.

Quigg, R., Gray, A., Reeder, A. I., Holt, A., & Waters, D. L. (2010). Using accelerometers and GPS units to identify the proportion of daily physical activity located in parks with playgrounds in New Zealand children. *Preventive Medicine, 50*, 235-240.

Reynolds-Haertle, R. A., & McBride, R. (1992). Single vs. Double data entry in CAST. *Controlled Clinical Trials, 13*, 487-494.

Rhodes, R. E., Macdonald, H. M., & McKay, H. A. (2006). Predicting physical activity intention and behaviour among children in a longitudinal sample. *Social Science & Medicine, 62*, 3146-3156.

Riddoch, C. J., Bo Andersen, L., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L. B., et al. (2004). Physical activity levels and patterns of 9- and 15-yr-old European children. *Medicine & Science in Sports & Exercise, 36*, 86-92.

Riddoch, C. J., Mattocks, C., Deere, K., Saunders, J., Kirby, 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.

Roberts, I. (1996). Children and Sport: Walking to school has future benefits. *British Medical Journal, 312*, 1229.

Rodriguez, D. A., Brown, A. L., & Troped, P. J. (2005). Portable global positioning units to complement accelerometry- based physical activity monitors. *Medicine and Science in Sports and Exercise, 37*(11), S572 - S581.

Rosenberg, D. E., Sallis, J. F., Conway, T. L., Cain, K. L., & McKenzie, T. L. (2006). Active transportation to school over 2 years in relation to weight status and physical activity. *Obesity (Silver Spring), 14*, 1771-1776.

Rossen, L. M., Pollack, K. M., Curriero, F. C., Shields, T. M., Smart, M. J., Furr-Holden, D. M., et al. (2011). Neighborhood incivilities, perceived neighborhood safety, and walking to school among urban-dwelling children. *Journal of Physical Activity and Health, 8*, 262 -271.

Rowe, D. A., & Mahar, M. T. (2006). Construct validity. In T. Wood & W. Zhu (Eds.), *Measurement theory and practice in kinesiology* (pp. 9-26). Champaign, IL: Human Kinetics.

Rowe, D. A., Mahar, M. T., Raedeke, T. D., & Lore, J. (2004). Measuring physical activity in children with pedometers: Reliability, reactivity, and replacement of missing data. *Pediatric Exercise Science, 16*, 343-354.

Rowe, D. A., Murtagh, S., McMinn, D., Ord, K. L., & Nelson, N. M. (2010). *Reliability and validity for measures of children's self-efficacy for walking to school.* Paper presented at the 57th Annual meeting of the American College of Sports Medicine.

Rowland, D., DiGuiseppi, C., Gross, M., Afolabi, E., & Roberts, I. (2003). Randomised controlled trial of site specific advice on school travel patterns. *Archives of Disease in Childhood, 88*, 8-11.

Rowlands, A. V., & Eston, R. G. (2007). The measurement and interpretation of children's physical activity. *Journal of Sports Science and Medicine, 6*, 270-276.

Rowlands, A.V., Stone, M.R. & Eston, R.G. (2007). Influence of speed & step frequency during walking & running on motion sensor output. *Medicine & Science in Sports & Exercise, 39*, 716-727.

Ryan, M. P. (2005). Physical activity levels in young adult Hispanics and Whites: Social cognitive theory determinants. *Psychology and Health, 50*, 709-727.

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

Sallis, J. F., & Saelens, B. E. (2000). Assessment of physical activity by self-report: Status, limitations, and future directions. *Research Quarterly for Exercise & Sport, 71*, S1 - 14.

Salmon, J., Salmon, L., Crawford, D., Hume, C., & Timperio, A. (2007). Associations among individual, social, and environmental barriers and children's walking or cycling to school. *American Journal of Health Promotion, 22*, 107-113.

Saunders, R. P., Pate, R. R., Felton, G., Dowda, M., Weinrich, M. C., Ward, D. S., et al. (1997). Development of questionnaires to measure psychosocial influences on children’s physical activity. *Preventive Medicine, 26*(241-247).

Schaffer, H. R. (2004). *Introducing child psychology*. Malden, MA: Blackwell Pub.

Schneider, P. L., Crouter, S. E., Lukajic, O., & Bassett, D. R. (2003). Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. *Medicine & Science in Sports & Exercise, 10*, 1779-1784.

Scotland's Chief Statistician. (2010). *National Travel Survey 2007/08: Scottish results*.

Scottish Executive. (2003). *Let's make Scotland more active: A strategy for physical activity*. Edinburgh: Astron.

Sechrest, L. (1984). Reliability and validity. In A. Bellack & M. Hersen (Eds.), *Research methods in clinical psychology* (pp. 24-54). New York: Pergamon Press.

Seeger, C. J., Welk, G. J., & Erickson, S. (2009). *Using global position systems (GPS) and physical activity monitors to assess the built environment.* . Paper presented at the URISA’s Second GIS in Public Health Conference, Putting Health in Place with GIS.

Silva, K. S., & Lopes, A. S. (2008). Excess weight, arterial pressure and physical activity in commuting to school: Correlations. *Arquivos Brasileiros de Cardiologia, 91*, 84-91.

Sirard, J., Ainsworth, B. A., McIver, K. L., & Pate, R. R. (2005). Prevalence of active commuting at urban and suburban elementary schools in Columbia, SC. *American Journal of Public Health, 95*, 236-237.

Sirard, J., Alhassan, S., Spencer, T. R., & Robinson, T. N. (2008). Changes in physical activity from walking to school. *Journal of Nutrition Education and Behavior, 40*, 324-326.

Sirard, J., Riner, W. F., McIver, K. L., & Pate, R. R. (2005). Physical activity and active commuting to elementary school. *Medicine & Science in Sports & Exercise, 37*, 2062–2069.

Sirard, J., & Slater, M. (2008). Walking and Bicycling to School: A review. *American Journal of Lifestyle Medicine, 2,* 372-396.

Sjolie, A. N., & Thuen, F. (2002). School journeys and leisure activities in rural and urban adolescents in Norway. *Health Promotion International, 17,* 21-30.

Sothern, M. S., Loftin, M., Suskind, R. M., Udall, J. N., & Blecker, U. (1999). The health benefits of physical activity in children and adolescents: Implications for chronic disease prevention. *Euopean Journal of Pediatrics, 158*, 271-274.

Spallek, M., Turner, C., Spinks, A., Bain, C., & McClure, R. (2006). Walking to school: Distribution by age, sex and socio-economic status. *Health Promotion Journal of Australia, 17,* 134-138.

Spinks, A., Macpherson, A., Bain, C., & McClure, R. (2006). Determinants of sufficient daily activity in Australian primary school children. *Journal of Paediatrics and Child Health, 42*, 674–679.

Staudenmayer, J., Pober, D., Crouter, S., Bassett, D., & Freedson, P. (2009). An artificial neural network to estimate physical activity energy expenditure and identify physical activity type from an accelerometer. *Journal of Applied Physiology, 107*, 1300-1307.

Staunton, C. E., Hubsmith, D., & Kallins, W. (2003). Promoting safe walking and biking to school:The Marin County success story. *American Journal of Public Health, 93*, 1431-1434.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum.

Stone, E. J., McKenzie, T. L., Welk, G. J., & Booth, M. L. (1998). Effects of physical activity interventions in youth: Review and synthesis. *American Journal of Preventive Medicine, 15*, 298-315.

Storti, K., Pettee, K., Brach, J., Talkowski, J. B., Richardson, C., Kriska, A. (2008). Gait speed and step-count monitor accuracy in community-dwelling older adults. *Medicine & Science in Sports & Exercise,40*, 59-64.

Strauss, R. S., Rodzilsky, D., Burack, G., & Colin, M. (2001). Psychosocial correlates of physical activity in healthy children. *Archives of Pediatrics & Adolescent Medicine, 155*, 897-902.

Suminski, R. R., Petosa, R. L., Poston, W. C. S., Stevens, E., & Katzenmoyer, L. (2006). An observation method for determining the number of children and adults walking/biking to elementary school. *Journal of Physical Activity and Health, 3*, 37-47.

Sustrans. (2009). *National Hands-Up Survey Scotland: Report on Data Collected 2008*. Bristol.

The Scottish Government. (2008). *Scottish transport statistics No. 27. 2008 Edition*.

Thomas, J. R., & Nelson, J. K. (1996). *Research methods in physical activity* (Third ed.). Champaign: Human Kinetics.

Thomas, N. E., & Fleming, S. (2008). "I'm fat, aren't I miss?": Reflections on field testing with children. *Leisure Studies Association Newsletter, 79*, 46-51.

Timperio, A., Ball, K., Salmon, J., Roberts, R., Giles-Corti, B., Simmons, D., et al. (2006). Personal, family, social, and environmental correlates of active commuting to school. *American journal of Preventive Medicine*, *30*, 45-51.

Timperio, A., Crawford, D., Telford, A., & Salmon, J. (2004). Perceptions about the local neighborhood and walking and cycling among children. *Preventive Medicine*, *38*(1), 39-47.

Troiano, 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 & Science in Sports & Exercise*, *40*, 181-188.

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

Trost, S. G., Mciver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Medicine & Science in Sports & Exercise, 37,* S531–S543.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., et al. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine & Science in Sports & Exercise, 34*, 350-355.

Tudor-Locke, C., Ainsworth, B., Adair, L. S., Du, S., & Popkin, B. M. (2003). Physical activity and inactivity in Chinese school-aged youth: The China

Health and Nutrition Survey. *International Journal of Obesity, 27*, 1093–1099.

Tudor-Locke, C., Ainsworth, B. E., & Popkin, B. M. (2001). Active Commuting to School: An overlooked source of children's physical activity? *Sports Medicine, 31*, 309-313.

Tudor-Locke, C., Burkett, L., Reis, J. P., Ainsworth, B. E., Macera, C. A., & Wilson, D. K. (2005). How many days of pedometer monitoring predict weekly physical activity in adults? *Preventive Medicine, 40*, 293–298.

Tudor-Locke, C., & Lutes, L. (2009). Why do pedometers work?: A reflection upon the factors related to successfully increasing physical activity. *Sports Medicine, 39*, 981-993.

Tudor-Locke, C., Neff, L. J., Ainsworth, B. E., Addy, C. L., & Popkin, B. M. (2002). Omission of active commuting to school and the prevalence of children's health-related physical activity levels: The Russian Longitudinal Monitoring Study. *Child: Care, Health, & Development, 28*, 507-512.

U.S. Department of Health and Human Services. (2008). *2008 Physical Activity Guidelines for Americans: Be Active, Healthy, and Happy*. Retrieved from www.health.gov/paguidelines.

van der Ploeg, H. P., Merom, D., Corpuz, G., & Bauman, A. E. (2008). Trends in Australian children traveling to school 1971-2003: Burning petrol or carbohydrates? *Preventive Medicine, 46*, 60-62.

van Sluijs, E. M. F., Fearne, V. A., Mattocks, C., Riddoch, C., Griffin, S. J., & Ness, A. (2009). The contribution of active travel to children's physical activity levels: Cross-sectional results from the ALSPAC study. *Preventive Medicine, 48*, 519-524.

Verplanken, B., & Orbel, S. (2003). Reflections on past behaviour: A self-report index of habit strength. *Journal of Applied Social Psychology, 33*, 1313-1330.

Voss, C., & Sandercock, G. (2010). Aerobic fitness and mode of travel to school in English schoolchildren. *Medicine & Science in Sports & Exercise, 42*, 281-287.

Vuori, I. (2004). Physical inactivity as a disease risk and health benefits of increased physical activity. *Perspectives, 6*.

Warburton, D. E. R., Nicol, C. W., & Bredin, S. S. D. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal, 174*, 801-809.

Ward, D. S., Linnan, L., Vaughn, A., Neelon, B., Martin, S. L., & Fulton, J. E. (2007). Characteristics associated with US Walk to School programs. *International Journal of Behavioural Nutrition and Physical Activity, 4*, 67.

Welk, G.J. (2005) Principles of design and analyses for the calibration of accelerometry-based activity monitors. *Medicine & Science in Sports & Exercise 37*, S501-511.

Welk, G. J., Blair, S. N., Wood, K., Jones, S. & Thompson, R. W. (2000). A comparative evaluation of three accelerometry-based physical activity monitors. *Medicine & Science in Sports & Exercise*, *32*, S489–S497.

Wen, L. M., Fry, D., Merom, D., Rissel, C., Dirkis, H., & Balafas, A. (2008). Increasing active travel to school: Are we on the right track? A cluster randomised controlled trial from Sydney, Australia. *Preventive Medicine, 47*, 612-618.

Wilkin, T. (2010). Can we modulate children's physical activity? Debate with John Reilly. BASES Annual conference, Glasgow, September, 2010.

Wilkin, T., & Voss, L. D. (2004). Physical activity in young children. *The Lancet, 363*, 1162-1164.

Wind, M., Kremers, S., Thijs, C., & Brug, J. (2005). Effects on toothbrushing behaviour, cognitions and habit strength. *Health Education, 105*, 53-61.

Witlox, F., & Tindemans, H. (2006). Activity patterns of children and youth in Ghent, Belgium: A research note. *Children, Youth and Environments*, *16*, 134-150.

World Health Organisation. (2008). Global strategy on diet, physical activity and health.

www.metoffice.gov.uk/weather/.

www.scotland.gov.uk/Topics/Statistics/SIMD.

www.sns.gov.uk.

Yarlagadda, A. K., & Srinivasan, S. (2008). Modeling children's school travel mode and parental escort decisions. *Transportation, 35*, 201-218.

Yelavich, S., Towns, C., Burt, R., Chow, K., Donohue, R., Sani, H. S., et al. (2008). Walking to school: Frequency and predictors among primary school children in Dunedin, New Zealand. *The New Zealand Medical Journal, 121*, 51-58.

Yeung, J., Wearing, S., & Hills, A. P. (2008). Child transport practices and perceived barriers in active commuting to school. *Transportation Research Part A, 42*, 895-900.

Yngve, A., Nilsson, A., Sjostrom, M., & Ekelund, U. (2003). Effect of monitor placement and of activity setting on the MTI accelerometer output. *Medicine & Science in Sports & Exercise, 35*, 320-326.

Ziviani, J., Scott, J., & Wadley, D. (2004). Walking to school: Incidental physical activity in the daily occupations of Australian children. *Occupational Therapy International, 11*, 1-11.

Appendices

Appendix A. Pilot study university ethical approval

Dear Dr Rowe

PROTOCOL APPROVAL
UEC0809/34 Active commuting for primary school children; pilot testing for the Travelling Green project

I can confirm that the Convener of the University Ethics Committee has approved this protocol, on behalf of the Committee. Appropriate insurance cover has also been confirmed.

I would remind you that the Committee must be informed of any changes that are made to the protocol, so that they have the opportunity to consider them. The Committee would also expect you to report back on the progress and outcome of your project, with an account of anything which may prompt ethical questions for any similar future project and with anything else that you feel the Committee should know.

On behalf of the Committee, I wish you success with this project.

Best wishes
Jo

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Appendix B. Main study departmental ethical approval

University of Strathclyde
Education

Department of Sport, Culture and the Arts

Ethics Approval Form

This form acknowledges that the research project has been given Ethics Approval to proceed from the date identified.

Name of researcher: Norah Nelson et Al

Name of Chief Investigator: David Rowe

Title of Project:
____A multi-disciplinary evaluation of Travelling Green – a primary school resource for encouraging active commuting to school.

Signed on behalf of the Department Ethics Committee by: [signature]

Date: 4/8/2009

Appendix C. Letter of permission to contact schools in West Dunbartonshire

Terry Lanagan MA (Hons)
Executive Director of Educational Services

Sandra Love: Head of Service

Council Offices, Garshake Road, Dumbarton G82 3PU
Tel: Direct Line (01389) 737304 Fax: (01389) 737348
Your Ref: Our Ref: SL/ac
Date: 02 December 2008
If phoning or calling please ask for Sandra Love
e-mail: sandra.love@west-dunbarton.gov.uk

West Dunbartonshire Council

Dr David Rowe
Reader in Exercise Science
Dr Norah Nelson
Lecturer in Physical Activity for Health
University of Strathclyde
Department of Sport, Culture and the Arts
Jordanhill Campus
76 Southbrae Drive
Glasgow G13 1PP

Dear Dr Rowe/Dr Nelson

RESEARCH PROJECT

Thank you for your letter dated 18 November 2008.

We are happy for you to contact primary schools in West Dunbartonshire Council for permission to conduct a research study into active travel in primary school children.. The final decision lies with the head teacher.

Yours sincerely

Sandra Love

Sandra Love
Head of Service

lsl02.12.08/ac

West Dunbartonshire ~ from the banks of Loch Lomond to the shores of the Clyde

OPPORTUNITY THROUGH LEARNING

Appendix D. Letter of permission to contact schools in Glasgow

Glasgow CITY COUNCIL

Executive Director
Children and Families
Margaret Doran

Education Services
Glasgow City Council
Wheatley House
25 Cochrane Street
Merchant City
Glasgow G1 1HL

Phone Direct Line 0141-287-4946
Fax 0141-287 3795
Email john.scougall@education.glasgow.gov.uk

Website www.glasgow.gov.uk
Our Ref JS/Rsrch
Date 15 June 2009
If phoning please ask for John Scougall

Mr David McMinn
PhD Student
Dept of Sport, Culture and the Arts
Sports Building
University of Strathclyde
Jordanhill Campus
76 Southbrae Drive
GLASGOW
G13 1PP

Dear Mr McMinn

Proposed Research Project – A multi-disciplinary evaluation of *Travelling Green* – a primary school resource for encouraging active commuting to school.

Thank you for your completed research application form regarding the above.

I now write to advise you that this department has no objection to you seeking assistance from our schools with your project. I would confirm however that it is very much up to the Head Teachers to decide whether or not their schools participate and assist you in your research.

A copy of this letter should be sent to the Head Teachers when contacting the schools.

This approval is also on the condition that as there is pupil involvement regarding this project, where the pupil is under sixteen years of age, parental/guardian consent **must be requested, and given,** before such involvement. All researchers in contact with the children must have recently approved Disclosure Scotland checks.

I hope that this is helpful and that you have success with your project.

Yours sincerely

JOHN SCOUGALL
Principal Officer
Service Reform

Appendix E. Email granting permission to include Kirkhill Primary in the study

David,

I give permission for Strathclyde University to include Kirkhill Primary School in its research study of Active Travel connected to the Travelling Green programme.

Ian Pye

Quality Improvement Officer - Sport, Leisure and Recreation

Education Department

Phone: 0141 577 3868

e-mail: ian.pye@eastrenfrewshire.gov.uk

EAST RENFREWSHIRE COUNCIL - Working for You

www.eastrenfrewshire.gov.uk

Appendix F. Study information sheet for intervention school children

University of Strathclyde Education

Department of Sport, Culture and the Arts

Project Information sheet for Child

Study title: Active commuting for primary school children; Evaluation of the Travelling Green project.

What is the study about?

We want to find out if you change how you travel to school after doing the Travelling Green project. We also want to know what you think about walking to school.

At the University Of Strathclyde before any project starts it has to be checked by university staff. They make sure that the research is OK to do. The Department of Sport, Culture, and the Arts Ethics Committee has said that the study is OK to do.

Do you have to take part?

No. It is your choice if you take part in the project or not. We will not be upset if you choose not to take part.

If at any time during the project you feel that you don't want to continue then you can tell the researcher to stop. You do not have to give a reason.

What will you do in the project?

You will be asked to do three things in this project.

- The first thing will be to wear a belt with 2 small gadgets on it during the day for 4 weeks. These gadgets will let us know how much walking you do during the day. You will be asked to wear the belt one week before you do Travelling Green and one week after you finish Travelling green. You will also be asked to wear the belt for one week, six months after you finish Travelling Green and one year after you finish Travelling Green. This will let us know if your walking behaviours have changed over time.

- The second thing you will be asked to do is carry another gadget in your bag on one journey home from school on each of the 4 weeks that you are wearing the belt. This gadget will let us know what route you take when you travel home.

- The third thing you will be asked to do is fill in a sheet about your journey to and from school. The sheet will ask about things that might stop you walking to school, and things that would make walking to school better. Students from the University of Strathclyde will be in your classroom to help you fill in the sheet if you find it hard. You will fill in this sheet at the start of the weeks that you wear the belt.

- Your parent or guardian will also be asked to fill in a sheet at the same times as you. They will answer questions like the ones you will answer.

Why have you been asked to take part?
You are the age that we are interested in studying. Your school has also been kind enough to let us come in to do the study with you.

What are the possible risks to you in taking part?
There will be no extra risk involved in this study, only the usual risks of going to and from school. The belt with the gadgets on it will be easy to wear.

What happens to the information in the project?
All the information which is collected about you in the project will be kept private. No one will know that the information belongs to you. All the information will be kept at the University Of Strathclyde.

Thank you for reading this sheet. Please ask any questions if you are unsure or confused about what you have read.

What happens next?

- If you are happy to be involved in the project. You will now need to take the consent form and information sheets home to your parent/guardian. There is a sheet for them to read which tells them about the project and a form for both of you to sign and return to the school.
- If you do not want to take part in the project then thank you for your time.

Who can you contact if you have any questions about the project?
Dr. David Rowe
Department of Sport, Culture, and the Arts
University of Strathclyde
Jordanhill Campus
76 Southbrae Drive
Glasgow
G13 1PP

david.rowe@strath.ac.uk 0141 950 3712

Who can you contact if you have a complaint about the project?
University of Strathclyde Ethics secretary: ethics@strath.ac.uk 0141 548 2752

Appendix G. Study information sheet for control school children

University of Strathclyde
Education

Department of Sport, Culture and the Arts
Project Information sheet for Child

Study title: Active commuting for primary school children; Evaluation of the Travelling Green project.

What is the study about?
We want to find out if you change how you travel to school after doing the Travelling Green project. We also want to know what you think about walking to school.

At the University Of Strathclyde before any project starts it has to be checked by university staff. They make sure that the research is OK to do. The Department of Sport, Culture, and the Arts Ethics Committee has said that the study is OK to do.

Do you have to take part?
No. It is your choice if you take part in the project or not. We will not be upset if you choose not to take part.
If at any time during the project you feel that you don't want to continue then you can tell the researcher to stop. You do not have to give a reason.

What will you do in the project?
You will be asked to do three things in this project.

- The first thing will be to wear a belt with 2 small gadgets on it during the day for 6 weeks. These gadgets will let us know how much walking you do during the day. You will be asked to wear the belt for 2 weeks in September/October, then for one week before you do Travelling Green and for one week after you finish Travelling green. You will also be asked to wear the belt for one week, six months after you finish Travelling Green and one year after you finish Travelling Green. This will let us know if your walking behaviours have changed over time.

- The second thing you will be asked to do is carry another gadget in your bag on one journey home from school on each of the 6 weeks that you are wearing the belt. This gadget will let us know what route you take when you travel home.

- The third thing you will be asked to do is fill in a sheet about your journey to and from school. The sheet will ask about things that might stop you walking to school, and things that would make walking to school better. Students from the University of Strathclyde will be in your classroom to help you fill in the sheet if you find it hard. You will fill in this sheet at the start of the weeks that you wear the belt.

- Your parent or guardian will also be asked to fill in a sheet at the same times as you. They will answer questions like the ones you will answer.

Why have you been asked to take part?
You are the age that we are interested in studying. Your school has also been kind enough to let us come in to do the study with you.

What are the possible risks to you in taking part?
There will be no extra risk involved in this study, only the usual risks of going to and from school. The belt with the gadgets on it will be easy to wear.

What happens to the information in the project?
All the information which is collected about you in the project will be kept private. No one will know that the information belongs to you. All the information will be kept at the University Of Strathclyde.

Thank you for reading this sheet. Please ask any questions if you are unsure or confused about what you have read.

What happens next?

- If you are happy to be involved in the project. You will now need to take the consent form and information sheets home to your parent/guardian. There is a sheet for them to read which tells them about the project and a form for both of you to sign and return to the school.
- If you do not want to take part in the project then thank you for your time.

Who can you contact if you have any questions about the project?
Dr. David Rowe
Department of Sport, Culture, and the Arts
University of Strathclyde
Jordanhill Campus
76 Southbrae Drive
Glasgow
G13 1PP
david.rowe@strath.ac.uk 0141 950 3712

Who can you contact if you have a complaint about the project?

University of Strathclyde Ethics secretary: ethics@strath.ac.uk 0141 548 2752

Appendix H. Study information sheet for intervention school parents

University of Strathclyde Education

Department of Sport, Culture and the Arts

Project Information sheet for Parents/Guardians

PLEASE READ THE FOLLOWING CAREFULLY

Study title: Active commuting for primary school children; Evaluation of the Travelling Green project.

What is the study about?

Your child has been asked to take part in this study because they will soon be taking part in the Travelling Green project. Travelling Green is a 6 week curricular resource that aims to encourage children to walk to school. We are interested to find out how children's activity levels change after taking part in Travelling Green. We are also interested in finding out what factors might stop them from or encourage them to walk to school. We are hoping that approximately 200 primary 5 children from 5 different schools will take part in our study.

Does your child have to take part?

No. Participation in this project is entirely voluntary and it is up to you and your child to decide whether or not they take part. You are both free to withdraw from the research at any time and without giving a reason. Whatever decision you make will not affect your child's education.

What will your child be asked to do?

Your child will be asked to take part in three activities.

- The first of these is to wear an elastic belt around their waist which will contain 2 small devices called activity monitors. These devices will tell researchers how much your child walks. The devices will cause no discomfort to your child. Your child will be asked to wear the elastic belt with the devices during the day for 4 weeks. One week before and after taking part in Travelling Green, and then one week 6 months and 1 year after taking part in Travelling Green.

- The second activity that your child will be asked to do is carry another device in their bag. This device is a GPS tracking device and it lets researchers know what routes participants take when travelling home. Your child will be asked to put the GPS device in their bag for one journey home during each of the 4 weeks of data collection.

- The third activity that your child will be asked to do is to fill in a questionnaire about their journey to and from school. The questionnaire will ask them about things that stop them walking to school and things that would make walking to school better. The questionnaire will take approximately 30 minutes to fill in and researchers from the University of Strathclyde will be in the classroom to help them. Your child will fill in a questionnaire once during each of the 4 weeks of data collection.

- In addition, we will ask you to fill in a similar questionnaire that will ask about your child's journey to and from school. The questionnaire will ask similar questions to the questionnaire filled in by your child. We are asking you to fill in a questionnaire because we are also interested in your views and opinions of how your child travels to school. If you need any help filling in the questionnaire, a researcher can be made available at the school to help. You will be asked to fill in the questionnaires at similar times to your children.

The study results will be used for two PhD projects and 4 undergraduate dissertations.

What has your child been told about the study?
Your child has been given a description of the study and what it involves. They have had the opportunity to ask questions about the study directly to the researcher.

What are the potential risks to your child by taking part?
Other than the risks your child usually encounters whilst travelling to and from school, there will be no added risk.

Who can you contact if you have any questions about the project?
Dr. David Rowe
Department of Sport, Culture, and the Arts
University of Strathclyde
Jordanhill Campus
76 Southbrae Drive
Glasgow
G13 1PP

david.rowe@strath.ac.uk 0141 950 3712

University of Strathclyde Ethics secretary: ethics@strath.ac.uk 0141 548 2752

Will your child's participation in the research project be kept confidential?
Yes. The information collected from your child in connection with this project will remain confidential during the duration of the study and after its completion. All records will be stored at the University Of Strathclyde with signed consent forms stored separately. The publication of the results will not result in your child being identified with particular responses.

Who can you contact if you have a complaint about the project?
If you have any complaints about the way you or your child have been treated during the project or any harm that your child has encountered as a result of involvement in the project the please contact the University of Strathclyde Ethics Secretary, Email; ethics@strath.ac.uk, Phone; 0141 548 2752.

What happens next?

- If you are happy for you and your child to be involved in the process we would ask you and your child to sign the consent form and return it to the research team at the school.
- If after reading this information you do not wish you or your child to take part you do not have to do anything – Thank you for your time.

Appendix I. Study information sheet for control school parents

University of Strathclyde Education

Department of Sport, Culture and the Arts

Project Information sheet for Parents/Guardians

PLEASE READ THE FOLLOWING CAREFULLY

Study title: Active commuting for primary school children; Evaluation of the Travelling Green project.

What is the study about?

Your child has been asked to take part in this study because they will soon be taking part in the Travelling Green project. Travelling Green is a 6 week curricular resource that aims to encourage children to walk to school. We are interested to find out how children's activity levels change after taking part in Travelling Green. We are also interested in finding out what factors might stop them from or encourage them to walk to school. We are hoping that approximately 200 primary 5 children from 5 different schools will take part in our study.

Does your child have to take part?

No. Participation in this project is entirely voluntary and it is up to you and your child to decide whether or not they take part. You are both free to withdraw from the research at any time and without giving a reason. Whatever decision you make will not affect your child's education.

What will your child be asked to do?

Your child will be asked to take part in three activities.

- The first of these is to wear an elastic belt around their waist which will contain 2 small devices called activity monitors. These devices will tell researchers how much your child walks. The devices will cause no discomfort to your child. Your child will be asked to wear the elastic belt with the devices during the day for 6weeks. Two weeks in September/October, one week before and after taking part in Travelling Green, and then one week 6 months and 1 year after taking part in Travelling Green.

- The second activity that your child will be asked to do is carry another device in their bag. This device is a GPS tracking device and it lets researchers know what routes participants take when travelling home. Your child will be asked to put the GPS device in their bag for one journey home during each of the 6 weeks of data collection.

- The third activity that your child will be asked to do is to fill in a questionnaire about their journey to and from school. The questionnaire will ask them about things that stop them walking to school and things that would make walking to school better. The questionnaire will take approximately 30 minutes to fill in and researchers from the University of Strathclyde will be in the classroom to help them. Your child will fill in this questionnaire once during each of the 6 weeks of data collection.

- In addition, we will ask you to fill in a similar questionnaire that will ask about your child's journey to and from school. The questionnaire will ask similar questions to the questionnaire filled in by your child. We are asking you to fill in a questionnaire because we are also interested in your views and opinions of how your child travels to school. If you need any help filling in the questionnaire, a researcher can be made available at the school to help. You will be asked to fill in the questionnaires at similar times to your children.

The study results will be used for two PhD projects and 4 undergraduate dissertations.

What has your child been told about the study?
Your child has been given a description of the study and what it involves. They have had the opportunity to ask questions about the study directly to the researcher.

What are the potential risks to your child by taking part?
Other than the risks your child usually encounters whilst travelling to and from school, there will be no added risk.

Who can you contact if you have any questions about the project?
Dr. David Rowe
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University of Strathclyde Ethics secretary: ethics@strath.ac.uk 0141 548 2752

Will your child's participation in the research project be kept confidential?
Yes. The information collected from your child in connection with this project will remain confidential during the duration of the study and after its completion. All records will be stored at the University Of Strathclyde with signed consent forms stored separately. The publication of the results will not result in your child being identified with particular responses.

Who can you contact if you have a complaint about the project?
If you have any complaints about the way you or your child have been treated during the project or any harm that your child has encountered as a result of involvement in the project the please contact the University of Strathclyde Ethics Secretary, Email; ethics@strath.ac.uk, Phone; 0141 548 2752.

What happens next?

- If you are happy for you and your child to be involved in the process we would ask you and your child to sign the consent form and return it to the research team at the school.
- If after reading this information you do not wish you or your child to take part you do not have to do anything – Thank you for your time.

Appendix J. Consent form

University of Strathclyde Education

Department of Sport, Culture and the Arts

Child and Parent Consent Form

Project Title: Active commuting to primary school in Ireland and Northern Ireland: Prevalence and correlates

Child's Consent

We will now ask if you would like to take part in the project. Please read these sentences.

The project has been explained to me [or I have read about the project on the information sheet]. I understand what the project is about and what I would be asked to do. I have been given time to ask questions. If I had any questions they have been answered in a way I understand. I know that I don't have to take part if I don't want to and that it is OK to stop taking part at any time.

Do you agree? And are you happy to take part?

I (write your name)	(today's date)
would like to be involved in the project	

If you **don't** want to take part, **don't** sign your name!

Parental Consent

I confirm that I have read and understand the parent information sheet for the above project and have been given the researcher's name and contact details if I require further information. I understand that my child is participating voluntarily and that my child is free to withdraw from the project at any time, without having to give a reason and without any effect on my child's education. I understand that any information recorded about my child will remain confidential and no information that identifies my child will be made publicly available.

I (PRINT NAME)	hereby agree to my child taking part in the above study
Signature of Parent:	Date

Child Questionnaire ID _____

About you

1. What is your full name? ______________________________

2. What is the name of your school? ____________________

3. How old are you?

   8 ☐

   9 ☐

   10 ☐

   11 ☐

4. What primary year are you in?

   Primary 4 ☐

   Primary 5 ☐

   Primary 6 ☐

   Primary 7 ☐

5. Are you a boy or a girl?

   Boy ☐

   Girl ☐

Mode of Travel

6. **On a normal day, how do you usually travel TO school?**

On foot---------------------- ☐ By school bus------------- ☐

By public transport------- ☐ By Car (given a lift)------ ☐

Bicycle---------------------- ☐ Other ....

A mixture of .... and ....

7. **On a normal day, how do you usually travel FROM school?**

On foot---------------------- ☐ By school bus------------- ☐

By public transport------- ☐ By Car (given a lift)------ ☐

Bicycle---------------------- ☐ Other ....

A mixture of .... and ....

8. **On a normal day, who do you usually travel TO school with?**

An adult--------------------- ☐ An adult and other------- ☐ Children

On my own --------------- ☐ Friends---------------------- ☐

Brother/sister-------------- ☐

9. **On a normal day, who do you usually travel FROM school with?**

An adult--------------------- ☐ An adult and other------- ☐ Children

On my own --------------- ☐ Friends---------------------- ☐

Brother/sister-------------- ☐

Walking to School

10. Please tick ONE sentence which best describes how you feel about walking to school.

- I do not walk any part of my journey to school and I do not plan to-- □
- I do not walk any part of my journey to school but I am thinking about it.-- □
- I sometimes walk part or all of my journey to school but no more than once a week.------------------------------ □

} Go to Q11

- I walk part or all of my journey to school on most days but I have only started recently.------------------------ □
- I walk part or all of my journey to school on most days and have been doing this for 6 months or more.--- □

} Go to Q13

- I used to walk part or all of my journey to school on most days but I don't any longer.----------------------- □

} Go to Q11

11. I don't walk to school because......

Please circle the most appropriate response.

An adult drives me all the way.	Agree	Undecided	Disagree
I live too far away.	Agree	Undecided	Disagree
I don't want to.	Agree	Undecided	Disagree
I don't have enough time.	Agree	Undecided	Disagree
I am not allowed to.	Agree	Undecided	Disagree
The weather is too bad.	Agree	Undecided	Disagree
My friends don't walk.	Agree	Undecided	Disagree
No one from my family walks with me.	Agree	Undecided	Disagree
I am frightened of meeting strangers	Agree	Undecided	Disagree
I am frightened of being bullied	Agree	Undecided	Disagree
The roads are too difficult to cross.	Agree	Undecided	Disagree
I don't know what walking route to take.	Agree	Undecided	Disagree
There are not enough lollipop people.	Agree	Undecided	Disagree
The traffic is too busy/ traffic is too fast.	Agree	Undecided	Disagree
There are too many cars near the school entrance.	Agree	Undecided	Disagree
The route does not have good lighting along the way.	Agree	Undecided	Disagree
I don't feel safe walking to school.	Agree	Undecided	Disagree

Are there any other barriers you feel stop you walking part or all of the journey to school?

____

____

____

12. I would be encouraged to walk part or all of the way to school if.....
Please circle the most appropriate response.

I was driven some of the way and dropped off within walking distance.	Agree	Undecided	Disagree
I lived closer to the school.	Agree	Undecided	Disagree
I had more time.	Agree	Undecided	Disagree
I was allowed to.	Agree	Undecided	Disagree
The weather was better.	Agree	Undecided	Disagree
My friends walked.	Agree	Undecided	Disagree
Someone from my family walked with me.	Agree	Undecided	Disagree
There was good lighting along the way.	Agree	Undecided	Disagree
I was less frightened of meeting strangers.	Agree	Undecided	Disagree
I was less frightened of being bullied.	Agree	Undecided	Disagree
There were more safe places to cross the road.	Agree	Undecided	Disagree
I knew what walking route to take.	Agree	Undecided	Disagree
There were more lollipop people.	Agree	Undecided	Disagree
There was less traffic/slower traffic.	Agree	Undecided	Disagree
Cars kept away from the school entrance.	Agree	Undecided	Disagree
I felt safer.	Agree	Undecided	Disagree

Is there anything else that you feel would encourage you to walk part or all of your journey to school?

____

____

____

____

NOW GO TO QUESTION 14

13. **Which of the following would make walking to and from school better?**
    Please tick the most appropriate boxes.

    Better weather-- ☐

    If my friends walked-- ☐

    If I was less frightened of meeting strangers--------------- ☐

    If I was less frightened of being bullied---------------------- ☐

    More safer places to cross-------------------------------------- ☐

    More school lollipop people------------------------------------ ☐

    Less/ slower traffic-- ☐

    Cars kept away from the school entrance------------------ ☐

    If my parents walked with me--------------------------------- ☐

    If my older brother(s) or sister(s) walked with me--------- ☐

    Nothing, I feel fine about walking to school----------------- ☐

Is there anything else that you think would make walking to school better?

____

____

14. **If you walked part or all of the way to school on most days, what benefits would there be?** *Please tick those that apply to you.*

My heart and lungs would be healthier---------------------- ☐

I would be alert and awake for school----------------------- ☐

I would be able to talk to my friends on the way----------- ☐

My body would become healthier----------------------------- ☐

It would be fun--- ☐

I would be helping the environment-------------------------- ☐

I would hear and see things that I wouldn't usually------- ☐

I would save money on fares--------------------------------- ☐

I would get lots of fresh air------------------------------------ ☐

I would be able to talk to my parents on the way---------- ☐

I would be able to talk to my brother(s) or sister (s)

on the way-- ☐

Is there anything else that you feel would benefit you if you walked part or all of the way to school on most days?

____

____

____

Preferred journey to school

15. If you could choose how you travelled to and from school, how would you like to travel?

On foot---------------------- ☐ By school bus------------- ☐

By public transport------- ☐ By Car (given a lift)------ ☐

Bicycle---------------------- ☐ Other ....

A mixture of .... and ....

16. If you could choose who you travelled to and from school with, who would you travel with?

An adult--------------------- ☐ An adult and other------- ☐ Children

On my own -------------- ☐ Friends---------------------- ☐

Brother/sister-------------- ☐

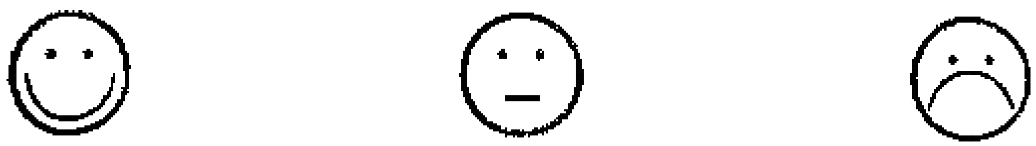
17. How sure are you that you can?
Please circle the most appropriate response.

Walk to school	Very Sure	Kind of sure	Not Sure
Ask a parent or other adult to walk to school with you.	Very Sure	Kind of sure	Not Sure
Walk to school even if your friends don't walk.	Very Sure	Kind of sure	Not Sure
Ask your friends to walk to school with you.	Very Sure	Kind of sure	Not Sure

Walk to school in bad weather.	Very Sure	Kind of sure	Not Sure
Cross difficult roads when walking to school.	Very Sure	Kind of sure	Not Sure
Walk to school even if there are not enough lollipop people.	Very Sure	Kind of sure	Not Sure
Walk to school even if there are many cars near the school entrance.	Very Sure	Kind of sure	Not Sure
Cope with busy traffic when walking to school.	Very Sure	Kind of sure	Not Sure
Walk to school even if I am frightened of meeting strangers.	Very Sure	Kind of sure	Not Sure
Find a route to walk to school.	Very Sure	Kind of sure	Not Sure
Walk to school even if there is poor lighting.	Very Sure	Kind of sure	Not Sure
Walk to school even if it takes a long time.	Very Sure	Kind of sure	Not Sure
Walk to school even if I am frightened of being bullied.	Very Sure	Kind of sure	Not Sure

18. Looking at the faces scale, which face shows best how you feel about living in your local area?

Circle only one



19. Please circle the most appropriate response…

Walking to school every day would be fun	Disagree in a big way	Disagree	Agree	Agree in a big way
Walking to school every day would be enjoyable	Disagree in a big way	Disagree	Agree	Agree in a big way
Walking to school every day would be good for me	Disagree in a big way	Disagree	Agree	Agree in a big way
Walking to school every day would be important for me	Disagree in a big way	Disagree	Agree	Agree in a big way
My family wants me to walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
My friends want me to be walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
My teachers want me to be walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
My family will walk to school or to work every day	Disagree in a big way	Disagree	Agree	Agree in a big way
My friends will walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
My teachers will walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
I could walk to school every day if I really wanted to	Disagree in a big way	Disagree	Agree	Agree in a big way
I have the time to walk to school every day if I really wanted to	Disagree in a big way	Disagree	Agree	Agree in a big way
I live in a place which allows me to walk to school every day if I wanted to	Disagree in a big way	Disagree	Agree	Agree in a big way
I plan to walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way
I intend to walk to school every day	Disagree in a big way	Disagree	Agree	Agree in a big way

20. ‘Walking to school is something….’ *(Circle one number)*

	Totally disagree				Totally agree
1. I do a lot	0	1	2	3	4
2. I do automatically	0	1	2	3	4
3. I do without having to remember.	0	1	2	3	4
4. That makes me feel weird if I do not do it.	0	1	2	3	4
5. I do without thinking.	0	1	2	3	4
6. That would require effort not to do it.	0	1	2	3	4
7. That belongs to my daily routine.	0	1	2	3	4
8. I start doing before I realize I’m doing it.	0	1	2	3	4
9. I would find hard not to do.	0	1	2	3	4
10. I have no need to think about doing.	0	1	2	3	4
11. That’s typically ‘me’.	0	1	2	3	4
12. I have been doing for a long time.	0	1	2	3	4

21. ‘Travelling by car or bus to school is something….’ *(Circle one number)*

	Totally disagree				Totally agree
1. I do a lot	0	1	2	3	4
2. I do automatically	0	1	2	3	4
3. I do without having to remember.	0	1	2	3	4
4. That makes me feel weird if I do not do it.	0	1	2	3	4
5. I do without thinking.	0	1	2	3	4
6. That would require effort not to do it.	0	1	2	3	4

7. That belongs to my daily routine.	0	1	2	3	4
8. I start doing before I realize I’m doing it.	0	1	2	3	4
9. I would find hard not to do.	0	1	2	3	4
10. I have no need to think about doing.	0	1	2	3	4
11. That’s typically ‘me’.	0	1	2	3	4
12. I have been doing for a long time.	0	1	2	3	4

You’re finished!

Thank you for your time and effort.

Appendix L. Parent questionnaire

Parent Questionnaire

About your child

1. What is your child's full name? ________________________

2. What is the name of your child's school? ________________

3. Does your child have any illness, health problem or disability that limits their ability to walk to and from school?

Tick only one Yes ☐ No ☐

4. Who decides whether your child walks to school or not?

Parent/guardian ☐

Child ☐

5. **To which of these groups do you consider your child belongs to?**

White British ☐

Any other White background (Please describe)...

Mixed

White and Black Caribbean ☐

White and Black African ☐

White and Asian ☐

Any other Mixed background (Please describe)...

Asian or Asian British

Indian ☐

Pakistani ☐

Bangladeshi ☐

Any other Asian background (Please describe)

....

Black or Black British

Caribbean ☐

African ☐

Any other Black background (Please describe)...

Chinese or other ethnic group

Chinese ☐

Any other (Please describe)...

Questions about you and your household

6. **Are you male or female?** *Tick one only* Male ☐ Female ☐

7. **What is your age?** *Write in* years ....

8. **How far does your child have to travel to get to school?**

   Tick one only

   Less than one mile ☐

   One mile or more ☐ *Write in number of miles* ....

9. **What is your postcode?** ....

10. **Does your household own or rent its accommodation?**

    Tick one only

    Rents it from the council, a housing association, or a charity ☐

    Rents it from a private landlord or letting agency ☐

    Partly owns it and partly rents it (shared ownership) ☐

    Owns it (including buying with a mortgage) ☐

    Other ☐

11. **How many cars or vans are owned or available for use, by members of your household?**
    Do not include motorcycles, scooters or mopeds.

    Write in number
    If none, write "0" ....

12. Thinking about the work you do, which of these best describes your situation at present?

Please answer for yourself and for your spouse or partner if you have one who lives with you.

	Yourself *Tick one only*	Your spouse/partner *Tick one only*
Doing paid work full time	☐	☐
Doing paid work part time	☐	☐
On a government training scheme	☐	☐
Retired	☐	☐
Full time student	☐	☐
Unemployed	☐	☐
Disabled, invalid or permanently sick	☐	☐
Caring for home and family or dependants	☐	☐
Other	☐	☐
Not living with a spouse or partner	☐	☐

Your Child's Mode of Travel

13. On a normal day, how does your child usually travel TO school?

On foot-------------------- ☐ | By school bus----------- ☐
By public transport------- ☐ | By Car (given a lift)----- ☐
Bicycle--------------------- ☐ | Other.................................

A mixture of .... and ....

14. On a normal day, how does your child usually travel FROM school?

On foot-------------------- ☐ | By school bus----------- ☐
By public transport----- ☐ | By Car (given a lift)----- ☐
Bicycle--------------------- ☐ | Other.................................

A mixture of .... and ....

15. On a normal day, who does your child usually travel TO school with?

An adult--------------------- ☐ | An adult and other children------ ☐
On their own--------------- ☐ | Friends-------------------- ☐
Brother/sister-------------- ☐

16. On a normal day, who does your child usually travel FROM school with?

An adult--------------------- ☐ | An adult and other children------ ☐
On their own--------------- ☐ | Friends-------------------- ☐
Brother/sister-------------- ☐

Walking to School

17. Do you agree or disagree with the following statements:

It is difficult for my child to walk or bike to school (alone or with someone) because…

1. There are too many hills along the way	Agree	Undecided	Disagree
2. There are no pavements or cycle paths	Agree	Undecided	Disagree
3. The route is boring	Agree	Undecided	Disagree
4. The route does not have good lighting	Agree	Undecided	Disagree
5. There is too much traffic along the route	Agree	Undecided	Disagree
6. There is one or more dangerous crossings	Agree	Undecided	Disagree
7. My child gets too hot and sweaty	Agree	Undecided	Disagree
8. No other children walk or bike to school	Agree	Undecided	Disagree
9. It's not considered cool to walk or bike	Agree	Undecided	Disagree
10. My child has too much stuff to carry	Agree	Undecided	Disagree
11. It is easier for me to drive my child to school on the way to something else	Agree	Undecided	Disagree
12. It involves too much planning ahead	Agree	Undecided	Disagree
13. It is unsafe because of crime (strangers, gangs, drugs)	Agree	Undecided	Disagree
14. My child gets bullied, teased, harassed	Agree	Undecided	Disagree
15. There is nowhere to leave a bike safely	Agree	Undecided	Disagree
16. There are stray dogs	Agree	Undecided	Disagree
17. It is too far	Agree	Undecided	Disagree

Only answer question 18 if your child does not walk part or all of the way to school.

18. **What do you feel would encourage your child to walk part, or all of the journey to school?**
Please tick the appropriate responses.

If they were driven some of the way and dropped off within walking distance-- ☐

If they lived closer to the school--------------------------------------- ☐

If they had more time---☐

If they were allowed to-- ☐

If the weather was better-- ☐

If their friends walked--- ☐

If someone from their family walked with them----------------------- ☐

If there was good lighting along the way----------------------------- ☐

If they were less frightened of meeting strangers--------------------- ☐

If they were less frightened of being bullied--------------------------- ☐

If there were more safer places to cross the road--------------------- ☐

If they knew what walking route to take------------------------------ ☐

If there were more lollipop people------------------------------------- ☐

If there was less traffic/ slower traffic---------------------------------- ☐

If cars kept away from the school entrance--------------------------- ☐

If they felt safer--- ☐

Is there anything else that you feel would encourage your child to walk part or all of their journey to school?____

Go to Question 20

Only answer question 19 if your child walks part or all of the way to school.

19. **Which of the following would make walking to and from school better for your child?**
Please tick the most appropriate boxes.

Better weather-- ☐

If their friends walked-------------------------------------- ☐

If they were less frightened of meeting strangers---------- ☐

If they were less frightened of being bullied--------------- ☐

More safer places to cross-------------------------------- ☐

More school lollipop people------------------------------ ☐

Less/ slower traffic--------------------------------------- ☐

Cars kept away from the school entrance----------------- ☐

If one of their parents walked with them------------------ ☐

If their older brother(s) or sister(s) walked with them------ ☐

Nothing, they feel fine about walking to school------------ ☐

Is there anything else that you think would make walking to school better for your child?

____

____

____

20. If your child walked part or all of the way to school on most days, what benefits would there be? *Please tick the most appropriate answers.*

- My child's heart and lungs would be healthier------------------- ☐
- My child would be alert and awake for school------------------ ☐
- My child would be able to talk to his/her friends on the way----- ☐
- My child's body would become healthier----------------------- ☐
- It would be fun--- ☐
- My child would be helping the environment--------------------- ☐
- My child hear and see things that he/she wouldn't usually------ ☐
- My child would save money on fares--------------------------- ☐
- My child would get lots of fresh air----------------------------- ☐
- They would be able to talk to me on the way------------------- ☐
- They would be able to talk to their brother(s) or sister (s) on the way--- ☐

Is there anything else that you feel would benefit your child if he/she walked part or all of the way to school on most days?

____

____

____

Preferred journey to school

21. How would you prefer your child travelled to school?

On foot------------------ ☐
By school bus--------- ☐
By public transport------ ☐
By Car (given a lift)---- ☐
Bicycle------------------ ☐
Other.................................

A mixture of .... and ....

22. Who would you prefer your child to travel to school with?

An adult----------------- ☐
An adult and other----- children ☐
On their own------------ ☐
Friends---------------- ☐
Brother/sister----------- ☐

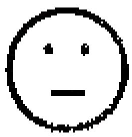
23. How confident are you that your child can…
Please circle the most appropriate response.

(1) Walk to school…………..	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(2) Ask a parent or other adult to walk to school with them…	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(3) Ask a friend to walk to school with them…………….	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(4) Walk to school even if their friends don't walk……..	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(5) Walk to school in bad weather………………………	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(6) Cross difficult roads when walking to school…………….	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident

(7) Cope with busy traffic when walking to school……...	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(8) Walk to school even if there are many cars near the school entrance…………	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(9) Walk to school even if there are not enough lollipop people……………………	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(10) Walk to school even if they are frightened of meeting strangers………	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(11) Walk to school even if they are frightened of being bullied………………………..	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(12) Walk to school even if there is poor lighting……	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(13) Walk to school even if it takes a long time………	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident
(14) Find a route to walk to school………………………..	Very Confident	Quite Confident	Somewhat Confident	Not Particularly Confident	Not at all confident

24. **Looking at the faces scale, which face shows best how you feel about living in your local area?**

Circle only one



Streets in my neighbourhood

Please circle the answer that best applies to the neighborhood where you and your child live.

25. The streets in our neighborhood do not have many cul-de-sacs (dead-end streets).

1	2	3	4
Completely true	somewhat true	somewhat untrue	completely untrue

26. The distance between intersections (where streets cross) in our neighborhood is usually short. (100 yards or less; the length of a football field or less).

1	2	3	4
Completely true	somewhat true	somewhat untrue	completely untrue

27. There are many different routes for getting from place to place in our neighborhood. (My child doesn't have to go the same way every time.)

1	2	3	4
Completely true	somewhat true	somewhat untrue	completely untrue

You're finished!

Thank you for your time and effort.

Please give this questionnaire to your child to take back to school.

Appendix M. Travel diary

Travel Diary

Fill in the table each day when you arrive at school (try to remember what time you arrived home from school the day before).

Monday

What time did you get home?	
How did you get home?	
Did you go anywhere on the way home, or did you go straight home?	

Tuesday

What time did you get home?	
How did you get home?	
Did you go anywhere on the way home, or did you go straight home?	

Wednesday

What time did you get home?	
How did you get home?	
Did you go anywhere on the way home, or did you go straight home?	

Thursday

What time did you get home?	
How did you get home?	
Did you go anywhere on the way home, or did you go straight home?	