ACTIVITY-RELATED PARENTING PRACTICES AND YOUNG PEOPLE'S PHYSICAL ACTIVITY

by

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Abstract

Despite the health benefits associated with regular physical activity only a small percentage of young people are meeting the physical activity recommendations. There is a need to further understanding of the factors that influence physical activity behaviour in young people to inform intervention programmes. This thesis provides six studies focusing on the objective measurement of young people's physical activity as well as social support for physical activity. Chapter 2.1 describes a systematic review of quantitative research examining parental influences on different types and intensities of physical activity in young people. Chapter 2.2 describes a systematic review of qualitative research examining the role of parents in young people's physical activity. Both reviews were conducted to examine the state of the current literature focused on parental influences on young people's physical activity and were used to inform the direction of the research in later chapters. Chapter 3 describes two cross-sectional studies examining the effects of key decisions researchers must make when using accelerometers on accelerometer ouput in children and adolescents. Chapter 3.1 describes a study examining the effect of epoch length on physical activity intensity in children and adolescents. Chapter 3.2 describes a study examining the impact of accelerometer processing decision rules, such as cut-points and non-wear period, on children's and adolescents' physical activity. The purpose of these studies was to systematically explore the pre- and post-data collection decisions associated with accelerometer use on accelerometer output in young people and inform accelerometer use in chapters 4 and 5. Chapter 4 was designed to explore activity-related parenting practices and children's (7-10 years) objectively measured physical activity. Chapter 5 describes a study examining five sources of social support and adolescent's physical activity measured two ways. This thesis demonstrated that parents play in key role in their child's physical activity through a variety of support avenues and in adolescence support for physical activity provided by peers appears to be important in shaping physical activity behaviour. Targeting such facets of the social environment offers a potentially useful avenue for interventions designed to increase physical activity. Finally, this thesis also demonstrated that there are a number of challenges with accelerometer use particularly in the area of processing data. The rich information provided by accelerometers makes them an invaluable tool to understand the complex

nature of young people's physical activity behaviour but further work needs to be conducted on standardising methods for cleaning, analysing and reporting accelerometer data.

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Introduction

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Introduction

In spite of the growing scientific knowledge on the benefits of active lifestyles for health and well-being (95, 258), current data show that many young people are not meeting the national recommendations for physical activity (99). An important prerequisite to designing and implementing physical activity interventions is to understand the factors that influence physical activity. In addressing this issue, this thesis examines the role of immediate significant others, especially parents, on young people's physical activity. The rationale and content of this thesis, and the six studies presented herein, is best understood within the behavioural epidemiology framework.

Behavioural epidemiology is the scientific study of the etiology and distribution of behaviours that affect health and disease (129). More importantly, behavioural epidemiology concerns itself with research that has the explicit purpose of understanding and influencing health behaviours, as part of population-wide initiatives to prevent disease and promote health (202). The behavioural epidemiology framework provides a means of organising the broad spectrum of descriptive, analytical and intervention research, which makes up behavioural epidemiology, and allows for an improved understanding of behaviours and the utilisation of knowledge to favourably influence behaviour and health in the population (202). The behavioural epidemiology framework applied to physical activity and health describes five main research phases and each phase of the framework builds upon the previous phases (Table 1.1).

The framework proposes a five-stage process in which physical activity correlates build on an understanding of the relationship between physical activity and health and the measurement of physical activity. Correlates then inform the development of interventions, the results of which are translated into action (28). It has become increasingly evident that the development and refinement of physical activity assessment techniques are critical for the continued advancement of the field (121, 260). Within the behavioural epidemiology framework it is clear why the development of valid and reliable measures of physical activity is an important research priority. Accurate assessment tools (Phase II) helps us better understand the correlates of

physical activity (Phase III), which in turns helps us to focus our intervention efforts on factors most likely to bring about behaviour change (Phase IV). There is also the possibility for reverse sequencing in the research phases. For example, as more valid and reliable measures of physical activity are developed, we are able to better clarify relationships between physical activity and health (Phase I) (129).

Table 1.1 The behavioural epidemiology framework applied to physical activity (201)

Phase	Purpose
I	Establish links between physical activity and health
II	Develop methods for accurately assessing physical activity
III	Identify factors that influence levels of physical activity
IV	Evaluate interventions to increase physical activity
V	Translate research into practice

This thesis provides original research focusing on the measurement of physical activity (Phase II) and research identifying important correlates of physical activity (Phase III). Whilst none of the studies presented here focus on clarifying the relationships between physical activity and health (Phase I), the evidence will be briefly described in the section that follows and it provides the underlying motivation for the studies presented in this thesis.

1.1 Physical Activity and Health in Young People

Regular participation in physical activity has long been recognised as essential to normal development in children (5), and in recent years, promotion of physical activity in children and adolescents has become a recognised goal of public health authorities (60, 61, 250). The case for promoting physical activity in young people is underpinned by the recognition that physical activity can provide immediate and long term health effects. It was suggested by Blair et al. (29) that there are three compelling reasons why

we should encourage young people to take part in regular physical activity: (a) to promote physical health and well-being during childhood and adolescence; (b) to modify disease risk factors in order to minimise future degenerative diseases; and (c) to develop active lifestyles at an early stage of life in order that it might be continued into adult life. The evidence underpinning these three reasons will be briefly presented in the following sections.

1.1.1 Physical health and well-being during childhood and adolescence

Cross-sectional studies have demonstrated an inverse association between physical activity levels and markers for adiposity, such as BMI (196, 227) however, these associations are often weak. Longitudinal studies, while still observational in nature, provide stronger evidence of cause and effect than cross-sectional studies. A longitudinal study demonstrated that a pronounced decline in physical activity during the transition from childhood to young adulthood was associated with an increase in BMI and sum of skinfolds (116).

The increased prevalence of obesity in children and adolescents is linked with the increasing prevalence of type 2 diabetes in young people (175). High levels of physical activity are inversely related to insulin resistance (112) and positively associated with insulin sensitivity (107). Furthermore, a longitudinal study demonstrated that reductions in physical activity between ages 9 and 15 were associated with higher fasting insulin levels (109). These findings suggest that regular physical activity could make a contribution to the prevention of type 2 diabetes in children and adolescents.

Childhood and adolescence is a crucial period for bone development and cross-sectional and intervention studies provide strong evidence that physical activity is effective in enhancing bone health in children and adolescents (127, 141, 261).

The strongest effects for health during childhood are for indices of psychological well-being. For example, higher levels of physical activity have been associated with positive psychological well-being in youth (166), better cognitive function (212) and self-esteem (72). A recent longitudinal study demonstrated that higher physical activity at age 9 and 11 predicted higher self-esteem at ages 11 and 13 years (209). Furthermore, physical activity can assist in the social development of young people by providing opportunities

for self-expression, building self-confidence, social interaction and integration (269). It has also been suggested that physically active young people more readily adopt other healthy behaviours (e.g., avoidance of tobacco, alcohol and drug use) (269). In summary, evidence indicates that regular physical activity is associated with improvements in various physical and psychological health parameters in young people. However, much of the evidence is based on observational research and effects are smaller in magnitude than those observed in adults.

1.1.2 Modify disease risk factors in order to minimise future degenerative diseases

Although cardiovascular disease (CVD) becomes evident in middle-age and beyond, the development of the disease begins in childhood and adolescence (137). Moreover, risk factors (e.g., elevated blood pressure and blood lipids) for cardiovascular disease track from childhood into adulthood (158). Most studies have examined the relationship between physical activity and risk factors for CVD rather than disease endpoints in young people, which is a limitation as risk factors are not always predictive of disease endpoints (222). Nevertheless studies of physical activity and CVD risk in young people are important in identifying the strength and direction of any likely association. A number of cross-sectional studies have observed an association between low levels of physical activity and elevations in risk factors for CVD (e.g., 195, 221). A recent study examining clustering of cardiovascular disease risk factors (blood pressure, triglyceride concentration, total cholesterol/high-density lipoprotein cholesterol ratio, insulin resistance and sum of four skinfolds) provided evidence of an inverse association between physical activity and clustering of cardiovascular risk factors that was independent of the degree of adiposity (7). These results suggest that physical activity in childhood may ameliorate the development of CVD.

There is some evidence that exercise-induced gains in bone mass in children are maintained into adulthood, suggesting that physical activity habits during childhood may have long-lasting benefits on bone health (119). Furthermore, in a recent review, it was concluded that adolescent physical activity may reduce fracture risk in later life, even if activity levels are reduced in adulthood (111). It has also been demonstrated that physical activity in adolescence decreases the risk of breast cancer (161). Decline in physical activity from childhood to adulthood has been associated with obesity and insulin resistance in adulthood (69).

1.1.3 Develop active lifestyles at an early stage of life in order that it might be continued into adult life

The persistence of a behaviour, or attribute, over time is called 'tracking' and refers to the maintenance of a rank order position over time in relation to one's peers (34). In reference to physical activity, 'tracking' is the notion that physical activity during childhood increases the likelihood of physical activity participation as an adult. Research has suggested that physical activity levels during childhood and adolescence are an important contributing factor to adult physical activity levels. For example, Telama et al. (230) concluded that a high level of physical activity at ages 9 to 18 significantly predicted a high level of adult physical activity. However, the magnitude of this association was low to moderate (95, 230). This finding is not surprising given that physical activity during adulthood is influenced by numerous personal, demographic, environmental and psycho-social variables (241). It has also been suggested in a number of studies that physical inactivity tracks more strongly into adulthood (87, 181) than physical activity. In summary, given that physical activity habits developed early in life may contribute to adulthood levels (230), regular participation in physical activity during childhood and adolescence may be of critical importance in the prevention of chronic disease later in life.

1.2 Physical Activity Recommendations and Youth Physical Activity Participation

Informed by the evidence described in the previous sections and expert opinion, government policy documents outline the quantity of physical activity required to benefit health specific to young people (60). Experts from the UK suggest that young people should achieve a total of at least 60 minutes of moderate intensity physical activity each day, and at least twice a week this should include activities to improve bone health, muscle strength and flexibility (60). Despite the health benefits of physical activity outlined in section 1.1, survey data indicate that many UK children and adolescents do not meet these physical activity recommendations. For example, self-reported data from the most recent Health Survey for England (99) suggests that only 32% of boys and 24% of girls achieved the recommended levels of physical activity. Figure 1.1 shows the proportions of children meeting government recommendations for physical activity, by sex and age. Among girls the proportion meeting the government recommendations generally decreased with age, ranging from 35% among girls aged 2 to 12% among those aged 14. Among boys however, no consistent pattern was found

according to age. It is important to note however, that although age differences are clearly evident these are cross-sectional findings and do not demonstrate change over time. Similar low participation rates have been observed using surveys in other countries (44, 62).

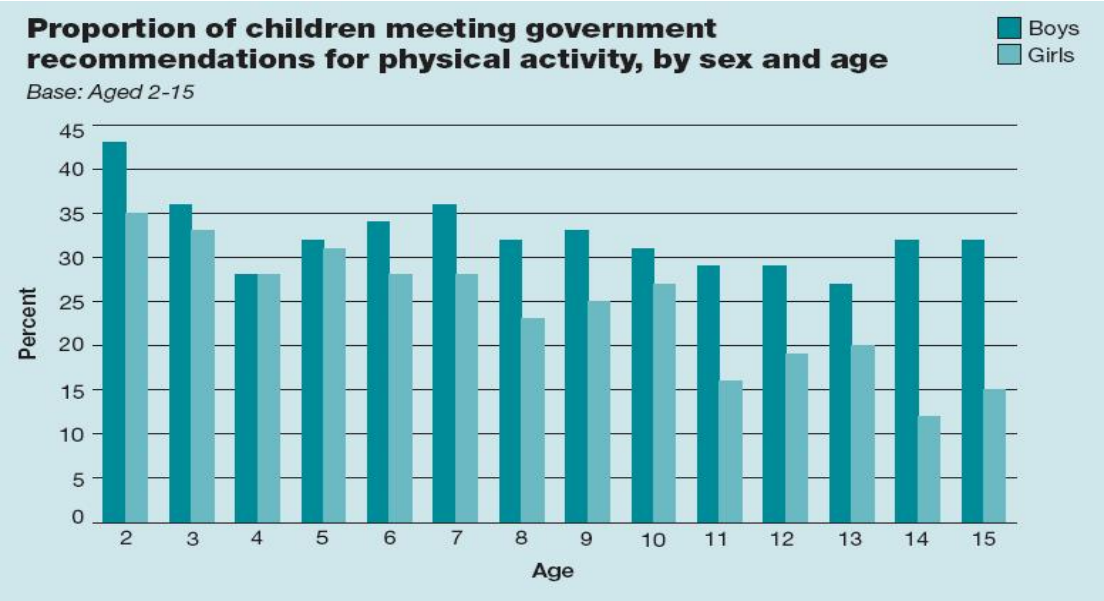

Figure 1.1 Proportions of children and adolescents meeting the government recommendations for physical activity, by sex and age, according to self-report (99).

These findings are lower than those reported in earlier Health Surveys of England. For example, HSE 2007 (98) suggested that 72% of boys and 63% of girls did at least one hour of physical activity every day of the week. The substantial decrease in these levels from 2007 to 2008 is a reflection of the questions asked and not of an actual decrease in the levels of physical activity among children. For example, in the new survey young people are asked on which specific days of the week they had participated in activities and for how long they had done the activities, in hours and minutes, rather than giving an average for all days using half hour bands like in previous surveys. Although these improvements to the 2008 survey lead to more refined estimates of child physical activity and the new instrument appeared to have good convergent and face validity, it was limited by the exclusion of activities during schools hours, and the assumption that all reported activities were of at least a moderate intensity. Both of these limitations will have impacted on estimations of time spent being active.

During the 2008 HSE objectively measured physical activity was also obtained from a small sample (n = 238) of the children involved. Results demonstrated very close estimates to self-reported data with 33% of boys and 21% of girls meeting the recommendations. There was considerable variation by age. For boys, 51% of those aged 4-10 years had met the government recommendations, but only 7% of boys aged 11-15 years had met these recommendations. For girls the pattern was similar, although fewer met the recommendations in either age group with no 11-15 year old girls meeting the recommendations (Table 1.2).

Table 1.2 Proportions of children and adolescents meeting the government recommendations for physical activity, by sex and age, according to objective measurement (99).

Objective summary activity levels, by age and sex

Aged 4-15 with 7 days' valid accelerometry data — *2008*

Objective summary activity level[a]	Age group		Total
	4-10	11-15	
	%	%	%
Boys			
Meets recommendations	51	7	33
Some activity	22	18	20
Low activity	28	75	47
Girls			
Meets recommendations	34	-	21
Some activity	28	4	18
Low activity	39	96	61

Another larger cross-sectional study in England employing accelerometry to measure physical activity levels, also demonstrated low percentages of children (aged 11 years) meeting the recommendations (188). It was observed that only 2.5% of children (5.1% for boys and 0.4% for girls) met the recommendations for physical activity. Despite the advantages of measuring physical activity with accelerometry, accelerometers are not

without limitations. Accelerometers are unable to measure common activities such as cycling, swimming, carrying heavy loads or walking up stairs. Furthermore, the studies mentioned (99, 188) captured physical activity in one minute epochs which have been shown to obscure short bursts of moderate-to-vigorous physical activity (MVPA) that are often exhibited by children (15, 26). The use of accelerometers to measure physical activity in young people is discussed in more detail in Chapter 3.

Regardless of the method used to assess physical activity levels (self-report or objective), the literature is fairly consistent in suggesting that physical activity levels are lower than desirable in children and adolescents. Furthermore, the percentage of youth meeting the recommendations declines precipitously with age (78, 87). A decline in physical activity has not only been demonstrated from childhood to adulthood but even in the short time from childhood to adolescence (36, 154). For example, a recent longitudinal study demonstrated that at age 9 years, children engaged in MVPA approximately 3 hours per day but by age 15 years, adolescents were only engaging in MVPA for 49 minutes per day (Figure 1.2) (154).

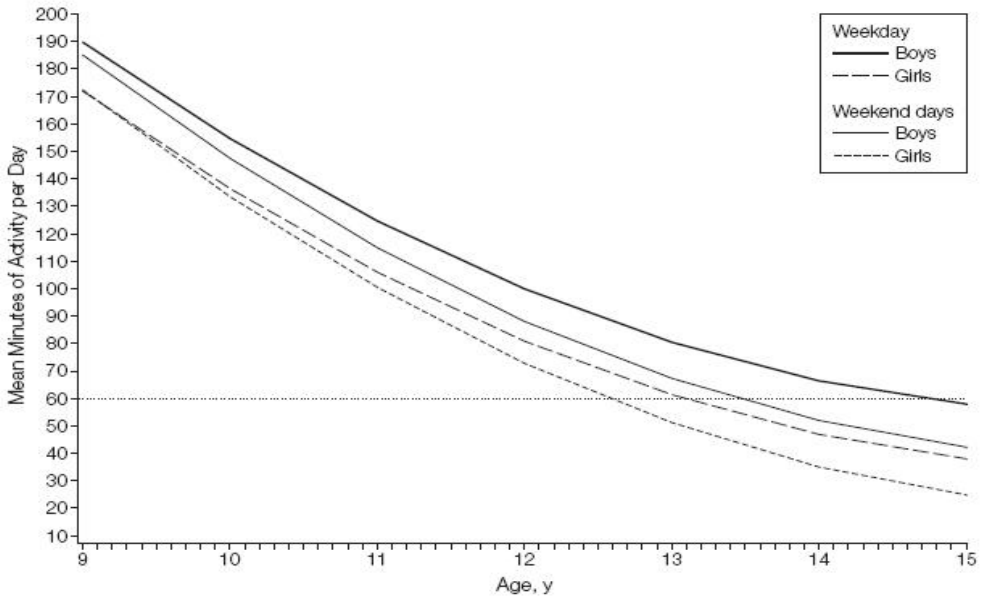

Figure 1.2 Decline in average weekday and weekend minutes of MVPA by sex (154)

1.3 Correlates of Physical Activity in Young People

The health benefits associated with regular physical activity, the large proportion of young people who are not meeting the recommended guidelines, and the declines in

physical activity during childhood to adolescence and further from adolescence to adulthood as described in the previous sections, underscore the need for physical activity intervention programmes for children and adolescents. The behavioural epidemiology framework proposes that before interventions are planned, the key variables that are correlated with physical activity need to be identified. This is because physical activity is not changed by the intervention per se, but by a change in some personal, social or environmental variables – that is, a change in a 'correlate'. The term 'correlates' reflects the factors that affect, or are thought to affect, participation in physical activity (28). Correlates may vary in the degree to which they can be modified and thus whether they act primarily as a moderator or mediator. Mediators can be defined as 'intervening causal variables that are necessary to complete a cause-effect pathway between an intervention and physical activity' (22, p.5). For example, if increasing parent support for children's physical activity brings about increases in physical activity, parent support is acting as a mediator of behaviour change. By examining several potential mediators, researchers may learn which mediators are most effective for increasing physical activity, which in turn may lead to more effective interventions. In the case of physical activity interventions, a mediator is a variable in the causal path that is specifically targeted to help promote changes in physical activity (262). Sometimes the strength of the relationship between a programme and outcome varies according to a third variable. This third variable is known as a moderator (22). For example, the effects of a programme may be much greater for boys than for girls, therefore gender is acting as a moderating variable. Therefore, moderators can identify target groups in interventions. Referring back to the behavioural epidemiology framework, having identified correlates of physical activity (phase III), these might be used as moderators or mediators in physical activity behaviour change interventions (IV).

Physical activity however, is a complex behaviour influenced by multiple correlates within the physical environment, social/cultural, and psychological/cognitive domains (16, 205). Of particular interest within the social/cultural domain is the role of social support as a correlate for physical activity in children and adolescents. Social support for physical activity is a key process that might promote and facilitate physical activity among children and adolescents (51).

1.4 Social Support and the Family

Social support has been defined in numerous ways, but generally refers to any behaviour that assists an individual in achieving desired goals or outcomes (41, 228). Social support is categorised along four direct supportive behaviours (Figure 1.3). According to Heaney and Israel (100) emotional support involves the provision of empathy, love, trust, and caring. Instrumental support involves the provision of tangible aid and services which directly assist a person in need. Informational support is to provide advice, suggestions, and information which a person can use in addressing problems. Appraisal support includes providing information which is useful for self-evaluation purposes, that is, constructive feedback, affirmation, and social comparison. In addition to direct forms of support, Bandura (13) describes a fifth less direct influence termed modelling whereby people learn from watching others.

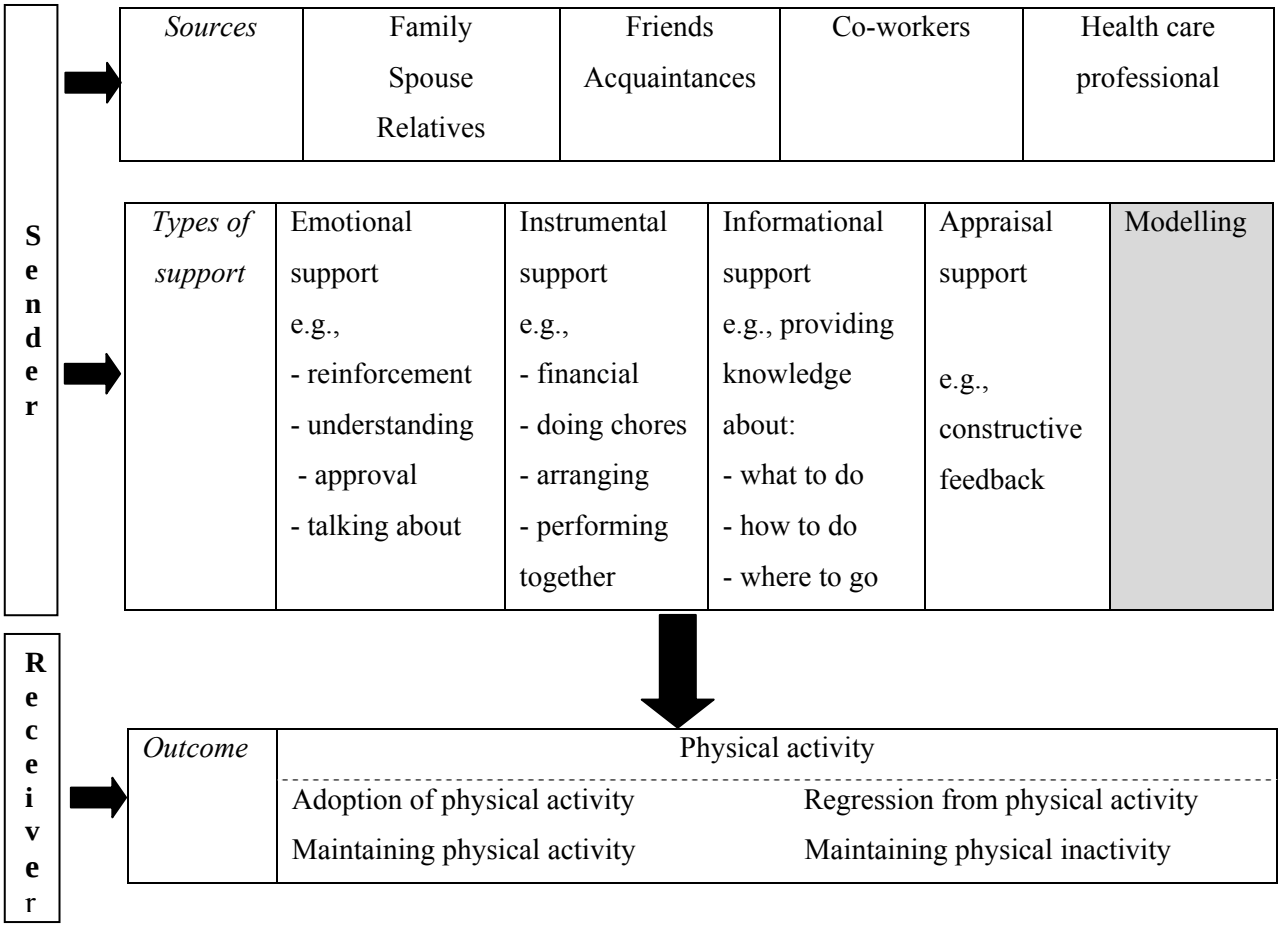

Figure 1.3 Social support in the context of physical activity behaviour (232)

There are multiple systems (sources) of social support that young people may be exposed to but the family is considered to be a major component of young people's

social and environmental contexts (231). The family is the child's most proximal environment and is expected to have the greatest influence on behaviour in childhood (126). Families teach skills and inculcate beliefs that can help shape important attitudes and behaviours associated with participation in physical activity. Children typically remain within the family unit for 18 years or more and during this time families can help develop appropriate attitudes in children so they will remain physically active for a lifetime (136). Within the family, parents are important teachers and social referents for children throughout childhood and adolescence (97). Kuczynski and Grusex (120) have argued that parents are the most important agents of socialisation for a number of reasons: (1) socialisation is a biosocial system set up to favour the parent's primary influence on the child; (2) society designates parents as primarily responsible for socialisation; (3) parents have greater time and opportunity to develop relationships with children, with these relationships essential for successful socialisation; and (4) parents also have greater opportunity to monitor their children's actions, another centrally important aspect of successful socialisation. In childhood therefore, parents may exert considerable influence over physical activity in numerous ways such as being physically active themselves (modelling), encouraging physical activity (emotional support), providing transport to places where their child can be active and financial assistance for equipment or clubs (instrumental support).

However, as children age they tend to become more independent of their parents, and spend increasing amounts of time with friends thus enhancing the potential for peer influence over their behaviour (146). Peers are assumed to be individuals who are at or near the same age as the target(s) of study (216). Researchers agree that the behavioural choices adolescents make are determined in part by how acceptable those behaviours are among their peers (77). For example, the peer group influence on physical activity participation could conceivably function in a number of ways: (1) adolescents mutually influence each other into starting physical activity; (2) an adolescent may engage in physical activity because his or her best friend is already active; (3) friendships are established between adolescents who are already engaged in physical activity (4) adolescents provide emotional support such as encouragement to be physically active; and (5) adolescents provide instrumental support such as sharing equipment or transportation.

Over the course of childhood and adolescence therefore, parents and peers may exert considerable influence over the health-enhancing and health-compromising behaviours youth exhibit (172, 203). Parents and peers, therefore, are aptly identified as the primary socialising agents for the health behaviours of youth (25). The conceptual framework for specifically studying social support provided by parents and peers and involvement in physical activity includes tenants from the social cognitive theory (SCT).

1.5 Social Cognitive Theory

SCT (14) is frequently used as an organising framework for understanding physical activity (134). SCT, unlike other commonly used and known health behaviour theories, operates at the interpersonal level. The SCT defines human behaviour as a triadic, dynamic, and reciprocal interaction of personal factors, behaviour, and the environment (Figure 1.4). According to this theory, an individual's behaviour is uniquely determined by each of these three factors. The personal factors are the individual's capability to perform a given behaviour, to anticipate the outcome of behaviour, to learn by observing others, to have confidence in performing a behaviour, to self-determine or self-regulate behaviour and to reflect and analyse experience. The concept of 'environment' in the social cognitive theory means both the objective factors that are physically external to the person in the social and physical environment that can affect a person's behaviour. Examples of the social environment include family members and peers.

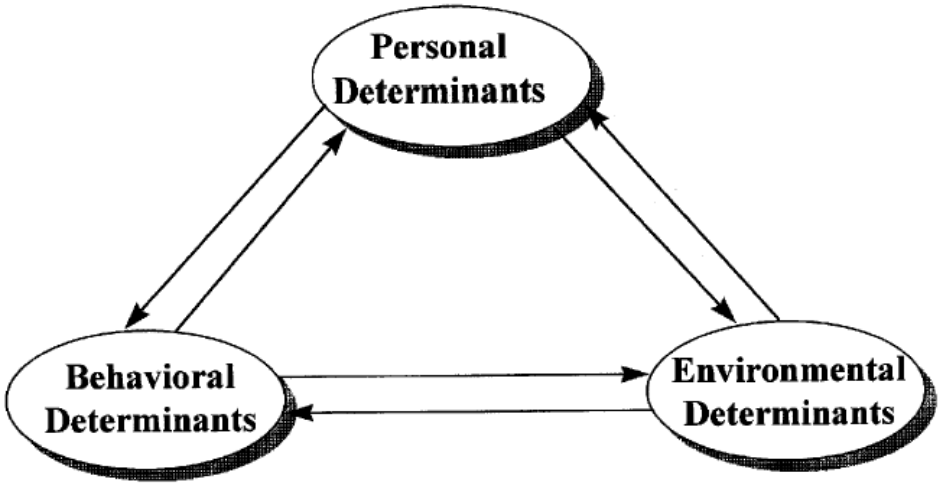

Figure 1.4 Overview of the Social Cognitive Theory

Bandura's ideas stemmed from social learning theory traditions, and therefore social reinforcement (e.g., encouragement and praise) is an important feature of his perspective. Constructs such as parent and peer support for physical activity offer a basic representation of reinforcement that is commonly employed in youth physical activity (217). The social environment is also important in SCT because it provides models for behaviour. A person can learn from other people (e.g., family, friends) not only by receiving reinforcements from them but also through observing them (modelling). This is a process whereby visual or verbal information contained in the actions of others is perceived, stored as a cognitive representation in memory, and then converted to one's own thoughts, feeling and actions (14). This process accounts for why people in the same family often have common behavioural patterns (18). The level of physical activity of parents or friends for example, often perceived by the young research participant, is a customary representation of parent or peer modelling. Overall, social cognitive theory has been significant in helping researchers conceptualise ways in which parents and peers can influence young people's lives because it draws attention to social agents as models of behaviours and sources of reinforcement (217).

1.6 Measurement Issues in Correlates Research in Young People

Although significant progress has been made in correlates research in recent years, it has still proven difficult to accurately predict physical activity behaviours (262). Psychometric work is needed to improve the specificity with which various psychological, social, or environmental constructs are assessed (262). Furthermore, additional work is needed to standardise the way physical activity is assessed because if the assessment of physical activity is weak, then it becomes more difficult to predict physical activity to any appreciable extent (262).

Physical activity is an exceedingly complex behaviour characterised by multiple dimensions and domains and this complexity presents significant challenges to measurement. Valid and reliable measures of physical activity are a necessity in studies designed to (a) document the frequency and distribution of physical activity in defined population groups, (b) determine the amount or dose of physical activity required to influence specific health parameters (Phase I of the behavioural epidemiology framework), (c) identify the psychosocial and environmental factors that influence physical activity behaviour in youth (Phase III) and (d) evaluate the efficacy or

effectiveness of programmes to increase habitual physical activity in youth (Phase IV) (118, 238).

To date, a wide variety of methods have been used to measure physical activity in children and adolescents. These include subjective methods such as self-report questionnaires, activity logs, diaries and interviews, as well as objective methods such as direct observation, heart rate monitoring, doubly-labelled water, accelerometers, and pedometers. For reasons of feasibility and cost the most frequently used method in previous correlates studies have been self-report methods (79, 205). One distinct advantage of self-report methods is that they provide information on the type and context of physical activity. However, self-report methods are subject to recall limitations, misinterpretation, and are inconsistent in reliability and validity (167). The utility of these instruments is especially problematic in children under 10 years of age (201) because of cognitive limitations which mean children younger than 10 cannot recall activities accurately and are unable to quantify the time frame of activity (17, 96) and because children's activity patterns tend to be sporadic in terms of intensity and duration (15, 26). In addition, younger children may not fully understand the concept of physical activity (239). Importantly, imprecision and/or inaccuracy in the measurement of physical activity behaviour can severely attenuate or even obscure its relationship to a given determinant variable (245).

The limitations associated with self-report methods support the notion that objective measures of physical activity such as accelerometers may be more appropriate in primary school-aged children (239). Accelerometers measure the acceleration and deceleration of body movement and provide a direct assessment of the frequency, intensity and duration of physical activity (263) and have been shown to be valid and reliable for use with both children and adolescents (180, 248). These devices are small in size, lightweight, relatively inexpensive in comparison to other objective measures and are minimally intrusive to normal subject movements during daily activities (240). Furthermore, they are designed with large memory storage so that several days or weeks of continuous activity, depending on the epoch length chosen, can be recorded and stored.

Although accelerometers have the potential to overcome many of the limitations associated with self-report methods, there are a number of challenges with accelerometer use particularly in the area of processing data. As Trost and colleagues suggested (240), using accelerometers in field-based research is not a 'plug and play' proposition. Very rich data can be obtained from an accelerometer, but making the most of this tool requires a thorough understanding of the relevant literature to enable careful planning of the research design, data analysis, and interpretation. This thesis considers the issues surrounding processing accelerometer data in order to most effectively examine social support and its relationship to young people's physical activity.

1.7 Overview of Thesis

This thesis was designed to further the understanding of the role of social support in children's and adolescents' physical activity in order to facilitate behaviour change. This thesis contains six studies, detailing original research (Figure 1.5).

Chapter 2 of the thesis describes two systematic reviews of literature. Systematic reviews are an essential component of evidence-based practice because they synthesize knowledge and speed the translation into practice (140). Chapter 2.1 describes a systematic review of quantitative research examining parental influences on different types and intensities of physical activity in youth[1]. It had been noted in several previous reviews that the correlates of different types and intensities of physical activity may be different, yet extant reviews have failed to make this distinction. Therefore, this systematic review updated existing reviews and addressed this important gap in the literature. Chapter 2.2 describes a systematic review of qualitative research investigating the role of parents in young people's physical activity[2]. In recent years there has been an increase in the number of qualitative studies aimed at providing a deeper understanding of how parents influence young people's physical activity, however extant reviews have typically disregarded qualitative evidence. Therefore, it was important to systematically identify and synthesise this qualitative literature in the expectation that it would provide a richness of detail and different perspective than that found within quantitative research.

[1] Findings from this chapter have been accepted for publication. Edwardson, C.L. & Gorely, T (in press). Parental influences on different types and intensities of physical activity in youth: A systematic review. *Psychology of Sport and Exercise.*

[2] Currently under review with *Psychology of Sport and Exercise.*

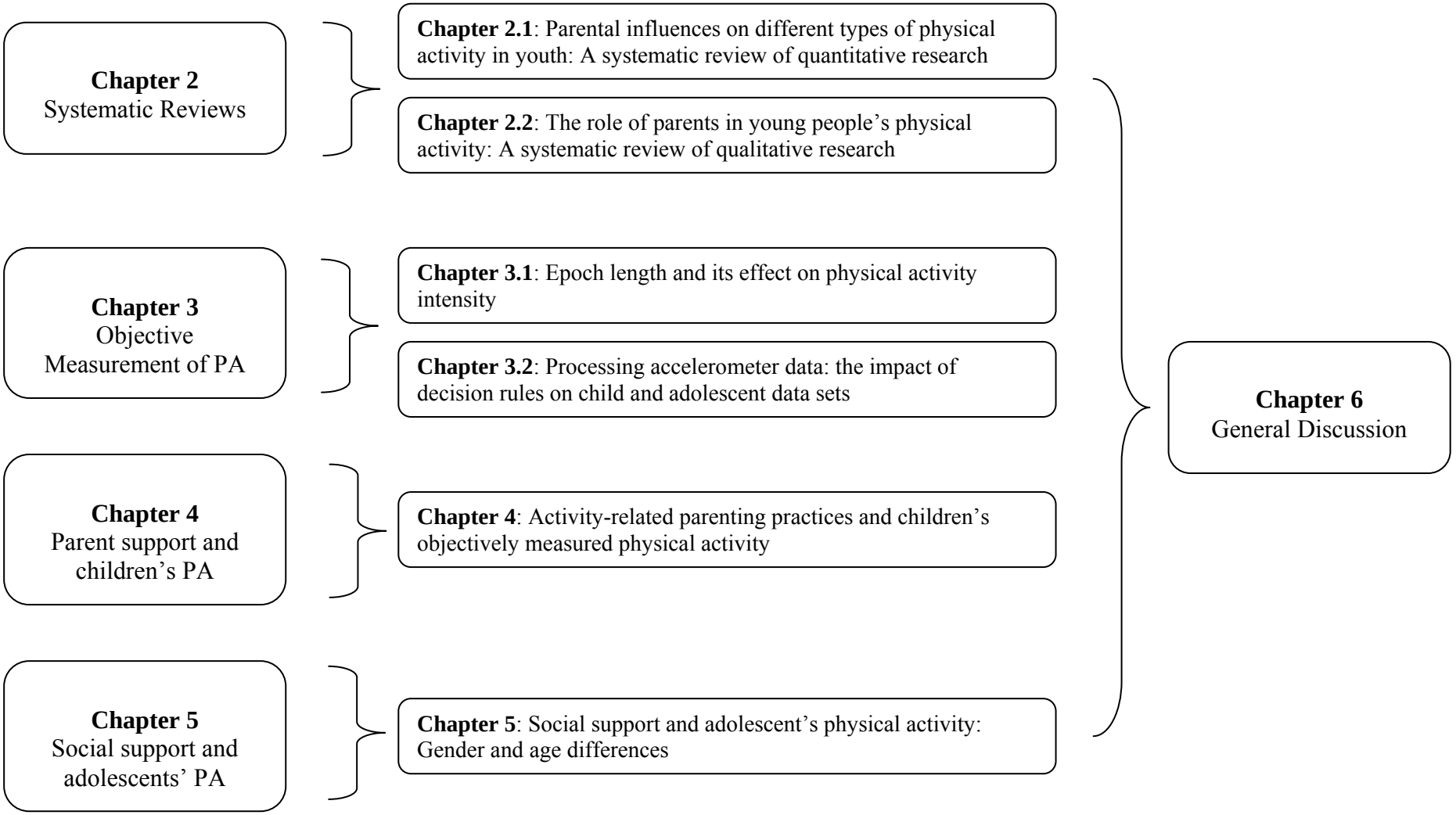

Figure 1.5 Illustration of the thesis structure

To avoid the limitations associated with self-reported physical activity, an accelerometer was chosen as the method to assess physical activity in both children and adolescents throughout this thesis. However, researchers have a number of decisions to make regarding how long they want to monitor physical activity, how frequently they want to collect data (epoch length), the number of hours that constitute a valid day, defining non-wearing time, deciding on the minimum number of days to be used in the analysis and extracting moderate-to-vigorous physical activity by applying cut-points to the data. The impact of these decisions on accelerometer output has not been widely explored in children and no studies had been conducted on an adolescent sample. Chapter 3 investigates the effects of key decisions researchers must make when using accelerometers on accelerometer output in children and adolescents. Chapter 3.1 describes a study examining the effect of epoch length on physical activity intensity in children and adolescents[3]. It can be argued that selecting the most appropriate epoch length is the first critical decision researchers have to make. Chapter 3.2 describes a study examining the impact of accelerometer processing decision rules, such as cut-points and non-wear period, on children's and adolescents' physical activity. The purpose of these studies was to systematically explore the pre- and post-data collection decisions associated with accelerometer use on accelerometer output in young people and inform the studies described in chapters 4 and 5.

Chapter 4 describes a study examining activity-related parenting practices and children's (7-10 years) objectively measured physical activity[4]. The majority of studies examining parental influence and children's physical activity have been conducted in the USA, assessed parent support using single item questions and measured physical activity using self-report methods. Furthermore, although previous research suggests that parents may play an important role in their children's physical activity, the ways in which mothers and fathers differ in their provision of support for physical activity is relatively unexplored. Therefore, there was a need for further investigation of multi-dimensional parent support and objectively measured physical activity in a UK sample of children. The purpose of this study was to explore gender differences in activity

[3] Findings from this chapter have been accepted for publication. Edwardson, C.L. & Gorely, T (in press). Epoch length and its effect on physical activity intensity. *Medicine and Science in Sports and Exercise*.
[4] Findings from this chapter have been published. Edwardson, C.L. & Gorely, T (2010). Activity-related parenting practices and children's objectively measured physical activity. *Pediatric Exercise Science*, 22, 105-113.

support, differences in mothers and fathers provision of support, differences in activity support for low and high physical activity groups and finally to determine whether boys and girls disproportionately fell into low and high activity groups as a function of their parents' overall support (no parent/one parent/both parents providing support) of their activity.

Chapter 5 describes a study examining social support and adolescents' physical activity. Previous research has predominantly focused on parents and peers with little consideration for the influence of siblings and the family unit as a whole. Furthermore, the relative importance of significant others at different stages of adolescence is not clear. The purpose of this study was to examine age (younger versus older adolescents) and gender differences in five sources of social support (family, mother, father, siblings and peers). A secondary aim was to examine the association between sources of social support and adolescent physical activity measured two ways (self-report and objective)[5].

This thesis, and the studies presented herein, are the original work of the author and have been disseminated through presentations and peer-reviewed publications.

1.8 Aims of Thesis

The aims of this thesis were as follows:

- To review both quantitative and qualitative research examining parental influences on children's and adolescents' physical activity.
- To investigate pre- and post-data collection decisions associated with accelerometer use on accelerometer output in children and adolescents.
- To explore mothers and fathers activity-related support in a sample of children.
- To examine mothers' and fathers' activity-related support and its effect on objectively measured physical activity using a sample of children.
- To examine age and gender differences in five sources of social support in adolescents.
- To examine the relationship between adolescent social support and physical activity measured two ways (self-reported and objective).

[5] Preliminary findings from this chapter were presented in poster form at the 8th Annual Conference of the International Society for Behavioural Nutrition and Physical Activity (ISBNPA), in Cascais, June 2009.

Chapter 2

Parental influences on physical activity in youth: Two systematic reviews

This chapter describes two systematic reviews of literature. Chapter 2.1 describes a systematic review of quantitative research examining parental influences on different types and intensities of physical activity in youth. Chapter 2.2 describes a systematic review of qualitative research investigating the role of parents in young people's physical activity. Early findings from Chapter 2.1 have been presented (poster) at the postgraduate presentation evening, Loughborough University, 15th February 2008. Findings from Chapter 2.1 have been accepted for publication in *Psychology of Sport and Exercise* (Edwardson, C.L. and Gorely, T., in press). Findings from Chapter 2.2 are currently under review in *Psychology of Sport and Exercise.*

Chapter 2.1

2.1 Parental Influences on Different Types and Intensities of Physical Activity in Youth: A Systematic Review of Quantitative Literature

Introduction

The family has been considered an important agent of socialisation as children spend the majority of their time within the context of the family during the formative years (122). Families teach skills and inculcate beliefs that can help to shape important attitudes and behaviours associated with physical activity (136). More specifically, parents may exert significant social influence over their child's physical activity through a variety of mechanisms which include parental encouragement, beliefs and attitudes towards physical activity, role modelling, involvement and facilitation such as transport and fee paying.

Considering the potential influence that parents may have on their child's physical activity, a comprehensive understanding and synthesis of the evidence of how parents influence their child's physical activity is needed. This will inform family-based intervention programmes to enable them to be designed in the most effective way to increase children's and adolescents' physical activity and also to identify any areas for future research.

Several authors (79, 93, 179, 205) have reviewed research on parental correlates of young people's physical activity. The main limitation with all previous reviews has been the grouping together of all types and intensities of physical activity regardless of what physical activity the individual studies actually measured. Ferreira et al. (79) noted this as a limitation of their review stating that this did not enable them to determine the specific environmental correlates of specific physical activities. Furthermore, in a recent review of reviews (157) it was noted that it would be helpful from the point of view of public health policy to be able to identify the correlates of different types of physical activity and reviews to date have made little distinction between types and intensities of activities. Young people's physical activity may take place in different contexts, for example, they may participate in organised physical activity or in games, play and other

recreational activities in their leisure time which are performed in formal and informal settings. The relative importance of correlates of young people's physical activity in these contexts may vary dependent on characteristics of the activities taking place (253). For example, organised physical activity may require more parental support in the form of transport and enrolment than leisure time physical activity. Thus, to further the understanding in this area it is important to examine whether parental influence varies depending on the type or intensity of physical activity examined. In addition, a predominant focus in previous reviews has been on cross-sectional data which is limited by data being collected at a single time point. It is therefore important to examine longitudinal data as they can clarify temporal relationships between correlates and physical activity and also assess the long-term relationship between parental influences and young people's physical activity. This present systematic review aims to investigate how parental influence relates to different types and intensities of physical activity by synthesising cross-sectional and longitudinal research.

Method

Search

Potentially relevant studies were located by searching electronic databases for primary and review articles. The following databases were searched: SportDiscus, Article First, Web of Science, Zetoc, Applied Social Sciences Index, MedLine, Biological Sciences, ERIC, PsycINFO, Sociological Abstracts and Physical Education Index. Searches were also conducted using Google Scholar and Science Direct. All databases were searched using combinations of the following keywords: physical activity, exercise, children, adolescents, parents, parental influence, modelling, support, encouragement, beliefs, attitudes, transport, correlates, determinants. The title and abstract of these identified articles were then screened for relevance against the inclusion criteria. If abstracts were not available or unable to provide sufficient information, the entire article was retrieved and screened to determine whether it met all of the inclusion criteria. The reference lists of the identified studies were then screened for any additional relevant articles.

Inclusion and Exclusion Criteria

In order to be included studies had to meet the following criteria: (1) include children (aged 6-11 years old or a mean age within these boundaries) or adolescents (aged 12-18 years old or a mean age within these boundaries); (2) have a measure of children's or

adolescent's physical activity; (3) measure at least one of the following potential correlates of physical activity: parents' physical activity, parental support, encouragement, beliefs and attitudes towards physical activity or parental facilitation (e.g., fee paying or transport); and (4) be published in peer reviewed journals in the English language. Studies involving preschool children, participants crossing the age brackets for children and adolescents, and studies focused solely on obese participants were excluded. Also excluded, were studies measuring individual competitive sports such as hockey as the outcome measure and measuring global family or social influences (i.e., including parents, siblings and other adults as a whole unit), therefore not specifically measuring parental influence. The census data for inclusion was September 2009.

Data Extraction

Data from the included studies were independently extracted onto a standardized form developed for this review. The following data were extracted: author, date and country of the study, study design, characteristics of participants (sample size, age, sex), measures/instruments, type of physical activity and parental influence and study outcomes.

Cross-sectional Studies: Analysis

Analysis of the cross-sectional studies followed the descriptive, semiquantitative review protocol outlined in Sallis et al. (205). Studies that found significant associations between parental influence and physical activity were entered into the 'related to physical activity' column and the directions of the associations were coded as '+' for positive associations or '-' for inverse associations. Studies finding no significant associations were entered into the 'unrelated to physical activity' column. Parental correlates reported in three or more samples are displayed in the summary tables (see Tables 2.3-2.6). A variety of statistical techniques were used within the identified papers to evaluate the associations between children's and adolescents' physical activity and parental correlates however, wherever possible only univariate associations were reported for consistency across studies.

An independent sample was used as the unit of analysis. If analyses were conducted separately for boys and girls, 'B' or 'G' is indicated and for mothers and fathers, 'M' or

'F' is indicated. The column 'number of samples' displays the number of samples that have been studied for each identified correlate. The 'summary' column contains the number of samples finding positive (+), inverse (-) and no (0) associations for each parental correlate. Based on the percent of findings supporting the association, the variable was coded as no association (0-33%), indeterminate (34-59%) and positive or negative association (60-100%) (205).

Longitudinal Studies: Analysis

A data table was constructed that summarised the state of the literature for parental influences and physical activity (see Table 2.7). Due to the limited number of longitudinal studies a short narrative summary of the data is provided in the results section under each physical activity type or intensity.

Results

General Findings

We identified a total of 96 published studies that met the inclusion criteria. Of these 36 focused on children, 55 on adolescents and 5 provided data on both children and adolescents. The results of the review are presented in two separate categories – child samples and adolescent samples and separated further by physical activity type or intensity within these two categories.

Characteristics of Child Studies

The 41 studies identified presented data on 65 independent samples (see Table 2.1). Independent sample sizes ranged from 29 to 3114, with a median of 109 and only 7.7% had a sample greater than 1000. Most studies employed a cross sectional design (81.5%) and were conducted in the USA (70.8%). A self report measure by the child only was used in 52.3% of the studies, with 35.4% employing an objective measure of physical activity.

Parental Influences on Children's Physical Activity

Twelve types of parental variables and seven types or intensities of physical activity (see Table 2.2 for definitions) remained in the analysis after applying Sallis et al.'s (205) recommendation of a minimum of three independent samples for the identification of correlates.

Physical activity intensity

There were four cross-sectional and three longitudinal studies that measured the relationship between parental influence and MVPA of which three employed objective measures of physical activity, three used self-report methods and the remaining study had parents report their child's activity as well as using a survey with the children. Cross sectional results demonstrated that mother modelling showed a positive association with MVPA. This finding is supported by a 12-month longitudinal study (32) in which mother physical activity but not father physical activity predicted child's MVPA at 12 months. In contrast, Trost, Pate, Saunders, Ward, Dowda, and Felton (244) found that mother and father modelling were not associated with boys' and girls' MVPA measured 12 months later. When examining physical activity behaviour change, Davison and Jago (53) found that compared with girls who did not maintain MVPA, girls who maintained MVPA had parents who reported higher parental modelling across all ages. Additionally, girls who maintained MVPA had parents who reported sustained levels of logistic support across ages 9 to 15 years. In the cross-sectional research all other variables (father modelling, transport and involvement) showed no association with MVPA.

Only four cross-sectional studies examined the relationship between parental influence and children's MPA of which two studies used self-report measures of physical activity, one employed an objective measure and one had parents report their child's behaviour. None of the identified variables (mother modelling, father modelling, mother physical activity and father physical activity) showed an association with MPA.

There were six cross-sectional and two longitudinal studies that measured the relationship between parental influence and VPA of which three studies administered an interview to assess physical activity, two used self-report, one study employed an objective measure and one study employed both self-report and objective measures of physical activity. Cross-sectional research demonstrated an indeterminate relationship between mother physical activity and VPA and all other variables (mother modelling, father modelling, parental physical activity and father physical activity) showed no association with VPA. DiLorenzo, Stucky-Ropp, Vander Wal, and Gotham (64) explored the predictive value of parents' physical activity on children's VPA measured

Table 2.1 Child and adolescent studies categorised by sample size, sample type, study type, country and type of physical activity measure

	Reference number	Child Samples	%	Reference number	Adolescent Samples	%
Sample Size						
<100	2 (G), 10 (B,G), 11 (B,G), 17 (G), 22, 23 (B,G), 28, 27 (B,G), 52 (B,G), 54, 73 (I), 75 (B,I,V; G,I,II,V), 79 (G), 83 (B), 84 (B,G), 95, 96	27	41.5	15 (G), 20 (B,G), 21 (B,G), 33 (II), 40, 41, 69, 73 (I,II), 75 (B,IV,VI; G,VI), 82 (B)	15	14.4
100-199	12, 16, 19, 39, 46, 72 (B,G), 73 (II), 75 (B,II), 79 (B), 81 (B,G), 83 (G)	13	20.0	3 (B,G), 15 (B), 29, 31, 33 (III), 53 (B,G), 63, 64 (B,G), 65 (B,G), 75 (B,III; G,III,IV), 82 (G), 90, 91	19	18.3
200-299	37 (B,G), 45, 74 (B,I; G,I), 80	6	9.2	9 (G), 18, 33 (IV), 50 (II), 57 (B,G), 66 (B,G), 67, 74 (B,II,III; G,II,III), 93 (B,III), 94	15	14.4
300-399	50 (I), 58, 59 (B), 71 (B,G), 93 (B,I; G,I)	7	10.8	7 (B,I; G,I), 8, 25, 68, 85, 92 (G), 93 (B,II; G,II,III)	10	9.6
400-499	59 (G)	1	1.5	4 (B,G), 6 (B,G), 33 (I), 48 (B,G), 55, 70 (B,G), 92 (B)	11	10.6
500-999	5 (B,G), 51 (B,G), 78, 89	6	9.2	7 (B,II; G,II), 13, 14, 24 (B,G), 26 (B,G), 30, 35 (B,G), 36 (II), 43, 44 (B,G), 42, 76 (I,II)	18	17.3
1000-2999	47, 56 (B,G), 62	4	6.2	1 (B,G), 32, 36 (I), 49 (B,G), 60, 61, 77 (B,G), 87, 88 (B,G)	13	12.5
>3000	34	1	1.5	38 (B, G), 86	3	2.9
Girls & Boys separately	5 (B,G), 10 (B,G), 11 (B,G), 23 (B,G), 27 (B,G), 37 (B,G), 51 (B,G), 56 (B,G), 59 (B,G), 64 (B,G), 71 (B,G), 72 (B,G), 73 (B,I; G,I), 74 (B,I; G,I), 75 (B,I,II,V; G,I,II,V), 79 (B,G), 81 (B,G), 83 (B,G),	44	67.7	1 (B,G), 3 (B,G), 4 (B,G), 6 (B,G), 7 (B,I,II; G,I,II), 15 (B,G), 20 (B,G), 21 (B,G), 24 (B,G), 26 (B,G), 35 (B,G), 38 (B,G), 44 (B,G), 48 (B,G), 49 (B,G), 53 (B,G), 57 (B,G), 64 (B,G), 65 (B,G), 66 (B,G), 70 (B,G), 73 (B,II; G,II),	67	64.4

	84 (B,G), 93 (B,I; G,I),			74 (B,II,III; G,II,III), 75 (B,III,IV,VI; G,III,IV,VI), 77 (B, G), 83 (B,G), 88 (B,G), 92 (B,G), 93 (B,II,III; G,II,III)		
Boys & Girls combined	12, 22, 28, 34, 45, 46, 50 (I), 54, 58, 78, 80, 89, 95, 96,	14	21.5	8, 18, 25, 29, 30, 31, 32, 33 (I,II,III,IV), 36 (I,II), 40, 41, 42, 43, 50 (II), 55, 60, 61, 63, 67, 68, 76 (I, II), 85, 86, 87, 94	30	28.9
Girls only	2, 16, 17 (G), 19, 39, 47, 62	7	10.8	9, 13, 14, 69, 91	5	4.8
Boys only				90	1	1.0
Cross-sectional design	2 (G), 10 (B,G), 11 (B,G), 16, 22, 27 (B,G), 28, 34, 37 (B,G), 39, 45, 46, 50 (I), 51 (B,G) 52 (B,G), 54, 56 (B,G), 58, 59 (B,G), 62, 72 (B,G), 73 (B,I; G,I), 74 (B,I; G,I), 75 (B,I,II,V; G,I,II,V), 78, 79 (B,G), 80, 81 (B,G), 83 (B,G), 84 (B,G), 89, 95, 96	53	81.5	1 (B,G), 3 (B,G), 4 (B,G), 6 (B,G), 8, 9 (G), 13, 14, 15 (B,G), 18, 20 (B,G), 21 (B,G), 24 (B,G), 25, 26 (B,G), 29, 30, 31, 32, 33 (I,II,III,IV), 35 (B,G), 36 (I,II), 40, 41, 42, 43, 44 (B,G), 48 (B,G), 49 (B,G), 50 (II), 53 (B,G), 55, 57 (B,G), 60, 61, 63, 64 (B,G), 65 (B,G), 66 (B,G), 67, 68, 69, 70 (B,G), 73 (B,II; G,II), 74 (B,II,III; G,II,III), 75 (B,III,IV,VI; G,III,IV,VI),76 (I,II), 77 (B,G), 85, 86, 87, 88 (B,G), 90, 91, 92 (B,G), 94	92	88.5
Longitudinal design	5 (B,G), 12, 17 (G), 19, 23 (B,G), 47, 71 (B,G), 93 (B,I; GI)	12	18.5	7 (B,I,II; G,I,II), 38 (B,G), 82 (B,G), 93 (B,II,III; G,II,III)	12	11.5
USA	2 (G), 5 (B,G), 10 (B,G), 16, 17 (G), 19, 22, 23 (B,G), 28, 34, 37 (B,G), 39, 47, 51 (B,G), 52 (B,G), 56 (B,G), 58, 62, 71 (B,G), 72 (B,G), 73 (B,I; G,I), 74 (B,I; G,I), 75 (B,I,II,V; G,I,II,V), 81 (B,G), 83 (B,G), 84 (B,G), 89	46	70.8	3 (B,G), 6 (B,G), 7 (B,I,II; G,I,II), 8, 9 (G), 13, 14, 15 (B,G), 18, 25, 29, 30, 31, 32, 35 (B,G), 38 (B,G), 40, 41, 42, 43, 48 (B,G), 49 (B,G), 53 (B,G), 60, 61, 63, 67, 69, 73 (B,II; G,II), 74 (B,II,III; G,II,III), 75 (B,III,IV,VI; G,III,IV,VI), 76 (I,II), 85, 82 (B,G)	56	53.9
Europe	12, 27 (B,G), 45, 46, 50 (I), 54, 78, 79 (B,G), 93 (B,I; G,I)	12	18.5	1 (B,G), 4 (B,G), 20 (B,G), 21 (B,G), 26 (B,G), 33 (I,II,III,IV), 50 (II), 55, 57 (B,G), 64 (B,G), 65 (B,G), 66 (B,G), 68, 77 (B,G),	35	33.7

				86, 87, 88 (B,G), 93 (B,II,III; G,II,III)		
Canada	80	1	1.5	70 (B,G)	2	1.9
Asia				44 (B,G), 92 (B,G)	4	3.9
Australia	11 (B,G), 59 (B,G), 95, 96	6	9.2	24 (B,G), 90, 91	4	3.9
Israel				94	1	1.0
New Zealand				36 (I,II)	2	1.9
Self report by child	5 (B,G), 16, 19, 22, 23 (B,G), 27 (B,G), 34, 39, 45, 47, 51 (B,G), 54, 56 (B,G), 58, 62, 71 (B,G), 73 (B,I; G,I), 74 (B,I; G,I), 78, 79 (B,G), 81 (B,G), 89, 93 (B,I; G,I)	34	52.3	1 (B,G), 3 (B,G), 4 (B,G), 6 (B,G), 7 (B,I,II; G,I,II), 8, 9 (G), 13, 14, 15 (B,G), 18, 24 (B,G), 25, 26 (B,G), 29, 30, 31, 32, 33 (I,II,III,IV), 35 (B,G), 36 (I,II), 38 (B,G), 40, 41, 42, 43, 44 (B,G), 48 (B,G), 49 (B,G), 55, 57 (B,G), 60, 61, 64 (B,G), 65 (B,G), 66 (B,G), 67, 68, 69, 70 (B,G), 73 (B,II; G,II), 74 (B,II,III; G,II,III), 76 (I,II), 77 (B,G), 82 (B,G), 85, 86, 87,88 (B,G), 90, 91, 92 (B,G), 93 (B,II,III; G,II,III), 94	90	86.5
Self report by parent	11 (B,G), 75 (B,I,II; G,I,II), 80	7	10.8	75 (B,III,IV; G,III,IV)	4	3.9
Self report by parent & child	12	1	1.5			
Objective measure	2 (G), 10 (B,G), 17 (G), 37 (B,G), 46, 50 (I), 52 (B,G), 59 (B,G), 83 (B,G), 84 (B,G)	16	24.6	50 (II)	1	1.0
Both objective & self report measures	28, 72 (B,G), 95, 96	5	7.7	20 (B,G), 21 (B,G), 53 (B,G), 63	7	6.7
Both objective and parent report	75 (B,V; G,V)	2	3.1	75 (B,VI; G,VI)	2	1.9

Note. B = boy; G = female; M = mother; F = father; I, II, III, IV = used to identify independent samples in which one study provided more than one independent sample within a category.

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Table 2.2 Definitions of physical activity types and parental influences

Physical Activity Type	
MVPA	Moderate-to-Vigorous Physical Activity (≥3 METs)
MPA	Moderate Physical Activity (3-5.9 METs)
VPA	Vigorous Physical Activity (≥6 METs)
Very hard VPA	Very Hard Vigorous Physical Activity (≥9 METs)
Overall PA	Physical activity throughout the whole day e.g. average daily counts per min or physical activity in a variety of situations and times e.g. school, after school, evening, weekend etc.
Leisure-time PA	Physical activity participated in out-of-school hours
Organised PA	Physical activity that is intentional, planned and controlled by an instructor e.g. lessons, clubs etc.
Steps	Average number of daily steps
PA Frequency	How many days the child has taken part in 60 minutes or more of physical activity in a typical week
Parental Influence	
Parental Modelling	Perceived physical activity level of parents
Mother Modelling	Perceived physical activity level of mother
Father Modelling	Perceived physical activity level of father
Parental Physical Activity	Parent reported physical activity
Mother Physical Activity	Mother reported physical activity
Father Physical Activity	Father reported physical activity
Involvement	Parents, mother or father doing physical activity with their child
Overall Support	Parents, mother or father provide overall support i.e. a number of different types of influence are grouped together e.g. encouragement, transport, involvement, modelling etc.
Encouragement	Encouragement from parents, mother or father to do physical activity
Transport	Parents, mother or father transporting child to a place where they can be active
Attitudes	Parents, mother or father attitudes about the importance of physical activity
Providing money	Parents, mother or father providing money for the child to be active
Help	Direct assistance from parents, mother or father for the child to be active
Watching	Parents, mother or father watch the child being active

Table 2.3 Summary of parental correlates of MVPA, MPA and VPA among children (6-11 yrs)

Correlate	Related to PA	Association (+ or -)	Unrelated to PA	No. of samples	Summary			% Assoc
	References		References		+	-	0	
MVPA								
Mother Modelling	**83 (B);** 86	+	**83 (G)**	3	2	0	1	+
Father Modelling	86	+	**83 (G) (B)**	3	1	0	2	0
Transport	45 (I)	+	45 (II); **59 (G) (B)**	4	1	0	3	0
Involvement		+	45 (I, II); **59 (G) (B)**	4	0	0	4	0
MPA								
Mother Modelling		+	58; **84 (G) (B)**	3	0	0	3	0
Father Modelling	**84 (B)**	+	58; **84(G)**	3	1	0	2	0
Mother PA	79 (B)	+	11 (G) (B); 79 (G)	4	1	0	3	0
Father PA	79 (B)	+	11 (G) (B); 79 (G)	4	1	0	3	0
VPA								
Mother Modelling	**84 (B)**	+	58; **84 (G)**	3	1	0	2	0
Father Modelling		+	58; **84 (G) (B)**	3	0	0	3	0
Parental PA	75 (B, II)	+	75 (B, I, **V**) (G, I, II, **V**)	6	1	0	5	0
Mother PA	27 (G) (B); 73 (I, II)	+	23 (B) (G); 79 (G) (B); 81 (G) (B)	10	4	0	6	?
Father PA	27 (G)	+	27 (B); 73 (I, II); 79 (G) (B)	6	1	0	5	0

Note: Numbers in the table refer to the numbers shown in Table 2.1. **Abbreviations: B** = boy, **G** = girl, **M** = mother, **F** = father, **MVPA** = moderate-to-vigorous physical activity, **VPA** = vigorous physical activity, **MPA** = moderate physical activity. Numbers in **bold** indicate objective measures.

Table 2.4 Summary of parental correlates of overall PA, leisure-time PA, organised PA and steps among children (6-11 yrs)

Correlate	Related to PA References	Association (+ or -)	Unrelated to PA References	No. of samples	Summary +	 -	 0	% Assoc
Overall PA								
Parental PA	74 (B, I)	+	74 (G, I); **72 (G, II) (B, II);** 71 (B) (G)	6	1	0	5	0
Mother PA	27 (G) (B); 28 (**I**, II); **50**; 73 (II);79 (G) (B); 93 (G,I)	+	51 (G) (B); **52 (G) (B)**; 73 (I); 93 (B,I); 95	16	9	0	7	?
Father PA	27 (G); 28 (II); **52 (G) (B)**; 79 (B); 93 (B,I) (G,I)	+	27 (B); **28 (I); 50**; 51 (B) (G); 73 (I, II); 79 (G); 95	16	7	0	9	?
Encouragement	89	+	39; 50; **72(G, II) (B, II)**; 71 (B) (G)	7	1	0	6	0
Transport	**72 (B, II)**	+	**72 (G, II)**; 71 (B) (G)	4	1	0	3	0
Involvement	89; 71 (B) (G)	+	**72 (G, II) (B, II)**	5	3	0	2	+
Fees		+	74 (B, I) (G, I); 71 (B) (G)	4	0	0	4	0
Attitudes/Beliefs		+	51 (G, M, F) (B, M, F)	4	0	0	4	0
Leisure-time PA								
Mother Modelling	86	+	78 (G) (B)	3	1	0	2	0
Father Modelling	78 (G) (B); 86	+		3	3	0	0	+
Parental PA	**37 (B)**; 80	+	**37 (G);** 72 (G, I) (B, I)	5	2	0	3	?
Encouragement		+	**37 (G) (B)**; 72 (G, I) (B, I); 80	5	0	0	5	0
Transport	72 (G, I)	+	**37 (G) (B)**; 72 (B, I)	4	1	0	3	0
Involvement	**37 (G) (B)**; 72 (B, I)	+	72 (G, I); 80	5	3	0	2	+
Organised PA								
Overall Support	16 (G, M); 19 (G)	+	16 (G, F)	3	2	0	1	+

Steps								
Mother PA		+	**46**; **95 (I, II); 96 (I, II)**	5	0	0	5	0
Father PA	**96 (II)**	+	**46**; **95 (I,II); 96 (I,)**	5	1	0	4	0
Encouragement		+	**10 (G, M, F I, II) (B, M, F,I,II)**	8	0	0	8	0
Involvement	**10 (B, F, II)**	+	**10 (G, M, F,I,II) (B, M, F,I) (B,M,II)**	8	1	0	7	0
Watching		**+**	**10 (G, M, F, I,II) (B, M, F,I,II)**	8	0	0	8	0

Note: Numbers in the table refer to the numbers shown in Table 2.1. **Abbreviations: B** = boy, **G** = girl, **M** = mother, **F** = father, **PA** = physical activity. Numbers in **bold** indicate objective measures.

Table 2.5 Summary of parental correlates of MVPA, MPA and VPA among adolescents (12-18 yrs)

Correlate	Related to PA References	Association (+ or -)	Unrelated to PA References	No. of samples	Summary +	 -	 0	% Assoc
MVPA								
Parental Modelling	61; 70 (B)	+	70 (G)	3	2	0	1	+
Mother Modelling		+	**20 (B) (G)**; **21 (B) (G);** 90; 91 (G, I, II)	7	0	0	7	0
Father Modelling		+	**20 (B) (G)**; **21 (B) (G)**; 90; 91 (G, I, II)	7	0	0	7	0
Mother PA	38 (B) (G)	+	24 (B) (G); 40	5	2	0	3	?
Support	24 (B) (G); 67 (F)	+	67 (M)	4	3	0	1	+
Encouragement	70 (G) (B); 91 (G,M,I)	+	63; **63**; 67; 90 (M, F); 91 (G, F, I, II) (G,M,II)	11	3	0	8	0
Involvement	63; 90 (M); 91 (G, M, II)	+	**63**; 67; 90 (F); 91 (G, M, F, I) (G, F, II)	9	3	0	6	0
Attitudes/Beliefs	38 (B) (B, M, F) (G,M,F); 70 (G) (B)	+	38 (G); 40 (M, F); 41	11	7	0	4	+
Help	90 (F)	+	90 (M); 91 (G, M, F, I, II)	6	1	0	5	0
Transport	63; 67	+	**63**	3	2	0	1	+
MPA								
Mother PA	65 (G)	+	65 (B); 66 (B) (G)	4	1	0	3	0
Father PA	65 (G) (B)	+	66 (G) (B)	4	2	0	2	?
VPA								
Parental Modelling		+	13 (G); 42; 53 (B) (G)	4	0	0	4	0
Mother Modelling		+	90; 91 (G, I, II)	3	0	0	3	0
Father Modelling		+	90; 91 (G, I, II)	3	0	0	3	0
Parental PA	26 (G) (B)	+	75 (B, III, IV, **VI**) (G, III, IV, **VI**)	8	2	0	6	0
Mother PA	26 (B); 73 (I, II)	+	26 (G); 65(G) (B); 66 (G) (B)	8	3	0	5	?

Father PA	26 (G) (B); 65 (B); 66 (G) (B)	+	65 (G); 73 (I, II)	8	5	0	3	+
Support	33 (I, II, III, IV)	+		4	4	0	0	+
Encouragement	42	+	90 (M,F); 91 (G, M, F, I, II)	7	1	0	6	0
Involvement	91 (G, M, I)	+	91 (G, F, I) (G, M, F, II); 53 (G) (B); 90 (M,F)	8	1	0	7	0
Help	90 (F); 91 (G, M, I)	+	90 (M); 91 (G, F, I) (G, M, F, II)	6	2	0	4	0
Very hard VPA								
Mother PA	66 (G)	+	65 (G) (B); 66 (B)	4	1	0	3	0
Father PA	65 (B); 66 (B) (G)	+	65 (G)	4	3	0	1	+

Note: Numbers in the table refer to the numbers shown in Table 2.1. **Abbreviations: B** = boy, **G** = girl, **M** = mother, **F** = father, **MVPA** = moderate-to-vigorous physical activity, **VPA** = vigorous physical activity, **MPA** = moderate physical activity. Numbers in **bold** indicate objective measures.

Table 2.6 Summary of parental correlates of overall PA, leisure-time PA, organised PA and PA frequency among adolescents (12-18 yrs)

Correlate	Related to PA References	Association (+ or -)	Unrelated to PA References	No. of samples	Summary +	 -	 0	% Assoc
Overall PA								
Parental Modelling	61	+	14 (G); **53 (G) (B)**; 70 (G) (B)	6	1	0	5	0
Mother Modelling	4 (G) (B); 30 (I); 87	+	15 (B) (G); 30 (II); 31; 90; 91 (G, I, II)	11	4	0	7	?
Father Modelling	4 (G) (B); 30 (I); 87; 91 (G, II)	+	15 (B) (G); 30 (II); 31; 90; 91 (G, I)	11	4	0	7	?
Parental PA	32; 43; 60; 77	+	3 (G) (B); 48 (G) (B); 85; 74 (B, II, III) (G, II, III)	13	4	0	9	0
Mother PA	31; 60; 64 (B) (G);73 (I, II); 77 (G) (B); 93 (B,II) (G,II,III); 94	+	**50**; 30 (II); 65 (B) (G); 68; 93 (B,III)	18	12	0	6	+
Father PA	29; 31; 60; 64 (B) (G); 65 (B) (G); 68; 73 (II); 77 (G) (B); 93 (B,II,III) (G,II)	+	30 (II); **50**; 73 (I); 93 (G,III); 94	19	14	0	5	+
Support	15 (B, M, F) (G, F); 18 (M, F); 44 (B) (G); 64 (B, M,F) (G, M, F); 76 (I,II); 85	+	8 (M, F); 9 (G, M, F); 15 (G,M); 25; **50**; 92 (B) (G)	25	16	0	10	+
Encouragement	4 (G, M, F) (B, M, F); 43; 48 (G, I, II) (B, I, II, III); 49 (G, M, F) (B, M, F); 70 (G)	+	48 (B, IV,V,VI); **50**; 70 (B); 90 (M, F); 91 (G, M, F, I, II)	26	15	0	11	?
Involvement	91 (G, M, II)	+	53 (B) (G); 90 (M, F); 91 (G, M, F, I) (G, F, II)	8	1	0	7	0
Fees	74 (B, II, III)	+	74 (G, II, III)	4	2	0	2	?
Attitudes/Beliefs	4 (B); 49 (G, M, F) (B, M, F); 70 (G)	+	4 (G); 48 (G) (B); 70 (B)	10	6	0	4	+
Help	90 (F); 91 (G, F, I)	+	90 (M); 91 (G, M, I, II) (G, F, II)	6	2	0	4	0
Leisure-time PA								
Mother PA	1 (G); 6 (G); 55; 57 (G) 6 (B)	+ –	1(B); 57 (B)	7	4	1	2	?
Father PA	6 (G); 55	+	1 (G) (B); 6 (B); 57 (B) (G)	7	2	0	5	0
Transport	35 (G)	+	34; 35 (B)	3	1	0	2	0

Organised PA								
Mother Modelling	21 (G)	+	20 (G) (B); 21(B)	4	1	0	3	0
Father Modelling	20 (G); 21 (B)	+	20 (B); 21 (G)	4	2	0	2	?
Transport	34; 35 (G) (B)	+		3	3	0	0	+
PA Frequency								
Encouragement	67; 70 (G) (B)	+		3	3	0	0	+

Note: Numbers in the table refer to the numbers shown in Table 2.1. **Abbreviations: B** = boy, **G** = girl, **M** = mother, **F** = father, **PA** = physical activity. Numbers in **bold** indicate objective measures.

Table 2.7 Longitudinal studies investigating the role of parental influence on physical activity in children and adolescents

Reference	Study design	Characteristics of study participants	Assessment of physical activity	Parental correlate	Main findings
Child samples					
Physical Activity Intensity					
Trost, Pate, Saunders, Ward, Dowda, and Felton (244)	Prospective 1 yr	*N* = 92 boys and 110 girls (fifth grade), 64% African-American	PDPAR completed on 3 consecutive days. MVPA and VPA were extracted	Mother and father modelling	Mother's PA related to girls VPA, but boys VPA or girls' or boys' MVPA. Fathers PA not related to boys' or girls' VPA or MVPA
DiLorenzo, Stucky-Ropp, Vander Wal, and Gotham (64)	Pre-post 3 yr	*N* = 54 girls and 57 boys (fifth and sixth grade)	Physical activity interview (PAI). VPA was extracted	Mother's PA and parent modelling	Mother's PA as well as parent modelling are not related to girls' or boys' VPA
Bois, Sarrazin, Brustrad, Trouilloud, and Cury (32)	Pre-post 1 yr	*N* = 84 girls and 68 boys *M* age = 9.5 yr	Parents' report of child's PA and interviewer-administered recall of PA. MVPA was extracted	Mother's and father's PA	Mother's but not father's PA predicted child's MVPA
Davison and Jago (53)	Girls and their parents were assessed when girls were 9, 11, 13 and 15 yrs	*N* = 174 girls *M* age 9.34 yr	PA was assessed with an accelerometer for 7 days and MVPA was extracted	Parental Modelling	Girls who maintained MVPA reported significantly higher parental modelling across all ages. Girls who maintained MVPA reported sustained levels of logistic support across ages 9-15 yr
Overall PA					
Yang, Telama, and Laakso (272)	Baseline , 3,6,9 and 12 yr follow ups	*N* = 316 boys and 319 girls *M* age = 9 yr	Frequency of leisure-time PA, intensity of PA, sports club	Mothers and father's PA	Father's PA in 1980 gave a significant prediction of boys' and

			training, participation in sporting competitions, habitual leisure time. The physical activity index (PAI) was a sum of these 5 variables (overall PA)		girls' PAI values 12 years later. Father's PA in 1980 predicted boys and girls PA 3 and 6 years later as well as fathers PA in 1983 and 1986. Mother's PA had a weak but significant relationship with girls PAI values but not boys
Sallis, Alcaraz, McKenzie, And Hovell (199)	Prospective 20 months	*N* = 370 girls and 362 boys (fourth grade)	One-day recall, accelerometer worn for one day and parents report of child's PA summed as overall PA	Parent's PA, Support, Transport, Encouragement, Involvement and Fee paying	For boys parental encouragement, playing with child, transport, parent PA, and fee paying significantly related to PA change. For girls no variables were significant.
Barnett, O'Loughlin, and Paradis (19)	Baseline and 2 annual follow ups	*N* = 961 boys and 912 girls *M* age = 10.3 yr	7-day physical activity recall and school sports team participation . Summed as overall PA	Parent modelling and encouragement	At 1 and 2 year follow up parent modelling and encouragement were not related to boys' or girls' PA
Organised PA					
Davison, Downs, and Birch (55)	Pre-post 2 yr	*N* = 174 girls *M* age = 9.3 yr	Activity checklist for participation in organised PA	Parent overall support	Parental support significantly associated with girls' organised sport at follow up
Leisure-time PA					
Madsen, McCulloch, and Crawford (128)	10 years of follow up	*N* = 1213 African-Amercian and 1166 Caucasian girls aged 9 or 10 years	Out-of-school PA assessed with Habitual Activity Questionnaire (HAQ) in years 1, 3, 5, 7 through 10	Mother and father modelling Involvement	Time-lagged girls' perceptions of both mothers' and fathers' PA significantly predicted log METs throughout the study. The impact of mothers' PA did not change over time but the impact of father' PA increased. Parental involvement predicted METS in years 3, 5,7 and 9 but the impact

					declined over time.
Adolescent samples					
Physical Activity Intensity					
Bauer, Nelson, Boutelle And Neumark-Sztainer (21)	Pre-post 5 yr	Group 1: *N* = 357 boys and 429 girls *M* age = 12.8 yr Group 2: *N* = 751 boys and 936 girls *M* age = 15.8 yr	Leisure time exercise questionnaire assessing MPA, VPA and MPA	Mother's and father's encouragement and beliefs/attitudes	Among younger and older males and females encouragement to be physically active by a same sex parent was associated with greater MVPA 5 years later. Father's but not mother's beliefs/attitudes were related to increased MVPA among younger and older adolescents
Kahn, Huang, Gillman, Field, Austin, Colditz And Frazier (110)	Baseline, 1 and 2 yr follow ups	N = 5575 boys and 7237 girls age 10-16 yr	A youth specific PA measure was developed that assessed 18 separate individual and team activities. MPA, VPA and MVPA were extracted	Perceived parental attitudes, actual parental attitudes and mother's PA	None of the parental variables predicted trajectories of PA in boys or girls
Overall PA					
Yang, Telama, and Laakso (272)	Baseline , 3, 6, 9 and 12 yr follow ups	Group 1: *N* = 321 boys and 327 girls age = 12 yr Group 2: *N* = 286 boys and 312 girls age 15 yr.	Frequency of leisure-time PA, intensity of PA, sports club training, participation in sporting competitions, habitual leisure time. The physical activity index (PAI) was a sum of these 5 variables (overall PA)	Mother's and father's PA	When the starting point was 12 years of age father's PA in 1980 did not predict boys' and girls' PAI values in later year. Among 15 year olds father's PA correlated only with boys' PA. Mother's PA did not correlate with boys or girls' later PA

Note. N = number, *M* = mean, PA = physical activity, MPA = moderate physical activity, VPA = vigorous physical activity, MVPA = moderate to vigorous physical activity

at 3 years and found no association between parental modelling and mother physical activity and VPA. In contrast, Trost et al. (244) found that mother modelling was associated with girls' VPA but not boys' 12 months later although no relationship was found for father modelling and girls' and boys' VPA.

Overall PA

There were 12 cross-sectional and three longitudinal studies that measured the relationship between parental influence and overall PA of which eight used self-report measures, three employed objective instruments, two studies used a combination of methods and the remaining studies used either an interview or parent report of their child's physical activity. Cross-sectional research demonstrated that parental involvement was the only variable to show a positive relationship with overall PA. For both mother and father physical activity there was an indeterminate relationship with overall PA. All other variables (parental physical activity, encouragement, transport, fee paying and attitudes) showed no association with overall PA. In the Cardiovascular Risk in Young Finns research programme (272) children and their parents were followed for 12 years at three-yearly intervals. Fathers' physical activity in 1980, when the children were 9 years old, predicted children's overall PA three, six, nine and twelve years later. Fathers' physical activity in 1983 and 1986 also predicted children's overall PA three and six years later. The activity level of mothers had a weak but significant relationship with girls' overall PA at three, six and twelve years later but only three years later for boys. Taking a different perspective, Barnett, O'Loughlin, and Paradis (19) examined predictors of decline in physical activity and concluded that parental physical activity and encouragement were not related to children's PA at 1 and 2 year follow up. When examining physical activity behaviour change over a 20 month period, Sallis, Alcaraz, McKenzie, and Hovell (199) demonstrated that parental physical activity, encouragement, involvement, transport and fee paying were all significantly associated with boys' but not girls' overall PA change.

Leisure-time PA

There were five cross-sectional studies and one longitudinal study that assessed leisure-time PA of which four employed self-report measures of physical activity, one used an objective instrument and one had parents report their child's activity. Cross-sectional research demonstrated that father modelling and involvement showed positive

relationships with leisure-time PA. For parental physical activity the relationship with leisure-time PA was indeterminate and no other variables (mother modelling, encouragement and transport) in the cross sectional research showed a relationship. In a longitudinal examination of parent modelling, Madsen, McCulloch, and Crawford (128) investigated whether parent modelling predicted girls' leisure-time PA over 10 years and whether the association declined over time. Results demonstrated that time-lagged girls' perceptions of mothers' and fathers' physical activity significantly predicted leisure-time PA in years 3, 5, 7, 9 and 10. The impact of mothers' physical activity did not change over time but the impact of fathers' physical activity increased. Exercising with a parent (involvement) significantly predicted leisure-time PA in years 3, 5, 7 and 9 but the impact declined with time.

Organised PA

Only two studies, that assessed organised PA, remained after applying Sallis et al.'s (205) recommendation of a minimum of three independent samples for the identification of correlates. One study employed a cross-sectional design and one a longitudinal analysis. In the cross-sectional study, overall support was the only variable that remained and demonstrated a positive relationship with organised PA. Davison et al. (55) was the only longitudinal study to measure organised PA and found that parental overall support, which was measured when girls were 9 year old, was associated with girls' organised PA participation two years later.

Steps

There were four cross-sectional studies that assessed the relationship between parental influences and steps. However, none of the identified variables (mother physical activity, father physical activity, encouragement, involvement and watching) showed an association with the number of steps.

Characteristics of Adolescent Studies

The 55 studies identified presented data on 104 independent samples (see Table 2.1). Independent sample sizes ranged from 22 to 7237, with a median of 325.5. Almost half had sample sizes less than 200 and only 15.4% greater than 1000. Most studies employed a cross sectional design (88.5%) and just over half were conducted in the USA (53.9%). A self report physical activity measure by the adolescent was used in

86.5% of the studies, with only 8.6% employing an objective measure of physical activity.

Parental Influences on Adolescents' Physical Activity

Thirteen types of parental variables and eight types of physical activity (see Table 2.2 for definitions) remained in the analysis after applying Sallis et al.'s (205) recommendation of a minimum of three independent samples for the identification of correlates.

Physical activity intensity

There were 11 cross-sectional and two longitudinal studies that examined the relationship between parental influence and MVPA of which eight used self-report survey measures for physical activity, two used objective instruments, two used an interview format and self-report survey and one study employed both objective and self-report methods. Cross sectional research demonstrated that parental modelling, attitudes, transport and overall support showed a positive relationship with MVPA. There was an indeterminate relationship between father modelling and MVPA. All other variables showed no association with MVPA. Bauer, Nelson, Boutelle and Neumark-Sztainer (21) measured mother and father encouragement and attitudes towards physical activity at baseline and how they influenced their child's MVPA five years later. Among younger and older males and females encouragement to be physically active by a same sex parent was associated with greater MVPA five years later. Encouragement provided by the mother also predicted more MVPA after five years among older males. Adolescents' perceptions of fathers' attitudes towards physical activity were related to MVPA five years later among younger and older males and older females. In contrast, mother's attitudes towards physical activity were not related to adolescents' MVPA. When examining physical activity behaviour, Kahn et al. (110) found that none of the parental variables (perceived and actual parental attitudes and mother physical activity) measured at baseline predicted trajectories of physical activity in boys or girls.

Only two cross-sectional studies examined the relationship between parental influence and adolescents' MPA and both studies used self-report measures of physical activity.

An indeterminate relationship was found between father physical activity and MPA. Mother physical activity showed no association with MPA.

Two cross-sectional studies measured both VPA and very hard VPA. Father physical activity showed a positive association with both VPA and very hard VPA and overall support was positively associated with just VPA. There was an indeterminate relationship between mother physical activity and VPA and very hard VPA and all other variables (parental modelling, parental physical activity, encouragement, involvement and help) showed no association.

Overall PA

There were 34 cross-sectional studies and one longitudinal study that examined the relationship between parental influence and overall PA of which 31 used self-report surveys to measure physical activity, two employed objective instruments, one used an interview technique and one study used both self-report and objective measures. Cross-sectional research demonstrated that mother physical activity, father physical activity, overall support and attitudes all showed positive relationships with overall PA. For mother modelling, father modelling and encouragement the relationship with overall PA was indeterminate. All other variables (parental modelling, parental physical activity, involvement and help) showed no association with overall PA in the cross sectional research. The Cardiovascular Risk in Young Finns research programme (272) described earlier also followed adolescents aged 12 and 15 years of age for twelve years. When the starting point was 12 years of age, fathers' and mothers' physical activity did not predict their child's overall PA in later years. When the starting point was 15 years of age, fathers' physical activity at baseline correlated with boys' overall PA three, nine and twelve years later. The activity of mothers did not predict children's later physical activity.

Leisure-time PA

There were six cross-sectional studies measuring leisure-time PA of which four used self-report surveys and two adopted an interview technique. There was an indeterminate relationship between mother physical activity and leisure-time PA. All other variables (father physical activity and transport) showed no association.

Organised PA

There were four cross-sectional studies focusing on organised PA of which three used self-report surveys and one conducted an interview to determine physical activity levels. There was a positive relationship between transport and organised PA, and an indeterminate relationship between father modelling and organised PA. The remaining variable (mother physical activity) showed no association with organised PA.

PA frequency

Only two cross-sectional studies measured frequency of physical activity and both used self-report surveys to assess physical activity. Encouragement showed a positive relationship with frequency of physical activity.

Discussion

The purpose of this review was to evaluate existing cross-sectional and longitudinal research examining parental influences on different types of physical activity in children and adolescents. We identified 96 studies in total of which only 11 were longitudinal designs. These studies were separated into child samples (aged 6-11 years) and adolescent samples (12-18 years) and by physical activity type and intensity.

In this review cross-sectional data showed a positive association between mother modelling and MVPA, parental involvement and overall PA, father modelling and parental involvement with leisure-time PA and finally overall support and children's organised PA. The cross-sectional findings therefore suggest that to facilitate activity for children aged 6-11 years, parents may need to be directly involved. Furthermore, children who perceive their mother and/or father to be physically active are more likely to engage in physical activity. However, for organised PA parents may need to provide broader support and facilitate their child's physical activity by encouraging their child to be active, transporting their child to places where they can be active as well as being active role models for their child.

Cross-sectional findings for adolescents demonstrated that parental modelling, attitudes, transport and overall support were positively associated with MVPA, father physical activity and overall support were positively related to VPA. Mother physical activity, father physical activity, overall support and attitudes were positively related to overall

PA, transport was positively related to organised PA and finally encouragement was positively associated with frequency of physical activity. In adolescents parental influence appears to be less clear but the evidence suggests that even as children reach their teenage years, they may still need to rely on their parents to transport them to be active, to be active role models, to adopt positive attitudes towards the importance of physical activity and to encourage them to be physically active. Furthermore, if adolescents are to achieve 60 minutes of physical activity daily then parents need to verbally encourage their child to be active.

Previous reviews examining the relationship between parental variables and young people's physical activity have produced mixed results. Some have concluded that parental modelling (179), support (93, 179) and encouragement (179) are positively related to young people's physical activity whilst others have reported indeterminate relationships or no association between parent modelling (93, 205), support (79) and encouragement (79, 205). The findings of the present review stand both in support of and in contrast to those of previous reviews. However, some previous reviews have grouped child and adolescent samples and all reviews have examined different types of physical activity together regardless of the type or intensity of physical activity the individual studies measured. It appears though that when you differentiate between types of physical activity positive relationships emerge between mother and father activity levels, involvement and support and specific forms of young people's physical activity as demonstrated in the current review of literature.

Although cross-sectional findings are important, evidence from cross-sectional data is limited to a single time point which makes it difficult to identify whether supportive and active parents have active children or vice versa. Therefore, it is important to examine longitudinal relationships to better tease out the role of parental influence on young people's physical activity behaviour. In the present review longitudinal research produced mixed results and in combination with the small number of studies, it is difficult to draw firm conclusions. Different questions were examined within the longitudinal designs, some studies examined physical activity behaviour at a later time point whereas others examined physical activity behaviour change. There is evidence of some agreement between cross sectional and longitudinal findings on which type of parental influence is consistently associated with children's and adolescents' physical

activity. Overall support was shown to be important for children to take part in organised PA and fathers' level of physical activity influenced adolescents' overall PA across both cross-sectional and longitudinal literature. Both cross-sectional and longitudinal findings have implications for possible intervention strategies for low active young people. Intervention strategies might include the promotion of opportunities for parents, especially fathers, and their children to be active together, or to target the fathers' physical activity level in order to increase physical activity in low active young people. Furthermore, parents need to be educated on how they can best support their child to be active and they must be made aware of how their actions (e.g., the amount of encouragement they give their child, taking part in physical activity with their child and providing transport for their child to be active) can influence their child's participation in organised PA perhaps through school newsletters or public health messages.

Measurement and Protocol Issues

Several methodological challenges could explain some of the inconsistencies observed in the cross-sectional and longitudinal literature including measurement, protocol and statistical issues. First, it is challenging to measure physical activity in young people due to their age, cognitive ability and the wide variety of activities that they participate in. Table 2.1 shows that 52% of studies relied purely on self-report to assess children's physical activity despite concerns over its reliability and validity when used with children. Although the majority of studies used self report, a few studies used both self reported and objectively measured physical activity levels and a small number employed only objective measures. As noted by Ferreira et al. (79) the degree of the relationship between self report and objective measures of physical activity is only moderate and the correlates of physical activity may differ as a function of the physical activity instrument used. As a number of cross-sectional studies employed objective measures of physical activity we were able to investigate any difference in the parental variables related to self-report and objective measures of physical activity. In the cross-sectional research 20 studies (35 independent samples – 27 in children and eight in adolescents) were identified using objective measures of physical activity. The results demonstrate that when objective measures are examined separately (still applying Sallis et al.'s recommendations) one variable was found to be indeterminate in the child sample and all other parental variables showed no association in the child or adolescent

samples. Conclusions however, are difficult to draw because of the limited number of studies that have been conducted using objective measures of physical activity, especially in adolescents. One possible explanation for the lack of associations found in this review may be because objective measures of physical activity are able to detect incidental physical activity throughout the day that may not be influenced by parents, and which may be missed in self-report methods. Conversely objective instruments are unable to measure common physical activities participated in by young people that could be reported using a survey or interview such as swimming, horse riding and cycling. Furthermore, it is important to note, that there were a variety of objective measures used in these studies including accelerometers, pedometers and heart rate monitors each of which measure different aspects of physical activity.

Another explanation for the inconsistencies could be attributed to the variety of self reported physical activity (with a variety of recall periods from 1-7 days) and parent support instruments that were used. In the child and adolescent samples, parental influences were measured by both the children's perceptions and the parent's actual report of their behaviour. It has been shown that there is low agreement between children and parent reports with regard to parental behaviour (101). Such variability in measurement instruments and protocol increases the likelihood that measurement error influences study outcomes and may explain some of the inconsistencies found. As noted by Stone, McKenzie, Welk, and Booth (225) a valuable contribution to the field would be to establish internationally accepted measures of physical activity and support for physical activity among young people.

The use of validated and unvalidated instruments to measure physical activity in studies could also influence results. Bias may have been introduced by the use of unvalidated physical activity questionnaires. To address this, a sub-analysis was conducted with studies that used validated physical activity measurement tools. The use of validated instruments to measure physical activity was seen in 69 out of 96 studies, 22 studies used unvalidated instruments and five studies used both self report and objective measures of physical activity in which only the objective measures were validated. Results for both children and adolescents demonstrated similar relationships to those identified in Tables 2.3-2.6. All but two (children's LPA and father modelling and adolescents' organised PA and transport) of the positive relationships that were seen in

the original analysis remained, however eight (two in the child sample and six in the adolescent sample) of the indeterminate relationships were no longer present due to an insufficient number of independent samples.

Different analysis strategies may also affect results. Some studies reported only univariate associations, some reported only multivariate results whilst others reported both. Although wherever possible univariate associations were reported in this review, some studies did only report multivariate results and a typical finding with multivariate analyses is that fewer variables are significant than in univariate analyses, so there is potential for bias toward null findings from studies that reported only multivariate results (205).

Study Design

The majority of the included studies were cross sectional, making conclusions about possible causality of associations impossible. More longitudinal research is therefore needed to determine the temporal sequence of parent influence and young people's physical activity and to assess the long-term relationship between parental factors and young people's physical activity. Furthermore, the dominance of samples from the USA has restricted opportunities for cross-cultural comparisons, and therefore limited the generalizability of findings.

Limitations

Despite the many advantages of conducting systematic reviews they are not without limitations. Concerns have been raised over search, inclusion and exclusion criteria, and potential sources of bias including publication and language (223). Although an extensive literature search was undertaken to identify all published studies, using only published data in the English language is acknowledged as a limitation.

In common with Sallis et al. (205) and Gorely, Marshall and Biddle (88) the present review focused on the consistency of reported associations and did not assess strength of associations. This may mean that the results of studies using strong measurement tools could be masked by the results of many studies employing weak measurement tools. Furthermore, samples sizes of individual studies identified for this review varied

from < 100 subjects to > 3000 subjects and these studies are treated equally with this method.

Conclusions

Findings from cross-sectional and longitudinal research lend support to the view that parents need to be involved in their child's physical activity in a variety of ways if their child is to lead a physically active lifestyle. Longitudinal findings provide an assessment of the long term relationship between parental factors and young people's physical activity and although limited in number demonstrated, in agreement with cross-sectional research, that the overall support provided by parents predicted children's organised PA and that fathers' physical activity predicted overall PA in the adolescent sample. These findings suggest that there appears to be merit in promoting the importance of physical activity to parents, especially to fathers, and encouraging them to increase their physical activity in order to increase physical activity in low active young people.

A number of issues worthy of further investigation emerged during this review: (a) variables whose associations with physical activity were classed as indeterminate and those that have been studied too few times to draw any firm conclusions, warrant further investigation to generate more compelling evidence; (b) only a small number of studies employing objective measures of physical activity were identified in this review, therefore studies employing objective assessments of physical activity combined with self-report measures are required in future studies; (c) to further understanding of how parents influence their child's physical activity more longitudinal research is needed to clarify temporal relationships and assess the long-term relationship between parental influences and physical activity; (d) studies have mainly investigated positive role modelling of parents and a small number of studies (80, 214) have suggested that modelling of inactive behaviour exerts more influence than modelling physical activity and this merits further investigation; and (e) it is possible that siblings and/or peers exert a greater influence on young people's physical activity than parents at certain life phases so how parents, siblings and peers influence physical activity at different developmental stages could be examined.

Chapter 2.2

2.2 The Role of Parents in Young People's Physical Activity: A Review of Qualitative Studies

Introduction

The case for promoting physical activity among young people is based upon a growing body of evidence linking physical activity to improvements in physical and psychological parameters. Physical activity and physical fitness have been shown to be inversely related to insulin resistance (112) and positively associated with insulin sensitivity (107) in young people. Furthermore, recent studies have also provided evidence of an association between physical activity levels and cardiovascular disease risk factors (7), markers for adiposity such as BMI (227), bone health (127, 261) and mental health (e.g., depression, self-esteem and anxiety) (72, 233) in young people.

Despite the identified importance of participating in regular physical activity, survey data indicate that many children and adolescents are not achieving the established physical activity guidelines of achieving a total of 60 minutes of moderate intensity physical activity each day (44, 62, 99, 168). For example, the most recent Health Survey for England suggests that only 32% of boys and 24% of girls achieved the recommended levels of physical activity. The large proportion of young people who are not achieving the recommended guidelines demonstrates the need to increase young people's physical activity levels. To do this most effectively, it is important to understand the correlates of physical activity in children and adolescents.

Within the literature numerous potential influences on young people's physical activity have been identified including demographic, biological, psychological, social, cultural and environmental factors (252). Social sources that impact upon children's and adolescents' physical activity have been frequently studied. One area in the social domain that has received a great deal of attention in the past few years is the influence of parents on their child's physical activity. Parents may exert significant social influence over their child's physical activity through encouraging them to be active,

being active with their children, providing transportation and funding for activity and by serving as role models for physical activity.

Parental influences have been extensively studied using quantitative data collection methods, which involve cross-sectional surveys of physical activity and its influences (4). In recent years, several reviews of quantitative literature focusing on parental correlates of young people's physical activity have been conducted (79, 93, 179, 205) but have produced mixed results. Some previous reviews have reported significant positive associations between parental modelling (179), support (93, 179) and encouragement (179) and children's and adolescents' physical activity whilst others reported indeterminate relationships or no association for parental modelling (93, 205), support (79) and encouragement (79, 205). These reviews demonstrate the extensive quantitative research that has been conducted in this area but the mixed results may indicate that focusing on specific, measurable variables may not fully capture the depth of parental influence on young people's physical activity.

In recent years there has been an increase in the number of qualitative studies aimed at understanding how parents influence young people's physical activity. Qualitative research encompasses a range of techniques including in-depth interviews, focus group interviews, and observation which allow for a greater understanding of specific topics. This type of methodology stresses the importance of studying the subjective experiences of the individual, thereby providing a richness of information to the field of physical activity which might have otherwise been undetected (153).

The purpose of this paper is to review published qualitative research studies which have examined parental influences on young people's physical activity.

Method

Search

Searches were conducted using the following electronic databases: SportDiscus, Article First, Web of Science, PubMed, Zetoc, Applied Social Sciences Index, MedLine, Biological Sciences, ERIC, PsycINFO, Sociological Abstracts and Physical Education Index. Searches were also conducted using Google Scholar and Science Direct. All databases were searched using combinations of the following keywords: qualitative,

physical activity, exercise, children, adolescents, parents, parental influence, modelling, support, encouragement, beliefs, attitudes, and transport. The reference lists of the identified studies were then screened for any additional relevant articles.

Selection

To be included in the review studies had to meet the following criteria: (1) include children (aged 6-11 years old or a mean age within these boundaries) or adolescents (aged 12-18 years old or a mean age within these boundaries); (2) address parental influences on children's or adolescents' physical activity e.g., parent's physical activity, parental support, encouragement, beliefs and attitudes towards physical activity or parental facilitation (e.g., fee paying or transport); (3) employ a qualitative methodology (e.g., interviews, focus groups or open-ended questions); and (4) be published in the English language. The census date for inclusion was September 2009.

Data Extraction and Synthesis

A standardized form was developed for this review to record the following data from each reviewed paper: author, date and country of the study, characteristics of participants (sample size, age, sex), qualitative methods employed and summary of findings. The key parental influence concepts from the papers were extracted and compared with one another for similarities. If similarities were identified they were grouped together under a key theme.

Results

We identified a total of twelve studies published between 2000 and 2009 that met the inclusion criteria. These studies were conducted in the USA (n = 2), UK (n = 4), Australia (n = 1), New Zealand (n = 1) and Canada (n = 4). A total of 789 boys and girls were involved in the included studies, with sample sizes ranging from 6-160 participants. Of the twelve identified studies, three focused on children and nine on adolescents. Half of the studies included both boys and girls and half focussed on girls only. The number and age of participants as well as data collection methodology and summary of findings of each individual study are shown in Table 2.8. Parents were found to influence their child's physical activity in a variety of ways in both the child and adolescent samples. Six themes arose from the synthesis and included parental

Table 2.8 Qualitative studies investigating the role of parental influence on physical activity in children and adolescents

Author, year and Country of study	Aim of the study	Participants	Data collection	Summary of findings
Brockman, Jago, Fox, Thompson, Cartwright, and Page (35), UK	To explore the influence of family and socioeconomic factors on children's physical activity	113 children aged 10-11 years from 11 primary schools	One or two focus groups were conducted at each primary school with a range of 2-12 children in each group	Participants from all socioeconomic groups reported that parents encouraged them to be active but approaches differed.
Casey, Eime, Payne, and Harvey (42), Australia	To identify a range of independent and interacting factors that influence physical activity participation	34 girls aged 12-13 years from four secondary schools	Focus groups were conducted with between 5-11 girls in each group. The socioecological model of health was used to develop questions e.g., how were you influenced by parents/teachers/siblings/friends to participate in physical activity?	Parents who were active participants in sports or physical activity facilitated participation by encouraging and providing opportunities for girls to be active. Girls' opportunities were restricted by parents unwilling to drive.
Coleman, Cox, and Roker (46), UK	To explore the leading influences upon physical activity participation of those who 'always' and 'never' participate	75 girls aged 15-19 years	In-depth interviews were conducted. To explore the contrasting activity levels (always and never) the range of possible influences were discussed completely open ended. The interview schedule then used the Oxford models of sports participation as a foundation for factors to consider e.g., social influences upon participation levels	Girls who always participate in sport reported that their parents also frequently participated in sport and physical activity. Active girls also reported high levels of parental encouragement and practical incentives. If parents increased their physical activity levels it may lead to an increase in the physical activity levels of girls who never participated.

Cox, Schofield, and Kolt (48), New Zealand	Examined the meaning of personal, parental, and third party responsibility for children's physical activity	32 boys and girls aged 11-12 years	Four focus groups were conducted with children (separated by gender)	Children from the lower decile school placed more emphasis on support mechanisms than parental role modelling behaviour.
Dwyer, Allison, Goldenberg, Fein, Yoshida, and Boutilier (68), Canada	To explore perceived barriers to physical activity participation among adolescent girls	73 adolescent girls in grades 10-11 from four secondary schools	90 minute focus groups were conducted with 8-12 adolescents in each group. First they were asked why they do moderate and vigorous physical activity. Second, they asked what makes it difficult for them to do physical activity	Parents were noted as role models girls felt that parents' level of physical activity influenced their physical activity level. Some parents discouraged their children from physical activity.
Humbert, Chad, Spink, Muhajarine, Anderson, Bruner, Girolami, Odnokon, and Gryba (106), Canada	To illustrate the factors that youth from low- and high-SES areas consider important to increase physical activity participation	80 boys and 80 girls aged 12-18 years from two high schools representing lower socioeconomic areas and two high schools representing higher socioeconomic areas	29 focus groups interviews were conducted with 5-7 participants in each group. The focus groups were centred on one open-ended question: 'If you could be the one in charge of increasing the physical activity levels of kids your age, what would you do?'	High-SES students needed parents to play a role in organisational tasks and support for their physical activity but low-SES students welcomed any kind of parental involvement.
Mulvihill, Rivers, and Aggleton (152), UK	To provide new data on the perceptions, motivations for and barriers to physical activity among children	30 boys and 30 girls aged 5-11 years from urban and rural/suburban areas	Children were interviewed in pairs matched for age and gender. Children were defined as 'very active' because they participated in a range of activities inside and outside of school	Parents encouraged children to play out and determined how far children were allowed to cycle and facilitated out-of-school activities.
Ramanathan and Crocker (182), Canada	To explore the role of personal, familial, and cultural attitudes and social norms for physical activity on actual physical activity behaviour	6 girls aged 15-19 years from a spiritual centre	Girls were interview individually and also as part of a focus group. The interview examined parental influence by asking ' do you think your parents want you to be physically active?' How do you know? facilitation and involvement.	Parents encouraged girls to play outside and served as role models by engaging in activities themselves. Parents served as sources of social support through encouragement,

Ries, Voorhees, Gittlesohn, Roche, and Astone (190), USA	To examine perceptions of environmental influences on physical activity	23 boys and 27 girls in 9th-12th grade (mean age 15.5 years) from 2 high schools	Small group brainstorming sessions. The participants were asked 'what things in the environment, both good and bad, might influence physical activity among adolescents?' The participants were then asked to sort and rate the brainstormed items.	Seven domains were identified including parental support and control.
Robertson-Wilson, Baker, Derbyshire, And Côte (192), Canada	To determine the role that influencing agents may have played on initiating involvement in physical activity	87 girls aged 18 years from a University	A structured interview was conducted with each participant. The participants were asked to recall activities they had performed from 6-18 years age and who was responsible for getting them involved initially	Parents influenced initial involvement for a greater number of activities in active females than in non-active females.
Whitehead and Biddle (266), UK	To identify factors perceived to relate to physical activity and to establish why these factors were felt to be influential in decision over whether or not to participate	47 girls aged 14-16 years from one high school	8 focus groups were conducted with 5-7 girls in each group. The topics for discussion were derived primarily from the gaps in current knowledge and an open-ended approach was adopted helped with their motivation.	Active girls received more parental encouragement. Parents of less active girls made very little effort to encourage. Active girls reported that parents being active with them
Wright, Wilson, Griffin, and Evans (270), USA	To assess how parental role modelling and parental social support influence physical activity in under-served adolescents	22 boys and 30 girls aged 10-14 years from two middle schools	Same gender focus groups were conducted with 6-10 children in each group. Focus group questions explored the types of activities parents engaged in with their adolescents and active their parents were on a daily basis. Several questions assessed types of social support the adolescents perceived getting from their parents.	Adolescents reported that parents engaged in a variety of different types of physical activity with them. Sex differences were noted in parental support indicating that girls reported receiving more negative support, while boys reported receiving more tangible types of support.

Note. SES = socioeconomic status

modelling, parental involvement, parental encouragement, logistic support, restriction of physical activity and initial involvement.

Parental Modelling

Parents' physical activity behaviour was seen as an influential factor for adolescent physical activity behaviour. In several studies adolescents attributed their physical activity behaviour to their parents' activity (68, 182, 190) and active adolescents reported living in an active household in which parents also frequently participated in physical activity. Conversely, the inactive adolescents reported living in an inactive household although these inactive adolescents felt that if their parents increased their activity levels and the importance of physical activity increased for them then it may lead to an increase in their own levels of physical activity (46). Children from middle/high socioeconomic status (SES) primary schools reported more often than children from low-SES schools that they were encouraged by their parents to take part in physical activity through modelling of physical activity behaviour (35). Therefore, it would appear that parents serve as role models for both children and adolescents by engaging in physical activities themselves.

Parental Involvement

Parents engaging in physical activities with their children was reported by both children and adolescents as a motivating factor for their physical activity (35, 266). Ramanthan and Crocker (182) found differences in the type of activities that mothers and fathers engaged in with their children. Adolescent girls reported playing active games with their fathers and taking walks with their mothers. Parental involvement was also important for children's physical activity, with children reporting that their parents encouraged them to engage in physical activity by being actively involved in activities with them (35). However, children from middle/high SES primary schools reported participating in physical activity more often with their parents than children from low SES schools. In one study (270) adolescent boys and girls indicated that they wanted their parents to be more directly engaged in physical activities with them. Boys most commonly reported wanting to be more physically active with their fathers, while girls wanted parents to engage with them in different non-traditional ways of being active such as walking in various different locations.

Parental Encouragement

Both children and adolescents reported that their parents verbally encouraged them to play out and be involved in physical activities as a means of preventing laziness (35, 152, 182). For example, children from lower SES primary schools mainly reported that they were encouraged by their parents to take part in physical activity through verbal demands such as parents telling their child to get off the sofa and play (35). In another study (48), children from low SES groups reported a reluctance from their parents to encourage them into physical activities that required support in terms of transportation and finance. However, children from high SES groups placed great importance on parents encouraging them into physical activity. In an adolescent sample, active girls reported receiving more parental encouragement than the less active girls (266). Active girls reported that their parents had encouraged them to take up physical activity at a young age. Some of the less active girls stated that their parents had tried unsuccessfully to encourage them to be active but most inactive girls stated that their parents made very little effort to encourage them to take part in physical activity. Furthermore, parents who were active participants in physical activity encouraged their children to be active (42) and more specifically encouraged them to get involved in the activities that they do (46).

As well as providing positive encouragement for physical activity young people reported perceiving encouragement in a negative way. A number of adolescent girls reported that parents' encouragement could become too pushy which led to physical activity being seen as something that they had to do rather than something that they wanted to do (46). In another study (270) girls but not boys reported a feeling of being forced to be active by their parents through their parents' repeated encouragement for them to be active. This perceived negative encouragement could then lead to a further disliking of participating in physical activity.

Logistic Support

Logistic support in the form of transport and subsidising activities financially appeared to be very important for both children and adolescents to take part in physical activity (35, 46, 68, 106, 190, 270). In one study (68) participants reported transportation from parents as an important factor for their physical activity participation and unless their parents drive them to places they can not get there. Furthermore, active girls reported

that parents provided practical incentives such as transport and contributing financially for them to participate in activities compared with their less active counterparts (46). In Wright et al., (270) girls actually reported wanting to have their parents sign them up to become involved in physical activities. Several studies reported differences between the support received from high and low SES groups (35, 106). Children from middle/high SES primary schools mainly reported that they were encouraged by their parents to take part in physical activity through non-verbal methods which included transport and financial support whereas children from low-SES primary schools reported that their parents were unable to provide this type of support (35). In another study (106) high-SES adolescents identified parent support in the form of providing transport as an important factor for participating in physical activity. In contrast, it was evident that among low-SES adolescents, any kind of parental involvement was welcomed. It was also noted that in comparison to the low-SES adolescents, the high-SES adolescents seemed to take the involvement of their parents for granted. Adolescents also noted that their parents served as sources of logistic support through buying or access to sports equipment (182).

Initial Involvement in Physical Activity

In one study (190), adolescents were asked to recall all organised physical activities and who was responsible for getting them initially involved in the activity. For both active and inactive groups, parents were the most influential element in initiating physical activity involvement and parents influenced initial involvement in a greater number of activities in active females than in non-active females.

Restricting Physical Activity

Interestingly, some young people stated that their parents discouraged them from engaging in physical activity and preferred them to participate in other activities that would progress them academically. Parents of year 6 students (aged 11) had discouraged them from joining after school physical activity clubs as they would shortly be joining secondary schools where they would have to spend more time on homework (152). In both the child and adolescent samples it was also reported that parents restricted after school and evening physical activity participation due to safety concerns (68, 190), for example, parents would not let their children cycle or play out too far from their houses (152). Furthermore, some stated that they had to convince their

parents to allow them to participate in physical activity (68) because of this. Children and adolescents also reported that their opportunities were limited and they were unable to access opportunities for physical activity because their parents were either unwilling to drive (42) or they had a lack of free time to assist with their activities (35). This affected children of all SES schools.

Discussion

This paper reviewed 12 qualitative studies which investigated the role that parents play in their child's physical activity. The review findings suggest that parents have a great deal of influence over both children's and adolescents' physical activity in a variety of ways. Children and adolescents reported that parents' physical activity behaviour and verbal encouragement influenced their physical activity levels and if inactive parents increased their activity levels inactive adolescents felt that this would influence their behaviour. Furthermore, logistic support such as transport and paying for their child to join clubs was identified as an important factor for physical activity participation. These results confirm the findings from Chapter 2.1 and the meta-analysis conducted by Pugliese and Tinsley (179) which found that parental modelling, encouragement and instrumental support had significant positive relations with child and adolescent physical activity.

Conversely, parents could also have a negative impact on physical activity participation by restricting their child's physical activity because of concerns for safety when being active outdoors. Research has shown that giving young people more independence to play outside is related to greater levels of physical activity and children are more apt to engage in vigorous play (163). Additionally, research has shown that time spent outdoors is one of the most consistent predictors of children's physical activity (205) and among primary school aged children, active-free play or unstructured physical activity that takes place outdoors in the child's free time may potentially be the major contributor to children's physical activity (40). Furthermore, outdoor play provides important opportunities for children to explore the natural world and learn about the environment. It is essential therefore that children are given the opportunity and freedom by their parents to be active outdoors. For adolescents parents restrict their physical activity because they would prefer them to engage in academic activities rather than physical activity. Once young children progress to secondary school parents want

their children to spend their spare time doing homework but they may need to be made aware of the importance of a balance between academic work and physical activity.

Girls often reported feeling forced to take part in physical activity by their parents which led to a disliking of physical activity. Parents may have good intentions by trying to encourage and introduce their daughters to physical activity but a child may view this as pressure to be active and it may contribute to lowered enjoyment and motivation to take part in physical activity. Previous quantitative research demonstrated that perceived parental pressure was a significant negative predictor of activity enjoyment (8). To avoid disliking of physical activity it is important that parents recognise that their encouragement may be perceived as 'nagging' or pressure to be active and that they need to be sensitive to their daughter's interpretation of their behaviour.

A difference in the way parents influence their child's physical activity was observed for children from low and high SES groups. Parents from high SES groups co-participated in physical activity and modelled behaviour and they assisted with transport and fee paying whereas parents from low SES groups appeared to rely on more verbal forms of encouragement to influence their child's physical activity behaviour. This is consistent with previous quantitative research which has shown that low SES youth might be less likely to receive involvement and encouragement from parents than their high-SES counterparts (254). One explanation could be that low SES families rely more on verbal encouragement due to financial constraints on transport, sports equipment and enrolment in sports club, which families of middle/high SES may not face.

It was found in one study that for active girls their parents had initiated involvement in a greater number of activities than in non-active girls. This suggests that the variety of exposure to physical activity at a young age may have a role in creating active young people. If parents introduce their children to a wide variety of activities they are perhaps more likely to find something that they enjoy.

The results of this qualitative review are significant because they provide insight for the development of interventions designed to increase physical activity in young people. The review demonstrates that schools and communities have a role in engaging parents

in initiatives when trying to increase physical activity for both children and adolescents. These initiatives could focus on the following:

- Educating parents about the importance of physical activity for both themselves and their children
- Encouraging parents to act as role models through their own participation
- Encouraging parents to participate in activities with their children and not just command them to be active
- Encouraging parents to work with their children to find activities that they enjoy
- Providing low cost suggestions for activities that parents can do with their children.

Limitations

There were relatively few qualitative studies conducted focusing on parental influence on young people's physical activity compared to the vast amount of data available from quantitative studies (79, 93, 179). In the small number of qualitative studies that were identified in this review parents were not always the sole focus and the richness of detail that is usually associated with qualitative data was not evident in the majority of studies - most studies simply stated that parents were important influences but failed to explore why and how. For example, in one study it was stated that parents had tried unsuccessfully to encourage less active girls to be more active but did not include detail on how they did this or why it was unsuccessful. The studies lacking detail may have been excluded if quality assessment of the individual papers included in this review was conducted. No quality criteria were applied to the studies because of the small numbers of papers that were identified. The application of quality criteria to qualitative research however is widely debated and it would be unwise to consider any single set of guidelines as definitive (133). Many researchers do however accept that a good qualitative study ensures the epistemological and theoretical stance of the researcher is stated clearly in the study which can be done through establishing distance from the data through guarantors of objectivity or defining the exact nature of proximity through reflexivity. Good qualitative research should also make the aims and objectives of the research and research question clear, ensure there is enough detail about sampling

techniques and clearly establishing the rationale and theory behind them. Furthermore, good qualitative research should include sufficient detail about how the data were collected and include sufficient information about the journey from data to conclusions which can both establish a transparent process. Finally, demonstrating exactly how the data themselves shaped the conclusions is important in re-enforcing the link between data and conclusions in qualitative work (145).

In this review the role of other family members such as siblings and grandparents was not considered and it is recognised that family members other than parents may play an important role in influencing children's and adolescents' physical activity. Furthermore, to provide a comprehensive understanding of the role that parents play in their child's physical activity, it would have been useful to examine both children's perceptions of how their parents influence their physical activity participation and parents' perceptions of how they influence their child's physical activity participation. However, only two of the twelve studies identified for this review included parents perspectives.

Conclusions

This review has identified qualitative studies examining how parents influence their child's physical activity levels. The results demonstrate that parental influence in young people's physical activity is diverse, ranging from verbal encouragement, providing transportation and money for clubs, co-participation and modelling of physically active behaviour. The study also suggests that the way in which parents encourage their children to be active differs according to socioeconomic background, with children from middle and high SES schools reporting proactive methods by parents, and children from low SES schools restricted to verbal encouragement. Parents can also have a negative impact on their child's physical activity by restricting after school participation and by girls perceiving encouragement as 'nagging'. Findings highlight the need to include parents in interventions to increase physical activity in young people.

Chapter 3

Measurement issues of accelerometer use in children and adolescents

This chapter describes two studies investigating the effect of pre- and post-data collection decisions on accelerometer output in children and adolescents. Data for this chapter were collected in primary and secondary schools between November 2005 and June 2008. Chapter 3.1 examines the effect of epoch length on minutes spent in different physical activity intensities. The findings from Chapter 3.1 have been accepted for publication in *Medicine and Science in Sports and Exercise* (Edwardson, C.L. and Gorely, T., in press). Chapter 3.2 examines the impact of accelerometer post-data collection decisions (e.g., defining non-wear time, deciding on the number of hours that constitute a valid day) on child and adolescent data sets. Findings from chapter 3.2 have been presented (poster) at the postgraduate presentation evening, Loughborough University, 15th February 2008.

Chapter 3.1

3.1 Epoch Length and its Effect on Physical Activity Intensity

Introduction

Over the past decade accelerometers have increased in popularity as an objective measure of physical activity to be used in free-living studies. Accelerometers measure the acceleration and deceleration of body movement and provide a direct assessment of the frequency, intensity and duration of physical activity (263). Accelerometers employ rapid sampling of accelerometer counts over a preset sampling period (e.g. 5 seconds) referred to as an epoch.

Much of the research conducted with children and adolescents has used 60 second epochs (11). This is mainly because in the past accelerometers were only capable of storing data collected using epoch lengths of <60 seconds for a limited number of days and ≥ 7 days has been suggested as the most appropriate length for measuring physical activity objectively in children and adolescents (242). However, researchers have described children's physical activity as spontaneous and intermittent (26), with the majority of physical activity bouts lasting between 3 and 22 s (15, 26). The use of 60 second epochs may therefore be inappropriate when measuring young people's physical activity and may result in an underestimation of moderate and vigorous physical activity (259). This is possible because if a child alternates between vigorous and light physical activity within a given minute, the accumulation of counts for that minute will only reflect the average activity level during that period resulting in a smoothing effect (240). Total volume of activity accumulated per day is not effected by epoch length, epoch length only becomes an issue when physical activity intensity is the outcome of interest.

Recent advances in accelerometer storage capacity has meant that researchers can select an epoch length of <60 seconds whilst still being able to measure physical activity for ≥ 7 days. Therefore, recent research measuring young people's physical activity is employing a variety of different epoch lengths (155, 189, 234) and it is unclear how these various epoch lengths effect recorded time spent in physical activity. Other decisions that researchers have to make regarding the number of hours that constitute a

valid day, defining non-wearing time, deciding on the minimum number of days to be used in the analysis and extracting moderate-to-vigorous physical activity by applying cut-points to the data have also varied across studies and some have been shown to effect accelerometer output (92, 132, 151, 186) which limits the ability to compare results across studies. These decisions can be collectively named post-data collection processing rules as these are choices that are made once physical activity data has been collected, however selecting an epoch length is a choice that has to be made prior to data collection and therefore it can perhaps be argued that selecting the most appropriate epoch length is the first critical decision to be made.

A small number of studies (159, 186, 194) have begun to investigate the effect of epoch length on physical activity intensities using small samples of children. Nilsson et al. (159) found that time spent in vigorous and very vigorous physical activity was inversely associated with epoch length in sixteen children aged 7 years. Using the same methods, Reilly et al. (186) using data from 32 children aged 5 and 6 years reported significant differences for moderate-to-vigorous physical activity between epoch settings, but noted that these differences were small. In another study of twenty-five 7-11 year old children, Rowlands et al. (194) reported a similar finding for very vigorous physical activity but interestingly found that a 60 second epoch resulted in a significantly greater number of minutes of moderate and vigorous physical activity. The empirical evidence on this topic is limited in children and to date no studies have examined the effect of epoch length on the measurement of adolescent's physical activity. Furthermore, with the use of different epoch lengths to measure young people's physical activity, it is not known if studies employing different epoch lengths are comparable and the most appropriate epoch length remains unclear.

The purpose of this study is to investigate the effect of different epoch lengths (5s, 15s, 30s, 60s) on derived levels of physical activity in both a child and adolescent sample to determine which epoch length would be most appropriate for use with young people. To do this post-data collection processing rules will be held constant in order to concentrate on the effect of a decision that is made prior to data collection. A secondary aim is to investigate whether studies employing different epoch lengths are comparable.

Methods

Participants

Participants consisted of two groups of young people: The first set of data were collected as baseline data for a larger study (89) involving four primary schools in the north-east of England who had agreed to take part in the 'GreatFun2Run' programme (a school-based healthy lifestyles intervention). These schools were matched with four schools in the East Midlands of England on the basis of size, ethnicity and socioeconomic status (SES) (as reflected in the Index of Multiple Deprivation (IMD)) for the school postcode. Using an α level of 0.05 and a β level of 0.9 to detect a difference of 0.33 SD around 270 children per group were needed. In total 589 children (310 from intervention schools and 279 from control schools) aged 7-11 years (95.7% white British, 37.6% low, 33% medium and 29.4% high SES) provided consent from parents and assent to participate of which 311 children (49% male) wore an accelerometer for 7 days. The second set of data were collected from adolescents recruited from three secondary schools in the East Midlands region of England. In total, 363 adolescents aged 12-16 years (95% white British, 71% high SES) provided consent from parents and assent to participate of which 234 adolescents (56% male) wore an accelerometer for 7 days. Staff at participating primary schools selected all pupils in years 3, 4 and 5 for participation and staff at participating secondary schools selected a subset of their year 7, 8, 9, 10, and 11 classes for participation and all pupils from nominated classes were eligible for participation. In the secondary schools socio-economic status was determined using the IMD and was based on the postcode of the participant's home. In all schools, informed consent was obtained from the head teacher and the parent or guardian of all participants and children provided assent before participation. Study procedures were approved by the Ethical Advisory Committee of Loughborough University.

Procedure

All participants were asked to wear an Actigraph GT1M accelerometer for 7 days during waking hours. The Actigraph was initialised with a start and end time and a 5 second epoch. The accelerometer was attached to a flexible belt that was fastened around the participants' waist. After 7 days accelerometers were collected and data were uploaded to a data reduction programme (ActiGraph Analysis Tool). A valid day was classified as ≥9 hours of monitoring per day (50) and mean monitor wear time was 12.3

± 1.0 and 13.2 ± 1.1 hours per day for children and adolescents respectively. Participants with less than 4 days (3 weekdays and 1 weekend day) of complete monitoring were excluded from the analysis (11). Missing data was defined as ≥20 minutes of consecutive zero counts (9). To determine time spent in rest, light (LPA), moderate (MPA), vigorous (VPA) and moderate-to-vigorous physical activity (MVPA) the age specific count ranges were derived from the energy expenditure prediction equation developed by Freedson, Sirard and Debold (82). Data, originally collected in 5 s epochs, were then reintegrated into 15-, 30-, and 60-second epochs using a software feature within the ActiGraph Analysis Tool and data were reprocessed. The count ranges used for a 5 second epoch were 0-8, 9-74, 75-288 and >289 for rest, LPA, MPA, and VPA respectively for the child sample and 0-8, 9-134, 135-397 and >398 for the adolescent sample. The count ranges were then multiplied to correspond to the outcome of 15-, 30- and 60-second epochs.

Statistics

All analyses were conducted using Statistical Package for Social Sciences, 16.0 (SPSS). Descriptive statistics were used to examine mean and standard deviation for time spent in rest, LPA, MPA, VPA and MVPA for the various epoch lengths. One-way repeated measures ANOVA examined the differences in time spent in the different intensity levels for 5-, 15-, 30-, and 60-second epochs. Post-hoc Tukey tests followed any significant ANOVA's. In cases when Mauchley's test revealed that the assumption of sphericity had been violated (p <0.05), the Greenhouse-Geisser procedure was applied to adjust the degrees of freedom. To determine the degree of agreement between epochs for different physical activity intensity levels the Bland-Altman method (30) was employed. The significance level was set at $p < 0.05$.

Results

The mean time spent in different physical activity intensity levels between each epoch length for both the child and adolescent data are shown in Figure 3.1a – 3.1e. Using a one-way repeated measures ANOVA, a significant epoch effect was seen for time spent in MVPA (F(1.13, 0.38) = 455.91), MPA (F(1.13, 0.38) = 929.51), VPA (F(1,29, 0.43) = 2081.04), LPA (F(1.11, 0.37) = 6467.84) and rest (F(1.08, 0.36) = 8384.49) in the child sample (all p< 0.05). Post hoc tests revealed that for time spent in all of these physical activity intensities, all epoch lengths significantly differed from each other (p<

0.05). For the adolescent sample, a significant main epoch effect was seen for time spent in VPA ($F(1.33, 0.44) = 30.78$, $p< 0.05$), LPA ($F(1.31, 0.44) = 470.75$, $p< 0.05$) and rest ($F(1.39, 0.46) = 113.95$, $p< 0.05$). Post hoc tests revealed that for time spent in all of these physical activity intensities, all epoch lengths significantly differed from each other ($p< 0.05$). No significant epoch effect was observed for time spent in MVPA and MPA between epoch lengths ($p>0.05$) in the adolescent sample. To examine whether the epoch effect was the same for both boys and girls, analyses were run separately by gender. For boys and girls in both the child and adolescent samples results for time spent in MVPA, MPA, VPA, LPA and rest showed identical patterns to those reported above.

Figures 3.2 and 3.3 present the bias and 95% limits of agreement for the children and adolescent sample respectively. In the child sample bias was close to zero and 95% limits of agreement were small between the 5 and 15s, 15 and 30s and the 30 and 60s epoch lengths for MVPA, MPA, VPA, LPA and rest. In the adolescent sample, bias was close to zero and 95% limits of agreement were small between the 5 and 15s, 5 and 30s and 15 and 30 s epoch lengths for MVPA, MPA, VPA, LPA and rest.

Discussion

The aim of this study was to determine the effect of integrating a 5 second epoch into a 15-, 30-, and 60 second epoch on different intensities of physical activity to determine which epoch length would be most appropriate for use with young people. A secondary aim was to investigate whether studies employing different epoch lengths are comparable. This was done in both a child sample (7-11 years) and an adolescent sample (12-16 years) to investigate whether an epoch effect would be present across age groups.

In the child sample, a significant epoch effect was observed for MVPA, MPA, VPA, LPA and rest. A shorter epoch was associated with less time in MVPA, MPA and LPA. In contrast, for VPA and rest, a shorter epoch was associated with more time being spent in that intensity. Further analysis using the Bland-Altman method showed reasonable agreement between the 5 and 15s, 15 and 30s and the 30 and 60s epoch lengths for MVPA, MPA, VPA, LPA and rest. For these epoch lengths bias was closer

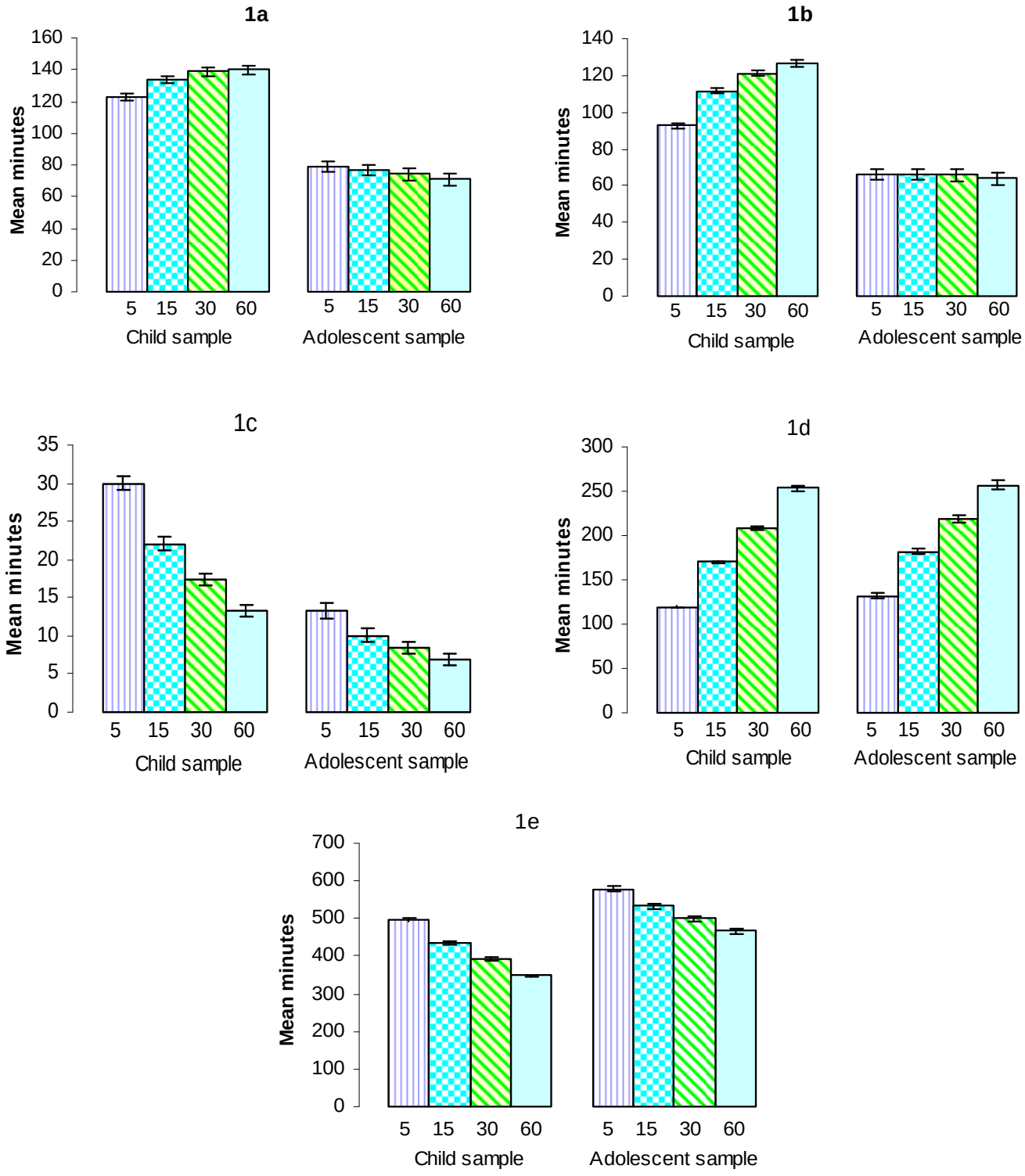
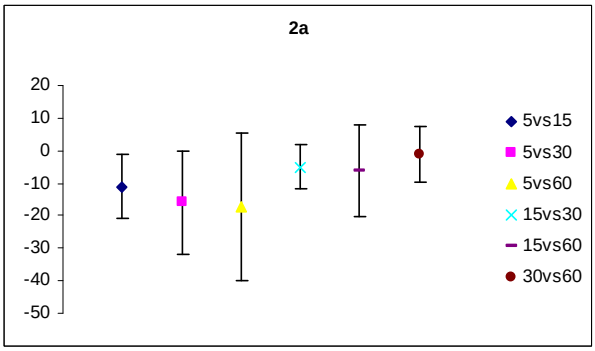
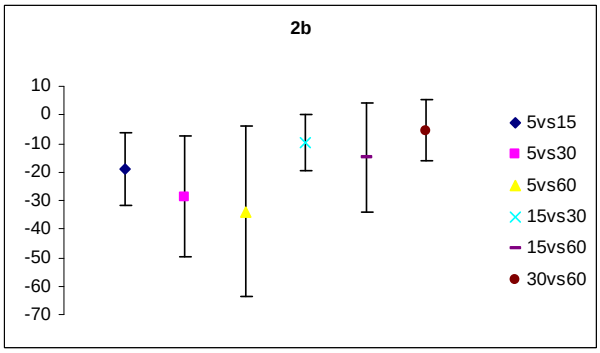
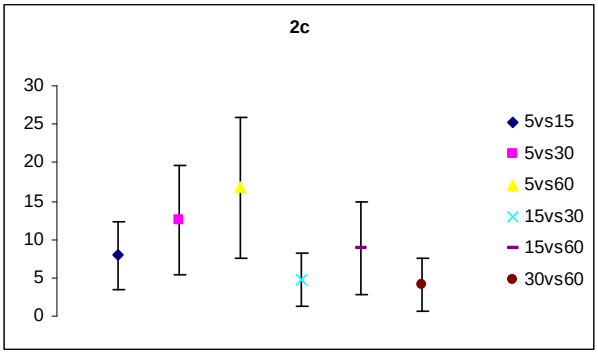
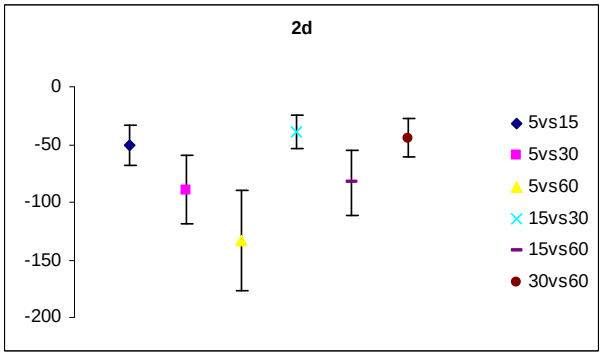


Figure 3.1 Mean number of minutes (y axis) spent in MVPA (1a), MPA (1b), VPA (1c), light PA (1d) and rest (1e) measured with four different epoch settings (x axis). A significant main effect was observed for time spent VPA, light PA and rest for both the child and adolescent samples ($p < 0.05$) and MVPA and MPA in just the child sample ($p < 0.05$).









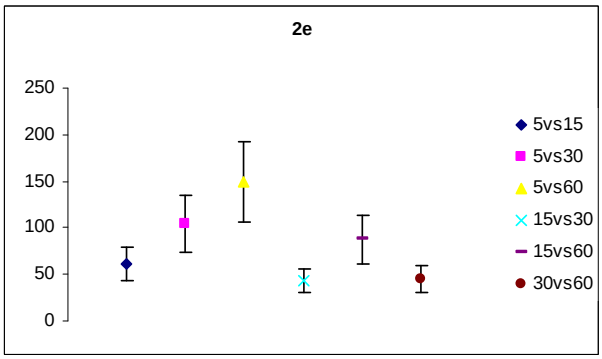
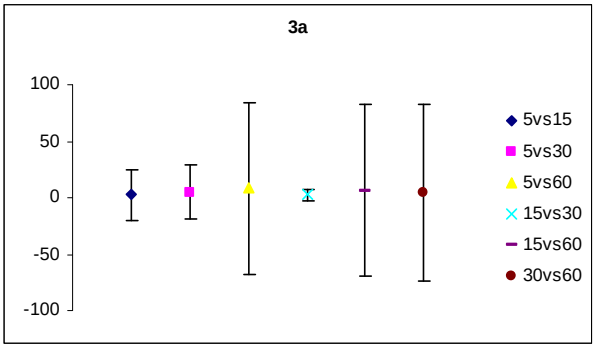
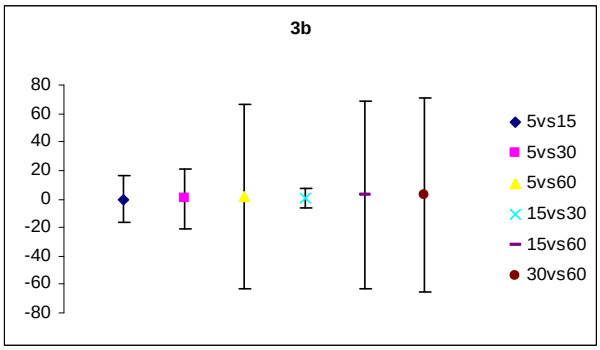
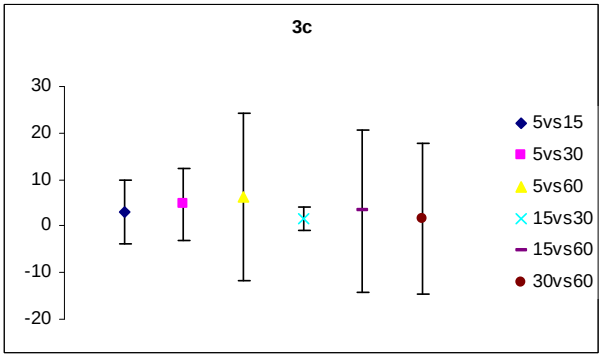
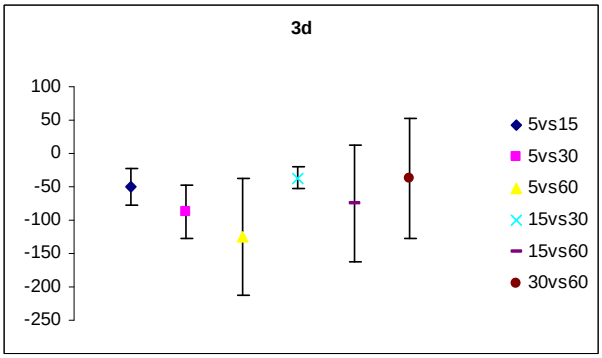


Figure 3.2 Bias and 95% confidence intervals (x axis) for each epoch for minutes (y axis) spent in MVPA (2a), MPA (2b), VPA (2c), Light PA (2d) and rest (2e) for children.









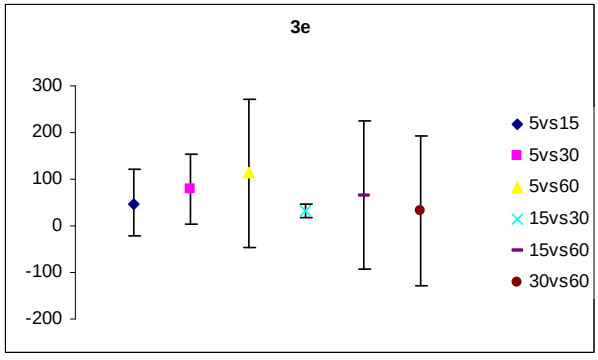


Figure 3.3 Bias and 95% confidence intervals (x axis) for each epoch for minutes (y axis) spent in MVPA (3a), MPA (3b), VPA (3c), Light PA (3d) and rest (3e) for adolescents.

to zero indicating that the epoch lengths are producing similar results and 95% limits of agreement were small suggesting that comparison of physical activity levels between activity prevalence studies employing these different epochs lengths could be made.

Previous research using child samples reported similar epoch effects for time spent in MVPA (186) and VPA (159, 194). However, for other intensities previous studies have either found no significant epoch effect or that a short epoch was associated with more time being spent in a given physical activity intensity which contrasts with the current study's findings. The inconsistencies could be attributed to the differences in epoch lengths examined between the present study and previous research. For example, Rowlands et al. (194) compared a 1 second and 60 second epoch, Nilsson et al. (159) reintegrated a 5 second epoch into 10, 20, 40 and 60 second epochs and Reilly et al. (186) reintegrated a 15 second epoch into 30, 45 and 60 second epochs. Another contributing factor may be the large differences in sample sizes between studies.

It is recommended for children to achieve at least 60 minutes of MVPA daily and although significant differences were observed in MVPA between epochs in the child sample, time spent in this intensity did not vary considerably. Using cut-points based on an age specific equation (82), average time spent in MVPA ranged from 122.67 – 139.92 using a 5 second to a 60 second epoch. Therefore, the recommended guidelines are achieved regardless of the epoch length used which is an agreement with previous research (186). This finding suggests that if the aim of a study is to measure MVPA then choice of epoch length is less important. It is important to note however, that the achievement of recommended guidelines is dependant on the cut-points employed to determine time spent in MVPA (151). As a result of employing different published cut-points average time spent in MVPA may not have reached recommended levels.

In the adolescent sample, a significant epoch effect was observed for time spent in VPA, LPA and rest. For VPA and rest, a shorter epoch was associated with more time being spent in that intensity. In contrast, for LPA a shorter epoch was associated with less time being spent in that intensity. Further analysis using the Bland-Altman method showed considerable agreement was observed between the 5 and 15s, 5 and 30s and 15 and 30 s epoch lengths for MVPA, MPA, VPA, LPA and rest. For these epoch lengths bias was closer to zero indicating that the epoch lengths are producing similar results

and 95% limits of agreement were small suggesting that comparison of physical activity levels between activity prevalence studies employing these different epochs lengths could be made.

Although significant differences in estimates of time spent in VPA, LPA and rest in both the child and adolescent sample and MVPA and MPA in just the child sample with different epoch lengths were found, the biological significance of these differences in accelerometer output is unclear. Further research examining whether these observed differences in estimates of time spent in different intensities of physical activity affect indices of health is needed.

Studies examining patterns of physical activity amongst children have concluded that children's physical activity is intermittent and characterised by rapid changes from rest to VPA. Bailey et al. (12) reported that the mean duration of LPA and MPA was 6s and a mean duration of 3s for VPA. In agreement with this, Baquet et al. (15) found that the mean duration of LPA and MPA was 9s and VPA mean duration was 3s with 80% of MVPA bouts and 93% of VPA bouts lasting less than 10s. The results of the current study demonstrate that using a 5 second epoch would be more effective than longer epochs in detecting these short bouts of physical activity and would therefore enable the 'real' patterns of children's physical activity to be measured. Further evidence to demonstrate that a 5 second epoch may be most appropriate for use with young people can be seen in bone health research. High intensities of strain to the musculoskeletal system appear to be more important than the volume of activity to bone development and therefore short periods of intense activity would be particularly important (194). It is important therefore, that these short intense periods are captured during physical activity measurement and this current study demonstrates that a 5 second epoch would be the most appropriate epoch length to detect these types of physical activity. Furthermore, McClain and colleagues (135) found that a 5-second epoch along with applying Freedson et al's (82) cut-points yielded similar mean estimates of MVPA compared with a direct observation criterion standard. Although they found that all Freedson epochs (5,10,15,20,30 and 60 seconds) yielded similar estimates of MVPA, a 5-second epoch yielded the lowest root mean squared error. It was concluded that short epoch lengths should be used to minimize error among individual estimates.

The unique contribution of the present study is the large sample size of 311 children and 234 adolescents. Previous research in this area included sample sizes ranging from 16 – 32 participants. Furthermore, to our knowledge this is the first study to examine the effect of epoch length in an adolescent sample. However, as with previous research that has examined the effect of epoch length on physical activity intensity, the results of this study should be interpreted with some caution. This is because studies have used 60 second epochs when determining cutpoints for different physical activity intensities and at present there is no evidence to support the validity of epoch-adjusted cutpoints (134). Furthermore, the ActiGraph GT1M was unable to assess physical activity for 7 days whilst using an epoch of < 5 seconds. An epoch length < 5 seconds may be more appropriate than 5 second epochs for measuring young people's physical activity. Finally, the lack of a criterion measure of physical activity intensity to allow for determination of which epoch length produced the most accurate estimate of physical activity was an additional limitation.

Conclusions

Overall, the results of the present study suggest that if MVPA and the recommended guidelines for physical activity are the outcome of interest then the choice of epoch length is less important. However, if time spent in individual intensities of physical activity and/or physical activity periods such as school break times and free play, in which physical activity is intermittent, are the main interest then a short epoch would be recommended. This would provide researchers with a 'real' picture of children's and adolescent's physical activity behaviour and prevent accumulation of counts reflecting the average activity level when longer epochs are used. For example, if young people participate in short bouts of vigorous physical activity followed by longer bouts of light physical activity the accumulation of counts for that minute will only reflect the average activity level during that period as a result of a smoothing effect (240). In addition, activity prevalence studies measuring physical activity at population levels which employ epoch lengths of 5 and 60 seconds in a child or adolescent sample should not be compared, nor should 15 and 60 second epochs and 30 and 60 second epochs in an adolescent sample.

Several issues on epoch length still remain unclear. Firstly, it is not known which epoch length produces the most accurate estimate of actual physical activity performed. To

address this issue comparison of time spent in rest, light, moderate, vigorous and moderate-to-vigorous physical activity against a criterion measure such as direct observation needs to be examined. Secondly, although this current study demonstrates that a 5 second epoch would be the most appropriate epoch length to detect short periods of intense physical activity even shorter epoch lengths (i.e., 1 or 2 second epoch lengths) may be more appropriate and therefore require further investigation. Thirdly, if epoch lengths other than 60 seconds are going to be employed and consequently different physical activity intensities determined then research into the validity of epoch-adjusted cut-points needs to be conducted. Finally, as noted by Cliff, Reilly, and Okley (45) clarification of the biological significance of differences in estimates of MVPA, MPA, VPA, LPA and rest according to differing epoch lengths is warranted.

Chapter 3.2

3.2 Processing Accelerometer Data: The Impact of Decision Rules on Child and Adolescent Data Sets

Introduction

Assessing physical activity in children and adolescents has long been a challenge for epidemiologists, exercise scientists, clinicians, and behavioural researchers (236). A variety of techniques are available to measure physical activity including doubly labelled water, direct and indirect calorimetry, direct observation, self report questionnaires (for the child and parent), activity diaries, heart rate monitoring, interviews, and motion sensors, such as pedometers and accelerometers (47).

Self-report questionnaires have been the most commonly used technique for assessing physical activity because of their low cost, feasibility and ease of administration. However, young people can have difficulty in accurately recalling their past physical activity (215) and therefore, objective measures of physical activity such as accelerometers, are increasingly being used as the preferred technique to measure physical activity in children and adolescents in free-living studies (2, 24, 148, 165).

Although accelerometers have helped to overcome some of the challenges of self-report instruments (e.g. recall bias), a number of other challenges have emerged particularly in the area of processing accelerometer data (130, 132).

Researchers have a number of important decisions to make when processing accelerometer data which include deciding on the number of hours that constitute a valid day, defining non-wearing time, deciding on the minimum number of days to be used in the analysis and extracting moderate-to-vigorous physical activity by applying cut-points to the data. In the absence of a single accepted protocol for processing accelerometer data, researchers have not consistently applied the same processing rules making it difficult to compare physical activity data across studies.

Mâsse et al (130) assessed the impact of using various decision rules with an adult data set on outcome variables such as counts per day, minutes of moderate-to-vigorous physical activity (MVPA) and prevalence of adults meeting physical activity recommendations. They concluded that the decision rules employed to process accelerometer data have a significant impact on commonly used outcome variables. This is important because it shows that we cannot compare studies which have employed different decision rules when processing accelerometer data in adults. Recently with a large sample of children aged 11 years, Mattocks et al. (132) investigated different combinations of minimum day length and minimum number of recording days in a large sample of children. They demonstrated that various combinations of days and minutes per day revealed little difference in power. Furthermore, systematic differences in counts/min between number of days were small. However, Mattcocks et al. (132) did not examine the effects of all processing decision rules and one important decision rule that the previously discussed studies did not examine was the impact of cut-points on outcome variables. Previous studies (73, 77, 82, 180, 235) have focused on interpreting counts by providing cut-points that correspond to various physical activity intensities, however the boundaries for defining intensity categories vary considerably among these studies. A small number of studies (9, 91, 92, 151, 186, 249) have compared the effect of various published cut points on physical activity data in children and adolescents. These researchers found that employing different published cut-points had implications for time spent in MVPA. Although studies investigating accelerometer decision rules are beginning to emerge, much still remains to be learned on how they can impact on outcome variables across participants of different ages. Furthermore, clarification of comparability of studies employing different decision rules is important as large differences in outcomes could affect data interpretation between studies.

The purpose of this research is therefore to investigate the impact of applying different processing rules to the same dataset on (a) participant numbers; (b) time in different intensities of physical activity; and (c) percentage of participants achieving the recommended guidelines for moderate-to-vigorous physical activity in a sample of children (aged 7-11 years old) and adolescents (aged 12-16 years old).

Methods

Participants

Participants consisted of two groups of young people from primary and secondary schools throughout England: The first set of data were collected between December 2005 and February 2006 as baseline data for a larger study and consisted of 311 children aged 7-11 years old (49% male). The second set of data were collected between October 2007 and May 2008 as part of a larger study and consisted of 234 adolescents aged 12-16 years old (56% male). Before participation informed consent was obtained from the head teacher and the parent or guardian of all participants and children provided assent. Study procedures were approved by the Ethical Advisory Committee of Loughborough University.

Procedure

All participants were asked to wear an Actigraph GT1M accelerometer (ActiGraph, Fort Walton Beach, FL) for 7 days during waking hours. The Actigraph was initialised with a start and end time and a 5 second epoch. The accelerometer was attached to a flexible belt that was fastened around the participants' waist. After 7 days the accelerometers were collected and data were uploaded to a data reduction programme. The decision rules we chose to apply to the data are shown in Table 3.1. As each decision was being investigated the other decisions were held constant. These constant values are marked with an * in Table 3.1. These decision rules were first applied to the children's accelerometer data and then repeated in the adolescent sample.

Statistical Analysis

The number of participants retained, minutes in MVPA, moderate physical activity (MPA), vigorous physical activity (VPA), light physical activity (light PA) and rest, and the percentage of participants achieving the guidelines for MVPA were the variables compared across decision rules. The processed data were automatically stored into the Statistical Package for Social Sciences, 16.0 (SPSS). Descriptive statistics were used to examine mean and standard deviation for time spent in different physical activity intensities for the various decision rules. Difference between mean minutes of MVPA, VPA, MPA, light PA and rest for each decision rule were assessed using one-way ANOVA. Four separate ANOVA's were conducted for each set of decision rules. Post-

Table 3.1 Accelerometer processing decision levels investigated

Decision	**Levels investigated**
Hours constituting a valid day	8, 9*, 10
Minutes of consecutive zero's indicating non-wearing	10, 20*, 30
Number of valid days required	Any 4 days, minimum of 4 days (including 1 weekend day)*, minimum of 3 days (including 1 weekend day), Any 3 days
Cut points for MVPA	Freedson et al. (82) 884cpm (children) & 1676cpm (adolescents) Ekelund et al. (73) 2000cpm Eston et al. (76) 501cpm Treuth et al. (235) 3000cpm Puyau et al. (180) 3200cpm

*Constant value employed when investigating other decisions

hoc Tukey tests followed any significant ANOVA's. Agreement between cut points for different physical activity intensity levels was investigated by employing the Bland-Altman method (30). The significance level was set at $p < 0.05$.

Results

The effect of each combination of decisions rules on participant numbers, time in MVPA and percentage of participants meeting the recommended physical activity guidelines are shown in Table 3.2.

Effect on sample size

Different levels of each decision rule resulted in different numbers of participants being retained. The decision rule of any 3 days being required as the minimum number of days used in the analysis, resulted in the greatest number of participants being retained for the child and adolescent samples (82.3% and 60.3% respectively).

Day Length

Altering the number of wearing hours required to constitute a valid day had a significant effect on the recorded hours of physical activity for children. For example, in the child sample significant differences were demonstrated in MVPA ($F(2, 551) = 3.14$, $p<0.05$), MPA ($F(2, 551) = 3.68$, $p<0.05$), light PA ($F(2, 551) = 4.56$, $p<0.05$) and rest ($F(2, 551) = 13.64$, $p<0.05$) between hours. Post hoc tests revealed that there were significant differences in recorded MVPA, MPA, and light PA between day length of 8 hours and 10 hours ($p<0.05$). For time spent in rest, significant differences were observed between all hours ($p<0.05$). No significant differences were seen for VPA ($p>0.05$). Greater levels of all intensities of physical activity were associated with longer days. However, in the adolescent sample no significant differences by day length were observed for any intensity of physical activity ($p>0.05$).

Non Wear Period

In both the child and adolescent data samples, altering the number of consecutive minutes of zero's required to indicate that the participant was not wearing the accelerometer did not have a significant effect on the recorded hours of MVPA, MPA,

Table 3.2. The effect of each combination of decisions rules on participant numbers, time in MVPA (minutes) and percentage of participants meeting the recommended physical activity guidelines

Decision	Level investigated	Number (%) of participants retained		Minutes (SD) in MVPA		Minutes (SD) in LPA		Minutes (SD) in rest		Percentage of participants achieving the guidelines for MVPA	
		Children	Adolescents	Children	Adolescents	Children	Adolescents	Children	Adolescents	Children	Adolescents
Hours constituting a valid day	8	213 (64.5%)	103 (44.0%)	119.5 (25.4)	79.5 (32.0)						
	9*	188 (60.5%)	93 (39.7%)	122.7 (25.1)	80.4 (32.6)						
	10	153 (49.2%)	83 (35.5%)	126.2 (25.4)	82.1 (34.7)						
Minutes of consecutive zero's indicating non-wearing	10	177 (56.9%)	86 (36.8%)	124.8 (24.5)	82.1 (33.7)						
	20*	188 (60.5%)	93 (39.7%)	122.7 (25.1)	80.4 (32.6)						
	30	194 (62.4%)	96 (41.0%)	121.9 (24.7)	79.5 (32.5)						
Number of valid days	Any 4 days	222 (71.4%)	107 (45.7%)	122.3 (24.9)	80.2 (31.4)						
	Minimum of 4 days including 1 weekend day*	188 (60.5%)	93 (39.7%)	122.7 (25.1)	80.4 (32.6)						
	Minimum of 3 days including 1 weekend day	200 (64.3%)	110 (47.0%)	122.1 (25.1)	82.0 (33.7)						
	Any 3 days	256 (82.3%)	141 (60.3%)	121.3 (24.7)	80.7 (32.3)						
Cutpoints for moderate intensity physical activity											
Freedson et al (82)*	884 cpm (child)/1676 cpm (adolescent)			122.5 (25.2)	80.4 (32.6)	119.1 (18.0)	131.8 (28.5)	496.6 (51.1)	578.3 (76.3)	100	72
Ekelund et al (73)	2000 cpm			65.2 (18.2)	70.1 (30.2)	93.3 (15.6)	72.2 (17.7)	575.9 (55.0)	648.2 (73.5)	57	57

Eston et al (76)	501 cpm	160.7 (29.4)	118.0 (33.3)	81.3 (12.3)	68.2 (14.3)	496.2 (51.0)	578.6 (76.3)	100	97.8
Treuth et al (235)	3000 cpm	38.0 (13.6)	35.3 (18.8)	206.3 (30.9)	167.8 (37.3)	493.8 (51.2)	576.9 (76.6)	7	21.5
Puyau et al (180)	3200 cpm	34.4 (12.9)	40.3 (21.8)	94.7 (16.8)	101.4 (53.0)	609.1 (54.1)	647.0 (91.1)	3	18.3

*Constant value employed when investigating other decisions

VPA and light PA (p>0.05). Significant differences however, were demonstrated for time spent in rest in both the child and adolescent samples (F(2, 556) = 16.46, p<0.05; F(2, 272) = 16.28, p<0.05 respectively). Post hoc tests revealed significant differences between all number of zeros in both the child and adolescent samples (p<0.05), with 30 minutes of continuous zeros resulting in the greatest time spent in rest.

Number of Days

Changing the number of days required for analysis in both the child and adolescent samples did not have a significant effect on recorded hours of MVPA, MPA, VPA, light PA and rest (p>0.05).

Cut-points

There is considerable variance in recorded time in MVPA when different published cut-points are applied to both the child and adolescent data sets (see Table 3.2). In the child sample significant differences were observed in MVPA (F(4, 940) = 1331.37, p<0.05), MPA (F(4, 940) = 2181.78, p<0.05), VPA (F(4, 940) = 411.32, p<0.05), light PA (F(4, 940) = 1247.47, p<0.05) and rest (F(4, 940) = 1247.47, p<0.05) between cut-points. Post hoc tests revealed significant differences in MVPA and MPA between all cut-points that were applied (p<0.05), with the exception being between Puyau and Treuth for MVPA (p>0.05) and between Ekelund and Treuth for MPA (p>0.05). Applying the Eston cut-point resulted in the greatest time in MVPA and MPA. For VPA, post hoc tests demonstrated significant differences between all cut-points (p<0.05), with the Ekelund cut-point resulting in the greatest time in VPA. Significant differences were observed in post hoc tests for light PA between all cut-points with the exception being between Ekelund and Puyau (p>0.05). Applying Treuth's cut-points resulted in the greatest time in light PA. Post hoc tests for time in rest revealed significant differences between the majority of cut-points with the exception being between Freedson and Eston, Freedson and Treuth, and Eston and Treuth (p>0.05). Applying Puyau's cut-points resulted in the greatest time spent in rest.

In the adolescent sample significant differences were observed in MVPA (F(4, 460) = 155.60, p<0.05), MPA (F(4, 460) = 243.49, p<0.05), VPA (F(4, 460) = 137.87, p<0.05), light PA (F(4, 460) = 148.36, p<0.05) and rest (F(4, 460) = 21.73, p<0.05) between cut-points. Post hoc tests revealed significant differences in MVPA between

the majority of cut-points with the exception being between Freedson and Ekelund and between Puyau and Treuth (p>0.05). For MPA, significant differences were demonstrated in post hoc tests between all cut-points that were applied with the exception being between Puyau and Treuth (p>0.05). Eston cut-points resulted in the greatest time in MVPA and MPA. Significant differences were observed in post hoc tests for VPA between all cut-points that were applied with the exception being between Freedson and Treuth (p>0.05). Applying Ekelund's cut-points resulted in the greatest time spent in VPA. Post hoc tests demonstrated significant differences in light PA between all cut-points with the exception being between Ekelund and Eston (p>0.05). Applying Treuth's cut-points resulted in the greatest time in light PA. For time in rest, significant differences were observed in post hoc tests between the majority of cut-points with the exception being between Freedson and Eston, Freedson and Treuth, Ekelund and Puyau, and Eston and Treuth (p>0.05).

Furthermore, there is substantial difference in the percentage of participants reaching physical activity guidelines depending on the cut-point applied in both the child and adolescent samples (see Table 3.2). The percentage of participants meeting the physical activity guidelines ranged from 3-100% in the child sample and 18-98% in the adolescent sample.

Table 3.3 presents the mean, bias and 95% limits of agreement. There is considerable lack of agreement between the majority of cut points for the various physical activity intensities in both the child and adolescent samples. The exception being between Puyau and Treuth's cut points, who showed reasonable agreement on estimates of MVPA, MPA and VPA in both the child and adolescent samples.

Discussion

The purpose of this study was to investigate the impact of applying different accelerometer processing decision rules, which are commonly used within the literature, on a child and an adolescent data set. In the literature researchers have differed in the decision rules they apply when processing accelerometer data. It is important to understand how these decisions impact on data to inform future comparability of studies. The current study's results demonstrated that processing rules significantly impact on physical activity data. The number of hours that constitute a valid day, the

cut-points employed and indicators of non wear time had significant effects on time spent in different intensities of activity.

At present there is no single accepted criterion for the identification of how many hours constitutes a valid day of measurement. Previous child and adolescent studies have used 8 hours (56, 71), 9 hours (49, 73), and 10 hours (7, 159, 164, 187). Another approach to determining a day is the 70/80 rule (43), where a day is defined as the period during which 70% of the study population has recorded accelerometer data, and 80% of that observed period constitutes a minimal day. The results of the current study demonstrate that the choice of day length effects recorded time spent in physical activity for children. Therefore, researchers need to decide on a standard day length to be used in analysis to allow for comparisons to be made between studies.

Although not all processing decision rules impacted on physical activity levels, they each had an impact on participant numbers which is also important for researchers. The largest sample size was found when using a minimum of any 3 valid days for analysis and changing the minimum number of valid days had no significant effect on MVPA. Previous research has found that a minimum of any 4 days of measurement produced a .8 reliability coefficient (242). However, Mattocks et al. (132) found that 3 days of physical activity measurement gave a reliability coefficient of .7 which they concluded was acceptable. In the current study a minimum of any 3 valid days reduced the number of participants excluded for analysis and did not effect time spent in MVPA, therefore any 3 valid days may be worthy of further investigation. Additionally, results demonstrated that including a weekend day within the minimum requirement of days did not effect time spent in MVPA. This finding is reinforced by research conducted by Mattocks et al. (132) who concluded that a weekend day was not necessary for analysis in their sample. Therefore, it appears that to specify a weekend day to be included as a requirement for analysis is not necessary and selecting a minimum of any 3 valid days for the analysis may be appropriate and would provide researchers with a larger sample size.

The cut-points employed to convert accelerometer counts into different physical activity intensities resulted in the largest significant differences in time in physical activity. Mean time in MVPA ranged from 34 – 161 minutes/day for children and 35 – 118

Table 3.3 Mean (minutes), bias (minutes) and level of agreement (minutes) between each cut-point in the child and adolescent sample

	Children				Adolescents			
Cut-points	Mean (mins)	Bias (mins)	95% Limits of agreement (mins)		Mean (mins)	Bias (mins)	95% Limits of agreement (mins)	
Freedson & Ekelund								
MVPA	93.83	57.27	-1.01	115.56	75.25	10.23	3.95	16.52
MPA	59.83	65.55	31.28	99.82	45.23	43.44	4.45	82.42
VPA	34.01	-8.28	-42.81	26.26	30.03	-33.20	-68.17	1.76
LightPA	106.20	25.81	-21.11	72.73	101.99	59.67	33.43	85.91
Rest	536.24	-79.32	-218.22	59.58	613.26	-69.90	-98.53	-41.28
Freedson & Eston								
MVPA	141.57	-38.19	-50.35	-26.04	112.05	-63.37	-93.78	-32.95
MPA	115.48	-45.76	-60.27	-31.25	92.48	-51.08	-78.87	-23.29
VPA	26.09	7.57	2.56	12.58	19.57	-12.29	-27.58	3.00
LightPA	100.17	37.86	25.81	49.91	100.00	63.64	32.86	94.42
Rest	496.40	0.35	-0.84	1.53	578.44	-0.27	-1.05	0.51
Freedson & Puyau								
MVPA	78.42	88.10	57.04	119.17	61.20	38.34	12.16	64.51
MPA	62.33	60.55	33.65	87.45	53.60	26.70	0.89	52.50
VPA	16.09	27.55	6.30	48.81	7.60	11.64	-5.16	28.44
LightPA	106.90	24.42	-2.69	51.52	116.63	30.38	-57.59	118.34
Rest	552.83	-112.50	-145.88	-79.12	612.67	-68.71	-155.65	17.93

Freedson & Treuth								
MVPA	80.24	84.47	54.86	114.07	63.12	34.50	11.61	57.40
MPA	59.52	66.17	41.70	90.65	51.13	31.63	9.90	53.37
VPA	20.72	18.30	5.18	31.41	12.00	2.87	-1.13	6.87
LightPA	162.71	-87.22	-117.89	-56.54	149.80	-35.96	-59.78	-12.15
Rest	495.19	2.76	0.75	4.78	577.58	1.46	-0.04	2.96
Ekelund & Eston								
MVPA	112.93	-95.47	-160.36	-30.57	106.93	-73.60	-109.28	-37.92
MPA	82.71	-111.31	-158.38	-64.24	70.76	-94.52	-145.09	-43.95
VPA	30.22	15.85	-16.14	47.83	36.17	20.91	-0.78	42.61
LightPA	87.27	12.05	-27.42	51.51	70.17	3.97	-18.02	25.95
Rest	536.06	79.67	-59.28	218.61	613.40	69.64	41.44	97.83
Ekelund & Puyau								
MVPA	49.78	30.83	-11.31	72.97	56.08	28.10	7.82	48.39
MPA	29.55	-5.00	-30.25	20.24	31.88	-16.74	-52.55	19.07
VPA	20.23	35.83	8.65	63.00	24.21	44.84	-1.25	90.93
LightPA	93.99	-1.40	-45.44	42.65	86.80	-29.29	-116.38	57.80
Rest	592.49	-33.18	-174.55	108.18	647.62	1.19	-83.66	86.04
Ekelund & Treuth								
MVPA	51.60	27.19	-15.74	70.13	58.00	24.27	7.34	41.20
MPA	26.74	0.62	-19.38	20.62	29.41	-11.80	-40.78	17.17
VPA	24.86	26.57	-2.21	55.35	28.59	36.07	-1.85	73.99
LightPA	149.81	-113.03	-180.67	-45.38	119.97	-95.63	-135.34	-55.93
Rest	534.85	82.08	-57.18	221.34	612.53	71.37	41.81	100.92

Eston & Puyau								
MVPA	97.52	126.29	84.83	167.75	92.88	101.70	49.28	154.12
MPA	85.21	106.31	68.35	144.27	79.14	77.77	31.96	123.59
VPA	12.31	19.98	3.08	36.88	13.75	23.93	-5.15	53.01
LightPA	87.97	-13.45	-40.21	13.32	84.81	-33.26	-129.49	62.98
Rest	552.65	-112.85	-146.16	-79.54	612.80	-68.45	-155.27	18.38
Eston & Treuth								
MVPA	99.33	122,66	82.51	162.80	94.80	97.87	48.01	147.73
MPA	82.40	111.93	74.95	148.91	76.67	82.71	38.45	126.99
VPA	16.94	10.73	2.36	19.09	18.13	15.16	-3.72	34.03
LightPA	143.78	-125.08	-166.22	-83.93	117.99	-99.60	-150.85	-48.35
Rest	495.02	2.42	0.74	4.10	577.71	1.73	-0.20	3.66
Puyau & Treuth								
MVPA	36.19	-3.63	-5.57	-1.70	43.95	-3.83	-7.57	-0.09
MPA	29.24	5.62	-2.71	13.96	37.78	4.94	-8.84	18.72
VPA	6.95	-9.23	-18.41	-0.10	6.17	-8.77	-22.42	4.87
LightPA	150.51	-111.63	-145.61	-77.65	134.61	-66.34	-152.61	19.93
Rest	551.44	115.26	80.78	149.75	611.94	70.17	-16.71	157.06

Mean = The average of the two methods. **Bias** = The average of the differences. The bias is computed as the value determined by one method minus the value determined by the other method. **Limits of agreement** = The standard deviation of the differences between the two methods.

minutes/day for adolescents when employing different cut-points. Further analysis using the Bland-Altman method showed considerable lack of agreement between the majority of cut-points. This lack of agreement between cut-points makes comparison between studies using different cut-points inappropriate and suggests such studies should not be compared. However, reasonable agreement was demonstrated on MVPA, MPA and VPA levels between Puyau (180) and Treuth's (235) cut-points and therefore, studies employing these cut-points on child and adolescent samples might reasonably be compared.

Applying cut-points to determine time spent in MVPA enables researchers to evaluate compliance with physical activity guidelines. The results of the current study show that the percentage of participants that complied with the physical activity guidelines differed across cut-points. In both the child and adolescent samples, nearly all of the participants would meet the guidelines when the Freedson (82) and Eston (76) cut-points were applied. However, when applying Puyau (180) and Treuth's (235) cut-points only a small percentage of the sample would reach the recommended guidelines. In the recent HSE (99) it was found that 33% of boys and 27% of girls aged 7-10 years and 30% of boys and 17% of girls aged 12-15 years achieved the recommended guidelines. These values fall between the values found with Ekelund's and Treuth's cut-points of 2000 and 3000 cpm for MVPA respectively. Very recently, Mattocks et al (131) conducted a calibration study using free-living activities in children aged 12. Moderate intensity activity had a lower threshold of 3581 counts per minute and vigorous intensity activity had a lower threshold of 6130. However, it is important to note that their moderate intensity threshold was based on 4 METs and previous calibration studies (180) have based moderate intensity activity on 3-6 METs. The lower threshold for 3 METs was 2306, which is close to Ekelund's (73) threshold for moderate intensity activity.

In recent years, researchers have employed accelerometers to measure time spent in sedentary activities. The cut-point thresholds for sedentary activities also vary and the current study demonstrates that employing different thresholds has a significant effect on time spent in sedentary activity. An agreement on a sedentary threshold is as important as an agreement on an MVPA because it would allow researchers to better examine the health consequences of sedentary behaviour in young people.

The lack of agreement between cut-points may be explained by the differences in study design from which the cut-points originated. Studies have differed in age range of participants, number of participants and physical activities used to determine cut-points. Furthermore, some have been created in laboratory settings and others in free-living situations. While laboratory-based studies may produce close estimates of energy cost for a set of structured activities in the laboratory, they are unlikely to be valid throughout the range of activities that take place in free-living situations. Moreover, all cut-point studies have chosen a 60 s epoch when defining all physical activity intensities, which has been shown to underestimate time in high intensity activity (159).

The strengths of this study include the use of both a child and adolescent data set and the comparison of five commonly used published cutpoints. Although this study demonstrated considerable variance in time spent in different intensities of physical activity with different cutpoints, this study is limited by the lack of a criterion measure of physical activity intensity which would have determined the cutpoint that produced the most accurate estimate of physical activity.

Conclusions

This study demonstrates the impact of a variety of common decisions researchers have to make when processing accelerometer data. The number of hours that constitute a valid day of measurement and the cut-points employed to estimate time spent in different intensities of physical activity have a significant effect on time spent in MVPA, MPA, VPA and light PA. Researchers do not employ the same decision rules, which makes comparability of physical activity between studies difficult. Although this study provides some insight into the comparability of studies employing different decision rules and cut-points, the important question of which cut-point is the right one to employ still remains to be answered. There is a risk of misinterpretation depending on the cut-points employed as the same group of participants can be described as either sufficiently active or inactive. Accurate knowledge of physical activity levels is important because it allows researchers to develop intervention programmes, to assess their effectiveness and to assess health outcomes associated with physical activity. A standardised approach to processing accelerometer data and an agreement on physical activity intensity thresholds is needed as this would allow direct comparison of physical activity between studies.

Chapter 4

Activity-Related Parenting Practices and Children's Objectively Measured Physical Activity

This chapter examines mothers' and fathers' activity-related support (explicit modelling, logistic support and limiting sedentary behaviour) and its effect on objectively measured physical activity using a sample of children from the UK. Data for this chapter were collected in primary schools between November 2005 and February 2006. Findings from this chapter have been presented (poster) at the postgraduate presentation evening, Loughborough University, 15th February 2008. The findings from this chapter have been published in *Pediatric Exercise Science* (Edwardson, C.L. and Gorely, T. 2010, 22(1), 105-113).

Chapter 4

Introduction

Physical activity surveys from several countries indicate that many children are not achieving the established guidelines for physical activity (44, 62, 99). In the UK 67% of boys and 73% of girls aged 7 – 10 years do not achieve the recommendation of moderate intensity physical activity for 60 minutes daily (99). These data demonstrate the need to increase physical activity levels within this age group and a first step in this process is to identify the correlates of physical activity among children.

A large number of correlates have been identified in the literature that may influence children's physical activity levels. These correlates include demographic, psychological, social, and environmental factors (102, 138, 162, 205, 208). Social sources that impact upon children's and adolescent's physical activity have been frequently studied. The family has been considered an important agent of socialisation as children spend the majority of their time within the context of the family during the formative years (122). Families teach skills and inculcate beliefs that can help to shape important attitudes and behaviours associated with physical activity (136). More specifically, parents may exert significant social influence over children's physical activity through encouraging them to be active, being active with their children, providing transportation and funding for activity and by serving as role models for physical activity. Encouragement of activity (162), parental participation in physical activity (105, 200, 206), parental role modelling (206, 264), and provision of transportation to sporting events (200) have all been linked to higher levels of physical activity among children.

Although previous research suggests that parents play an important role in their children's physical activity, the ways in which mothers and fathers differ in their provision of support for physical activity is relatively unexplored (52). Furthermore, the majority of studies examining parental influence and children's physical activity have been conducted in the US, assessed parent support using single item questions and measured physical activity using self-report methods. Self-report can be problematic when used with young children due to difficulties in accurately recalling past behaviour.

Therefore, there is a need for further investigation of multi-dimensional parent support and objectively measured physical activity.

The aim of this study was to explore mothers' and fathers' activity-related support and examine its effect on objectively measured physical activity using a sample of children from the UK.

Methods

Participants

Participants were part of a larger study of 589 children aged 7-10 years. Participants were only included in this analysis if they had support data for both mother and father as well as 3 days of accelerometer data (Chapter 3.2). After applying these rules the final group of participants consisted of 117 children (54 boys and 63 girls). Participants were predominantly White British (95%). Before participation informed consent was obtained from the head teacher and the parent or guardian of all participants and children provided assent. Study procedures were approved by the Ethical Advisory Committee of Loughborough University.

Measures

Parents' activity-related parenting practices. A questionnaire adapted from Davison et al. (52) assessing parents' activity-related parenting practices was completed by both parents. The questionnaire measured logistic support (3 items, e.g. I take my child to places where he/she can be active), explicit modelling (5 items, e.g. I enjoy exercise and physical activity) and support for limiting sedentary behaviour (4 items) e.g. I limit how long my child plays video or computer games). Cronbach's alpha coefficients ranged from 0.71-0.86 for the three subscales indicating satisfactory internal consistency.

Physical Activity. Physical activity was assessed with the Actigraph GT1M accelerometer for 7 days. The Actigraph was initialised with a start and end time and attached to a flexible belt that was fastened snugly around the waist of the participant. For the current study 5-s epochs were used in order to gain a detailed picture of children's physical activity levels. This epoch length has been recommended from analysis conducted in Chapter 3.1 and by Nilsson et al. (159).

Data Reduction

Accelerometer data were uploaded to a data reduction programme (ActiGraph Analysis Tool) for determination of time spent in moderate-to-vigorous physical activity (MVPA), moderate physical activity (MPA) and vigorous physical activity (VPA). The age specific count ranges corresponding to intensity levels were derived from the energy expenditure prediction equation developed by Freedson et al. (82). To account for the use of 5 second epochs the ActiGraph Analysis Tool divided the Freedson equation by 12 to obtain cut points for each physical intensity. A valid day was classified as >9 hours of monitoring per day and participants with less than 3 days of complete monitoring were excluded from the analysis (Chapter 3.2). Missing data was defined as ≥20 minutes of consecutive zero counts.

Statistical Analyses

Differences in Activity Support. Mean scores for each source of support for boys and girls were calculated and gender differences were assessed using analysis of variance. Differences in mothers' and fathers' logistic support, explicit modelling and support for limiting sedentary behaviour was assessed using paired t-tests.

*Relationship between Activity Support and Physical Activity***.** Associations between parents' activity support and children's physical activity were examined using Pearson correlation analysis. To further examine links between activity support and children's physical activity, high and low active groups were created for boys and girls based on a gender-specific mean for time spent in MVPA. Analysis of variance was then used to examine differences in mean levels of activity support for the high and low active groups.

*Combined influence of maternal and paternal support***.** To examine the combined influence of maternal and paternal support on children's physical activity, three parent groups were created. Mothers and fathers were each categorised as providing above or below average support. Above average support was defined as reporting above average logistic support and explicit modelling. The three groups included families in which neither parent, one parent, or both parents reported above-average support. Children were classified as exhibiting high or low levels of physical activity based on gender-specific mean for time spent in MVPA. Using the three parent support groups (no

parent/one parent/both parents) and children's activity groups (high/low), a chi-square analysis was performed to assess whether boys and girls disproportionately fell into each of the activity groups as a function of their parents' overall support of their activity.

Results

Mean and standard deviations for participant characteristics are presented separately for boys and girls in Table 4.1.

Differences in activity support

No significant gender differences in the mean level of activity support were identified for any source of support ($p > 0.05$). Another important question to answer is whether mean levels of logistic support, explicit modelling and support for limiting sedentary behaviour differ between mothers and fathers. Results indicated that there were no significant differences in the mean levels of logistic support and explicit modelling provided by mothers and fathers for boys although mothers reported significantly higher levels of support for limiting sedentary behaviour ($M = 3.15$, $SD = 0.51$) than fathers ($M = 3.05$, $SD = 0.44$) ($t(53) = 2.16$, $p < 0.05$). For girls mothers reported significantly higher levels of logistic support ($M = 3.03$, $SD = 0.59$) than fathers ($M = 2.87$, $SD = 0.63$) ($t(61) = 2.48$, $p < 0.05$) and mothers reported significantly higher levels of support for limiting sedentary behaviour ($M = 3.18$, $SD = 0.48$) than fathers ($M = 3.06$, $SD = 0.54$) ($t(56) = 2.25$, $p < 0.05$).

Relationship between activity support and physical activity

Tables 4.2 and 4.3 present the associations between parenting strategies and accelerometer output. Fathers' explicit modelling was significantly associated with MVPA and VPA for boys. All other variables showed no association with children's physical activity. One-way ANOVA showed no significant differences in the mean level of activity support for any source of support for boys or girls in the high and low active groups ($p > 0.05$).

Combined influence of maternal and paternal support

The combined level of support from mothers and fathers was not related to activity level in boys (χ^2 (2, 50) = 1.35, p> 0.05) or girls (χ^2 (2, 60) = 1.69, p>0.05).

Table 4.1 Mean (M) and standard deviations (SD) for participants

	Boys (n = 54)		Girls (n = 63)	
	M	SD	M	SD
Age (yrs)	8.4	.90	8.3	.90
Height (cm)	134.5	7.3	132.4	8.6
Weight (kg)	31.9	7.3	31.1	8.1
Body Fat (%)	18.1	6.7	24.7	6.1
MVPA (mins)	126.2	27.2	115.1	19.0
MPA (mins)	92.6	17.4	89.9	14.4
VPA (mins)	33.6	13.3	25.2	8.1
MLS	3.03	.66	3.03	.59
PLS	3.05	.66	2.87	.64
MEM	2.93	.60	2.94	.58
PEM	3.02	.54	3.05	.56
MLSB	3.16	.51	3.17	.49
PLSB	3.05	.44	3.07	.53

Abbreviations: MVPA = Moderate-vigorous physical activity, **MPA** = Moderate physical activity, **VPA** = Vigorous physical activity, **MLS** = Maternal logistic support, **PLS** = Paternal logistic support, **MEM** = Maternal explicit modelling, **PEM** = Paternal explicit modelling, **MLSB** = Maternal limiting sedentary behaviour, **PLSB** = Paternal limiting sedentary behaviour.

Table 4.2 Pearson correlations for boys between the subscales of the activity support scale and accelerometer data

	MVPA	MPA	VPA
Maternal logistic support	0.13	-0.00	0.28
Maternal explicit modelling	0.17	0.19	0.09
Maternal sedentary	-0.10	-0.15	-0.01
Paternal logistic support	0.16	0.05	0.26
Paternal explicit modelling	**0.31***	0.19	**0.37***
Paternal sedentary	0.10	0.10	0.08

Note: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

Abbreviations: **MVPA** = Moderate to vigorous physical activity, **MPA** = Moderate physical activity, **VPA** = Vigorous physical activity.

Table 4.3 Pearson correlations for girls between the subscales of the activity support scale and accelerometer data

	MVPA	MPA	VPA
Maternal logistic support	0.14	0.13	0.09
Maternal explicit modelling	0.15	0.25	-0.08
Maternal sedentary	-0.21	-0.16	-0.21
Paternal logistic support	0.23	0.19	0.19
Paternal explicit modelling	0.09	0.18	-0.09
Paternal sedentary	0.00	0.10	-0.15

Note: ** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.

Abbreviations: **MVPA** = Moderate to vigorous physical activity, **MPA** = Moderate physical activity, **VPA** = Vigorous physical activity.

Discussion

The aim of this study was to explore mothers' and fathers' activity-related support and examine its effect on children's objectively measured physical activity using a UK sample of boys and girls.

Data from the present study, as well as data from previous investigations that have utilised a multidimensional activity support instrument (51, 244) suggest that boys and girls do not receive different amounts of activity-related support. In contrast, Sallis et al. (200) found that boys were more likely to be transported to sporting events and receive more encouragement to be active than girls. Furthermore, Beets and colleagues (25) reported that boys perceived more support from parents than girls. The lack of agreement between studies may be due to variations in how activity support was assessed in each study.

The ways in which mothers and fathers differ in their activity-related social support are relatively unexplored (52). The current results indicate that mothers and fathers tended to favour different strategies when encouraging their children to be active. For both boys and girls, mothers provided higher levels of support for limiting sedentary behaviour (i.e. limit TV and computer use) than fathers and also higher levels of logistic support (i.e. enrolling, transporting) for girls than fathers. Such findings are consistent with previous research (52) showing that mothers were more likely than fathers to enrol their children in sport and physical activities and to support them at sporting events. However, in a study where the child's perceptions of parental support were explored, neither boys nor girls perceived different amounts of support from their mother or father indicating no sex-specific support influence from the child's perspective (25).

Despite finding that mothers and fathers favoured different strategies when encouraging their children to be active only explicit modelling from fathers was found to be associated with boys' MVPA and VPA, with no significant associations found with girls' physical activity. This suggests that a possible intervention strategy for low-active boys might be to provide opportunities for fathers and sons to be active together (e.g. discounted sessions at local leisure facilities for fathers and sons), or to target the father's physical activity levels in order to increase physical activity in low-active boys. Similar to current results, previous investigations employing accelerometers (245, 246)

reported that modelling from mothers and fathers was not associated with girls' MPA and MVPA. Furthermore, Adkins et al. (2) found that parent support was not related to children's accelerometer derived MVPA. The lack of associations between activity-related parenting practices and children's objectively measured physical activity could be explained by several factors. Firstly, the activity support was reported by the parents and not the child. Secondly, the relationship may be attenuated because accelerometers are unable to assess common physical activities such as bicycling and swimming which would be measured by other forms of physical activity measures such as a self-report questionnaire. Furthermore, accelerometers capture incidental physical activity that may not require parent support. Another possible explanation for the lack of associations found may be due to the fact that siblings, peers or teachers could exert a greater influence on children's physical activity than parents.

Exposure to activity support did not vary for boys and girls who reported high versus low levels of physical activity and maternal and paternal logistic support, explicit modelling and support for limiting sedentary behaviour were not associated with higher levels of physical activity in boys or girls. This finding both contrasts and reinforces previous research. Two studies (274, 275), utilising an objective measure of physical activity concluded that modelling from mothers and fathers was not related to higher step counts for boys and girls. Furthermore, Bogaert et al. (31), employed a parent proxy report to measure children's physical activity, and reported that father's modelling was not associated with either boys' or girls' physical activity. However, Davison et al. (52) found that logistic support from mothers and explicit modelling from fathers were associated with higher levels of self-reported physical activity in girls.

It is clear that much inconsistency exists between studies. Conflicting findings may be due to variations in the parent support instruments used. Previous studies have employed a variety of different instruments to measure support and also differ on whether support is perceived by the child or reported by the parents. It may be more important to measure the child's perceived support when physical activity is being assessed objectively or being reported by the child using a self report instrument. Furthermore, the amount of support perceived by the child may be different to amount of support reported by parents. Another possible source of inconsistency may arise from the use of different measures of physical activity. Self report, objective measures and

parental proxy measures of physical activity have been employed, but all measure different aspects of physical activity (e.g. moderate-to-vigorous physical activity, organised sport, and leisure time physical activity). It was demonstrated in chapter 2.1 that the relationship between parent support variables and physical activity varied depending on the type of physical activity measured. As noted by Stone et al. (225) a valuable contribution to the field would be to establish internationally accepted measures of physical activity and support for physical activity among young people to overcome some of the inconsistencies and enable comparison between studies.

This paper makes a unique contribution because few studies have examined activity-related parenting practices using a UK sample and employing objective measures of physical activity. Methodological strengths of the present study include the use of an objective measure of physical activity, reporting paternal and maternal supportive behaviour separately and employing a questionnaire that assessed a broad range of parenting practices that promote physical activity. However, the results of this study are limited by the relatively small sample size which was due to difficulties in attaining compliance when using accelerometers, poor response rate from parents and the requirement that children had support data from both mothers and fathers. Furthermore, the generalisability of the results is limited because participants were predominantly white and from two areas in England, thus findings should not be generalized beyond this population. Finally, the cross-sectional design is a limitation because it does not allow causality to be examined. Clearly, further research using longitudinal designs to assess the temporal sequence of parent support and children's physical activity is needed. The influence of siblings, peers and teachers should also be investigated as it is possible that they exert a greater influence on children's physical activity than parents.

Conclusions

Overall, this study shows that mothers and fathers favoured different activity-related parenting practices when encouraging their children to be active and explicit modelling from fathers appears to be important in shaping physical activity in boys. Therefore, interventions to increase physical activity in low-active boys might be focused on father and son interactions and fathers should be encouraged to participate in physical activity and use their own behaviour to encourage their sons.

Chapter 5

Sources of social support and adolescents' physical activity: Gender and age differences

This chapter describes a study examining social support and adolescents' physical activity. Data for this study were collected in secondary schools in the East Midlands region of the UK between October 2007 and June 2008. Findings from this chapter have been presented (poster) at the 8th Annual Conference of the International Society for Behavioral Nutrition and Physical Activity (ISBNPA), Cascais, Lisbon, 17th-20th June 2009.

Chapter 5

Introduction

Despite the physiological and psychological benefits of taking part in regular physical activity (27), many adolescents are not physically active enough to benefit their health. According to recent data from the UK only 17% of girls and 30% of boys aged 12-15 years are meeting the recommended physical activity guidelines (99) and as young people progress through high school a marked decline in physical activity has been noted (154, 229, 237).

To prevent this decline in physical activity, it is important to identify the correlates of physical activity in adolescents in order to develop effective interventions. Physical activity however, is a complex behaviour and within the literature numerous demographic, psychological, social, and environmental factors have been identified as potential influences on adolescents' physical activity (205). Of particular interest in the social domain is the influence of significant others on adolescents' physical activity either through modelling of behaviour, direct involvement, encouragement or other forms of support.

Previous research has predominantly focused on parents and peers with little consideration for the influence of siblings and the family unit as a whole. Furthermore, the relative importance of significant others as adolescents progress through high school is not clear. Parents are thought to continue to influence adolescents' physical activity but the role of peers is believed to increase with age (70) as adolescents experience a shift in social support from more to less dependence on their families (138). However, some researchers have shown families (207, 257) to have a continued important role in providing support for physical activity to adolescents whilst others have identified peers as the most important influence (51, 67, 83, 178, 207, 255). Moreover, previous studies suggest that significant others influence boys and girls differently (67, 183, 247, 270, 271) although others have found no gender differences (51).

Few researchers have examined the relative influence of significant others for younger and older adolescents. Duncan and colleagues (67) found that older middle school

students perceived less parent and sibling support than younger ones, and middle school students in general who perceived an increase in support from friends had higher levels of physical activity. In contrast, Robbins, Stommel, and Hamel (191) found that older boys continued to identify parents, especially fathers, as the main support person.

Much inconsistency exists in the literature between social support and physical activity. This could be attributed to variations in support measures and physical activity assessment used in different studies. For example, it has been suggested that the correlates of physical activity may differ as a function of the method used to measure physical activity, thereby impairing the generalisation of the findings obtained with the use of one or the other method (65). In support of this, Prochaska and colleagues (178) reporting on unpublished data within a previous review (205) noted that studies that relied on self-reported physical activity were more likely to find a significant association (M = 57% of tests), than studies that used objective measures of physical activity (M = 25% of tests) (178). It has been recommended that further studies of correlates employ concurrent estimates of activity from different physical activity methods (262).

Further research, utilising reliable and valid support and physical activity instruments, is needed to better understand the relative importance of significant others on boys' and girls' and younger and older adolescents' physical activity. This present study examined age and gender differences in five sources of social support (family, mother, father, siblings and peers) and examined the association between sources of social support and adolescent physical activity measured two ways (self-reported and objective).

Methods

Participants

Participants were 186 boys and 142 girls aged 12-16 years of age who were recruited from three secondary schools in central England. Before participation consent was sought from head teachers and parents and adolescents provided assent. Study procedures were approved by the Ethical Advisory Committee of Loughborough University.

Procedure

Staff at participating schools selected a subset of their classes for participation. All pupils from nominated classes (n= 363) were eligible and received written information on the study. Participants completed the Activity Support Scale under the supervision of trained researchers and class teachers. On completion of the questionnaire participants were given the ActiGraph GT1M accelerometer to wear for 7 days and a questionnaire for their parents to complete. On returning the accelerometer participants completed the 3DPAR in the classroom under the supervision of trained researchers and class teachers.

Adolescent Measures

Physical Activity Support. The Activity Support Scale (51) is a self-report questionnaire assessing: (a) general familial support (3 items, e.g., 'my family and I do active things together'); (b) maternal (12 items) and paternal (12 items) support. These items reflected how much support the mother or father provided in each of the following domains, explicit modelling (5 items, e.g., 'my father often exercises or does something active'), logistic support (3 items, e.g., 'my mother takes me to places where I can be physically active') and limiting sedentary behaviour (4 items, e.g., 'my father limits how long I play video/computer games'); (c) peer support (5 items, e.g., 'my friends think it is important to be physically active'); and (d) sibling support (5 items, e.g., 'my sibling and I like to do active things together'). The questionnaire was answered on a four point scale ranging from strongly disagree to strongly agree. Previous studies have demonstrated adequate psychometric properties for the Activity Support Scale (51) and in the current study Cronbach's alpha coefficients ranged from 0.71 – 0.90 for the subscales indicating satisfactory internal consistency.

Physical Activity. Physical activity was assessed with two instruments, one objective measure, the Actigraph GT1M accelerometer, worn for 7 days and one self-report measure, the 3-day physical activity recall (3DPAR, 269). The Actigraph was initialised with a start and end time and a 5-s epoch (Chapter 3.2). Participants were instructed to wear the accelerometer during waking hours, except during water-based activities. The 3DPAR assessed the previous 3 days of physical activity. It is organised into 34 30-min blocks beginning at 7:00AM and continuing through 12:00AM. Forty-four common activities, including sedentary activities were listed on the form and each participant entered the main activity in which he or she participated during each of the 30-min time

periods on the previous 3 days. The main activity was defined as the activity which occupied the majority of the 30-min time period. For each 30-min block, the student rated the intensity of the designated activity as light, moderate, hard or very hard. For each level of intensity, participants were provided with illustrations depicting activities typical of each intensity level. The 3DPAR shows acceptable reliability (r = 0.68) and validity (r = 0.28) for assessing MVPA in adolescents when compared against the ActiGraph accelerometer (144).

Parent Measures

Parents' Physical Activity Support. A questionnaire assessing parents' activity-related parenting practices (52) was completed by both parents. The questionnaire measured logistic support (3 items, e.g., I take my child to places where he/she can be active), explicit modelling (5 items, e.g., I enjoy exercise and physical activity) and support for limiting sedentary behaviour (4 items, e.g., I limit how long my child plays video or computer games) that the mother and father provided. The questionnaire was answered on a four point scale ranging from strongly disagree to strongly agree. Previous studies have demonstrated adequate psychometric properties for the Activity Support Scale (52) and in the current study Cronbach's alpha coefficients ranged from 0.74 – 0.87 for the subscales indicating satisfactory internal consistency.

Data Reduction

Actigraph GT1M. Accelerometer data were uploaded to a data reduction programme (ActiGraph Analysis Tool) for determination of time spent in moderate-to-vigorous physical activity (MVPA). The age specific count ranges corresponding to intensity levels were derived from the energy expenditure prediction equation developed by Freedson, Sirard, and Debold (82). A valid day was classified as >9 hours of monitoring per day and participations with less than 3 days of complete monitoring were excluded from the analysis (Chapter 3.2). Non-wear period was defined as ≥20 minutes of consecutive zero counts.

3DPAR. Based on the specific activity and the level of intensity reported by the subject, each 30-min block was assigned a literature-based MET value (3). In cases in which the self-reported activity type and intensity level were considered incompatible, the block in question was assigned a MET value considered appropriate for that activity. Participants

who had four or more incompatible responses were excluded from the self-report analysis (169). For each day, the sums of the number of blocks at 3-5.9 METs, classified as moderate physical activity (MPA), and the number of blocks at 6 METs or greater, classified as vigorous physical activity (VPA) were summed to provide the number of blocks per day of moderate-to-vigorous physical activity (MVPA). The average number of blocks of MVPA across the 3 days was calculated and carried forward for analysis. Participants with less than 3 days of physical activity data were excluded from the analysis.

Statistical Analyses

All analyses were conducted using SPSS software version 16.0. Descriptive statistics were used to summarise participant characteristics, physical activity and social support. A 2 x 2 MANOVA was performed to examine gender and age differences in mean levels of activity support. Nine dependent variables (sources of support) were entered and gender (male/female) and age (young/old) were entered as independent variables. Adolescents were split into young and old groups by their school year (i.e. adolescents in school years 8 and 9 were grouped as young adolescents and adolescents in schools years 10 and 11 were grouped as old adolescents). These groupings were chosen because they represent adolescents in middle (years 7-9) and high schools (years 10-11). Correlations were used to examine associations between the five sources of social support and adolescents' physical activity. Variables that showed significant associations at or below .10 level were entered into hierarchical regression models explaining self-reported and objective MVPA. Age and gender were controlled for within the regression analyses. Regression analyses were run separately for self-reported and objectively measured MVPA and perceived and parent-reported support.

Results

In total, 328 adolescents provided parental consent to participate in the study, of these 261 provided perceived support data and either 3 days of self-report data or 3 days of accelerometer data or both. The sample comprised of 139 boys and 122 girls (mean age = 14.2 and 14.3 years respectively). The majority of the sample were white British (95%) and from middle and upper socio-economic backgrounds. Table 5.1 presents mean time spent in physical activity and mean sources of social support by gender for the whole sample and for younger and older adolescents by gender.

Gender and age differences in physical activity and social support

Significant gender and age differences were found for both self-reported and objective MVPA. Boys participated in significantly more self-reported and objective MVPA than girls ($F(1,216) = 13.88$, $p < 0.05$; $F(1,173) = 6.56$, $p < 0.05$ respectively) and younger adolescents participated in significantly more self-reported and objective MVPA than older adolescents ($F(1,216) = 11.47$, $p < 0.05$; $F(1,173) = 26.57$, $p < 0.05$ respectively). The 2 x 2 multivariate analysis of variance examining gender and age differences in mean levels of activity support revealed that the interaction between gender and age was nonsignificant ($F(9,195) = .92$, $p > 0.05$) but there was a main effect for gender ($F(9,195) = 3.81$, $p < 0.05$) and age ($F(9,195) = 2.51$, $p < 0.05$). Specifically boys perceived more support than girls and younger adolescents perceived more support than older adolescents. Univariate analysis revealed that boys perceived more support from their peers than girls ($F(3,203) = 11.87$, $p < 0.05$) and younger adolescents perceived more family support ($F(3,203) = 7.19$, $p < 0.05$), father and mother explicit modelling ($F(3,203) = 7.86$, $p < 0.05$; $F(3, 203) = 17.04$, $p < 0.05$ respectively) and father and mother limiting sedentary behaviour ($F(3,203) = 4.77$, $p < 0.05$; $F(3,203) = 14.22$, $p < 0.05$ respectively) than older adolescents.

Social support and physical activity: Univariate associations

The amount of MVPA measured by the accelerometer was significantly associated with the amount of MVPA blocks reported in the self-report instrument ($r = .30$, $p < 0.05$). All of the perceived parental support variables were significantly associated with the matching parent reported variables ($r = .26$ - $.53$, $p < 0.05$).

Gender Differences

Table 5.2 presents the correlations between self-reported and objective MVPA and each source of adolescent perceived support and parent reported support. Results are reported separately for boys and girls.

Objective MVPA: Perceived peer support was significantly associated with objective MVPA for boys. All other sources of perceived social support showed no association with boys' objective MVPA. For girls no sources of perceived social support were associated with objective MVPA. None of the parent-reported variables were associated with boys' or girls' objective MVPA.

Table 5.1 Physical activity and sources of social support (mean and SD)

	Male	**Female**	**Male**		**Female**	
			Young	**Old**	**Young**	**Old**
Objective MVPA (mins) (n=175)	51.40 (25.98)	42.14 (23.66)	59.63 (28.33)	42.24 (19.05)	51.44 (26.04)	33.05 (16.90)
Self Report MVPA (blocks) (n=218)	4.71 (3.71)	3.03 (2.82)	5.82 (3.35)	3.87 (3.77)	3.67 (3.02)	2.52 (2.57)
Adolescent Perceived Support	**(n = 139)**	**(n = 122)**	**(n = 64)**	**(n = 75)**	**(n = 56)**	**(n = 66)**
Family Support	2.59 (.75)	2.59 (.75)	2.71 (.69)	2.49 (.78)	2.76 (.77)	2.44 (.72)
Mother Logistic Support	2.64 (.73)	2.74 (.75)	2.74 (.69)	2.57 (.76)	2.76 (.74)	2.73 (.76)
Mother Explicit Modelling	2.52 (.58)	2.52 (.63)	2.69 (.55)	2.38 (.56)	2.73 (.63)	2.34 (.58)
Mother Limiting Sedentary Behaviour	2.31 (.65)	2.49 (.66)	2.54 (.64)	2.13 (.59)	2.66 (.73)	2.35 (.57)
Father Logistic Support	2.87 (.81)	2.69 (.78)	2.83 (.87)	2.90 (.76)	2.76 (.81)	2.62 (.76)
Father Explicit Modelling	2.51 (.73)	2.49 (.60)	2.65 (.77)	2.39 (.68)	2.58 (.64)	2.40 (.55)
Father Limiting Sedentary Behaviour	2.49 (.73)	2.41 (.70)	2.60 (.76)	2.40 (.69)	2.53 (.73)	2.31 (.66)
Sibling Support	2.49 (.82)	2.59 (.77)	2.56 (.69)	2.43 (.91)	2.71 (.75)	2.49 (.78)
Peer Support*	3.16 (.55)	2.87 (.59)	3.22 (.51)	3.12 (.58)	2.90 (.57)	2.85 (.62)
Parent Reported Support	**(n=63)**	**(n=71)**	**(n = 27)**	**(n = 38)**	**(n = 35)**	**(n = 36)**
Mother Explicit Modelling	2.93 (.62)	2.83 (.55)	3.02 (.68)	2.88 (.56)	2.95 (.60)	2.71 (.48)
Mother Logistic Support	2.99 (.66)	2.99 (.68)	3.06 (.77)	2.93 (.57)	2.99 (.66)	2.98 (.72)
Mother Limiting Sedentary Behaviour	2.82 (.55)	2.78 (.51)	2.94 (.63)	2.73 (.48)	2.87 (.54)	2.69 (.47)

Father Explicit Modelling	2.95 (.57)	2.85 (.54)	2.88 (.55)	2.99 (.59)	2.87 (.67)	2.83 (.39)
Father Logistic Support	2.96 (.72)	2.99 (.64)	2.70 (.77)	3.11 (.65)	3.06 (.66)	2.93 (.63)
Father Limiting Sedentary Behaviour	2.61 (.53)	2.75 (.49)	2.62 (.58)	2.61 (.51)	2.92 (.55)	2.58 (.37)

Table 5.2 Correlations for perceived and parent reported social support sources and physical activity in boys and girls.

Variable	**Boys**		**Girls**	
Adolescent Perceived Support	**MVPA (Ob)**	**MVPA (SR)**	**MVPA (Ob)**	**MVPA (SR)**
Family Support	.03	.07	.07	.24*
Sibling Support	.02	.12	.11	.30**
Peer Support	.24*	.26*	.05	.27**
Mother Logistic Support	.12	.07	-.12	.21*
Mother Explicit Modelling	-.01	.12	.10	.14
Mother Limiting Sedentary Behaviour	.05	.19*	.02	.39**
Father Logistic Support	.17	.19	-.04	.43**
Father Explicit Modelling	.06	.16	-.22	.19
Father Limiting Sedentary Behaviour	.10	.18	-.00	.17
Parent Reported Support				
Mother Explicit Modelling	-.01	.23	-.08	.35**
Mother Logistic Support	-.11	.07	.01	.19
Mother Limiting Sedentary Behaviour	.20	.24	-.11	.18
Father Explicit Modelling	.02	.20	.03	.10
Father Logistic Support	-.15	.01	-.19	-.04
Father Limiting Sedentary Behaviour	-.05	.15	.02	.15

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level

Self-Report MVPA: Perceived peer support and mother limiting sedentary behaviour were positively associated with self-reported MVPA for boys. All other sources of perceived social support showed no association with boys' self-reported MVPA. For girls, perceived family, sibling and peer support, mother and father logistic support, and mother limiting sedentary behaviour were positively associated with self-reported MVPA. In addition, parent-reported mother logistic support was positively associated with girls' self report MVPA.

Age and Gender Differences

Table 5.3 presents the correlations between self-reported and objective MVPA and each source of adolescent social support for younger and older boys and girls respectively.

Objective MVPA: Perceived father logistic support was positively associated with older boys' objective MVPA. All other sources of perceived social support showed no association with older or younger boys' objective MVPA. For younger girls, perceived mother and father logistic support, perceived mother limiting sedentary behaviour, and perceived father explicit modelling were all negatively associated with objective MVPA. When social support was reported by parents, only mother limiting sedentary behaviour was positively associated with objective MVPA in older boys.

Self-Reported MVPA: None of the perceived sources of social support showed any association with older or younger boys' self-reported MVPA. Perceived mother and father logistic support and perceived mother limiting sedentary behaviour were positively associated with younger girls' self-reported MVPA. For older girls, perceived sibling support, perceived peer support and perceived mother and father logistic support were positively associated with self-reported MVPA. When social support was reported by parents, only mother logistic support was positively associated with self-reported MVPA in older girls.

Social support and physical activity: Multivariate associations

Objective MVPA: Table 5.4 presents the results of the hierarchical regression analysis for objective MVPA. On step 1, the demographic influences of gender and age accounted for 16% of the variance in objective MVPA ($F(2, 172) = 16.73$, $p < 0.05$). Peer support was entered on step 2 and only accounted for an additional 2% of the

variance in objective MVPA ($F(3,172) = 12.62$, $p < 0.05$) and approached significance ($p = .051$) as an independent predictor.

Self-Reported MVPA: Table 5.5 presents the results of the hierarchical regression analysis for self-reported MVPA and adolescent perceived social support variables. On step 1 the demographic influences of gender and age accounted for 8% of the variance in self-reported MVPA ($F(2,181) = 7.65$, $p < 0.05$). Perceived social support variables were entered on step 2 and accounted for an additional 7% of the variance in self-reported MVPA ($F(10,173) = 2.90$, $p < 0.05$). Of the social support variables only father logistic support approached significance ($p = .051$) as an independent predictor.

No regression analysis was conducted for objectively measured MVPA and parent-reported support variables as there were no significant correlations observed (see Table 2). Table 5.6 presents the results of the hierarchical regression analysis for self-reported MVPA and parent reported support variables. On step 1 the demographic influences of gender and age accounted for 3% of the variance in self-reported MVPA ($F(2,104) = 1.46$, $p > 0.05$). When parent reported variables were entered on step 2 they accounted for an additional 6% of the variation in self-reported MVPA ($F(4,102) = 2.54$, $p < 0.05$). Of the two parent reported variables that were entered only mother logistic support emerged as a significant predictor ($p < 0.05$).

Discussion

The present study examined gender and age differences in five sources of social support and physical activity among younger and older adolescent boys and girls.

In line with previous research our results demonstrate that boys participated in significantly more MVPA than girls (187, 243) and younger adolescents of middle school age are more physically active than their older counterparts of high school age. These findings support those of previous research indicating that physical activity tends to decline as youth progress through high school, with a widening sex gap (154, 156, 229, 237).

Table 5.3 Correlations for perceived and parent reported social support sources and physical activity in younger and older boys and girls

Variable	Boys				Girls			
	Younger		Older		Younger		Older	
Adolescent Perceived Support	**MVPA (Ob)**	**MVPA (SR)**	**MVPA (Ob)**	**MVPA (SR)**	**MVPA (Ob)**	**MVPA (SR)**	**MVPA (Ob)**	**MVPA (SR)**
Family Support	-.13	-.13	.07	.05	-.20	.19	.14	.23
Sibling Support	-.10	.28	.11	-.11	-.08	.19	.24	.38**
Peer Support	.26	.11	.23	.24	.05	.24	-.04	.33*
Mother Logistic Support	-.07	.04	.25	-.01	-.39*	.37*	.16	.45**
Mother Explicit Modelling	-.15	.14	-.03	-.07	-.18	.26	.11	-.01
Mother Limiting Sedentary Behaviour	-.29	.10	.17	.01	-.36*	.39**	.07	-.04
Father Logistic Support	.06	.21	.40*	.18	-.31*	.37*	.23	.49**
Father Explicit Modelling	-.11	.09	.15	.05	-.41**	.16	-.26	.18
Father Limiting Sedentary Behaviour	-.11	.07	.27	.12	-.22	.08	.04	.23
Parent Reported Support								
Mother Logistic Support	-.01	-.09	-.04	.29	.01	.27	-.16	.41*
Mother Explicit Modelling	-.04	-.07	-.15	.04	-.06	.31	-.08	.09
Mother Limiting Sedentary Behaviour	-.03	.18	.51*	.01	-.22	.30	-.08	.07
Father Logistic Support	.21	.12	.04	.26	-.14	.08	.12	.15
Father Explicit Modelling	-.19	.11	.06	-.07	-.38	-.07	.00	.02

Father Limiting Sedentary Behaviour	-.08	.29	.12	-.04	-.16	.28	.06	.04

*Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level

Table 5.4 Perceived support hierarchical regression analysis results explaining objective MVPA

	B	SEB	β
Step 1			
Constant	77.75	5.69	
Age	-8.67	3.51	-.17*
Gender	-17.90	3.51	-.36*
Step 2			
Constant	56.96	12.00	
Age	-7.50	3.53	-.15*
Gender	-17.28	3.50	-.34*
Peer Support	6.34	3.23	.14*

* $p < 0.05$

Table 5.5 Perceived support hierarchical regression analysis results explaining self-reported MVPA

	B	SEB	β
Step 1			
Constant	6.35	.82	
Gender	-1.56	.48	-.23*
Age	-1.11	.48	-.17*
Step 2			
Constant	2.32	1.85	
Gender	-1.38	.52	-.21*
Age	-1.00	.51	-.15
Family Support	-.16	.45	-.04
Sibling Support	-.20	.40	-.05
Peer Support	.43	.45	.08
Father Explicit Modelling	-.10	.64	-.02
Father Logistic Support	.89	.45	.22*
Mother Logistic Support	.27	.45	.06
Father Limiting Sedentary Behaviour	-.13	.73	-.03
Mother Limiting Sedentary Behaviour	.31	.57	.06

* $p < 0.05$

Table 5.6 Parent reported support hierarchical regression analysis results explaining self-reported MVPA

	B	SEB	β
Step 1			
Constant	5.47	1.19	
Gender	-.83	.67	-.12
Age	-.86	.67	-.12
Step 2			
Constant	.12	2.64	
Gender	-.62	.66	-.09
Age	-.49	.69	-.07
Mother Logistic Support	1.19	.54	.23*
Mother Limiting Sedentary Behaviour	.40	.71	.06

* $p < 0.05$

In the present study some gender and age differences have been described regarding sources of social support received. Both boys and girls reported higher levels of activity support from peers than from general family, siblings, mother and father, reinforcing previous research utilising the same support questionnaire (51). This finding is also consistent with developmental psychologists who suggest that as children move into adolescence the relative influence of parents lessens while peers begin to take on a greater role (37). Gender differences in the amount of support received between boys and girls were demonstrated for peer support, with boys perceiving more support from their peers than girls. This finding contrasts previous research utilising the same questionnaire which demonstrated no gender differences in activity support for any source of support i.e., family, siblings, peers, mothers and fathers (51).

With advancing age, boys and girls usually transition from relying on parents to using peers as major sources of support (138). In this study it was found that the amount of perceived family support, explicit modelling and limiting sedentary behaviour from mothers and fathers was lower for older adolescents. Findings support those of Duncan et al. (67) who found that younger adolescents perceived greater amounts of social support from parents than did older adolescents. No differences were found in the amount of sibling support, peer support and mother and father logistic support perceived by younger and older adolescents. These findings suggest that throughout adolescence (12-16 years of age) perceptions of support from siblings and peers and specifically logistic support from parents remains stable. The declining levels of family support and explicit modelling likely reflect developmental declines in the time children spend with their parents and in opportunities for joint physical activity with the family. However, findings for logistic support suggest that as adolescents get older they still need to be transported to places where they can be active and have their parents watch them being active. It is important to note however that although age differences in the amount of perceived support were evident, these are cross-sectional findings and do not demonstrate change over time but are indicative that forms of support may change as children become older, such that certain types of support may become less influential. In a recent longitudinal study, Davison and Jago (53) found that parental modelling showed a linear decline between ages 9 and 15 years. Logistic support however,

increased between ages 9 and 11 years and then decreased between ages 11 and 15 years.

In the current study univariate associations between social support and adolescents' MVPA differed by gender and age. Furthermore, although physical activity and some perceived parental support variables and parent-reported support variables were significantly correlated, the associations varied by physical activity measurement approach (objective vs self-report). In agreement with previous research (178) more associations were demonstrated for self-reported MVPA, especially for girls. Because of the variations with associations by gender and age, multivariate analyses were performed controlling for these demographics. Results demonstrated that peer support was a significant predictor of objective MVPA, father logistic support and parent reported mother logistic support were significant predictors of self-reported MVPA. However, these social support variables explained only a very small amount of variance in MVPA suggesting that many other factors in addition to these influence adolescents MVPA.

The finding that peer support is associated with physical activity is consistent with previous research demonstrating that adolescents who reported greater amounts of peer support also displayed greater levels of physical activity (25, 67). Together with previous research this finding indicates that among adolescents, peers exert some influence over physical activity which suggests that there may be benefit in encouraging adolescents to participate in physical activity with their peers and educating young people on how they can verbally and physically encourage physical activity with friends.

Logistic support was also shown to influence adolescents' self-reported physical activity. A previous study (183) employing the same questionnaire found that logistic support and explicit modelling were associated with adolescent physical activity. The present study however, demonstrated that explicit modelling from parents was not an important factor for adolescent physical activity. To increase adolescents' physical activity efforts could be made to encourage parents to transport their child to places where he/she can be active, enrol their child in physical activities and watch their child

participating in physical activity. However, it was demonstrated in chapter 2.2 that parents from low socioeconomic groups did not provide logistic support for their children. Providing logistic support may be difficult for parents from low socioeconomic groups due to financial constraints on transport, sports equipment and enrolment in sports clubs, which parents from middle/high socioeconomic groups may not face. Further research could be conducted to establish the best way for parents from low socioeconomic groups to assist their children in being active.

Inconsistency in results across physical activity measures may be explained by several factors. Although MVPA was extracted from both physical activity measures, the way this was assessed was very different. The self-report instrument required adolescents to recall their main activity in 30 minute blocks whereas the accelerometer recorded actual activity every 5 seconds. Therefore one possible explanation for the lack of associations found in this study when using objective measures may be a result of accelerometers detecting incidental physical activity that may not be influenced by parents, which may also be missed in the 3DPAR. Furthermore with accelerometers, average minutes per day spent in MVPA are reported and it may be more important to examine specific segments of the day with accelerometers rather than including all physical activity accumulated throughout each day. Examining specific segments of the day is possible with accelerometers because of the internal clock mechanism. It may then be found that positive relationships emerge between objective measures of physical activity and social support.

The strengths of this study include the use of valid and reliable instruments to assess physical activity including an objective measure which rules out the potential for subjective bias in recall. An additional strength was the use of a valid multidimensional measure of support, which enabled us to separate both sources of support and forms of support i.e. parental modelling, logistic support and limiting sedentary behaviour from mother and fathers. This study is limited by its relatively small sample size due to difficulties in attaining compliance when using accelerometers with adolescents and its cross-sectional design which does not allow causality to be examined. Longitudinal designs are needed to assess change in sources and forms of support across time. Furthermore, the generalisability of the results is limited because participants were

predominantly white, of higher socioeconomic status and from one area in England, thus findings should not be generalized beyond this population. Very little is known about the impact of different sources and forms of support on physical activity among ethnic minority youth and youth from lower socioeconomic groups.

Conclusions

Overall, this study demonstrates that adolescents perceive more support from their peers compared to any other source of support. The only gender difference in sources of support was found for peer support with boys perceiving more than girls. Younger adolescents perceive greater amounts of family support, explicit modelling and limiting sedentary behaviour than older adolescents however, logistic support appears constant throughout adolescence. Inconsistency across gender, age and physical activity measures makes it difficult to draw any firm conclusions regarding the univariate associations between sources and forms of support and adolescent physical activity. Multivariate analyses demonstrated that peer support and father and parent reported mother logistic support were significant predictors of objective and self-reported MVPA respectively.

Chapter Six

General Discussion

Chapter 6

General Discussion

The six studies presented in this thesis have: reviewed both quantitative and qualitative research examining parental influences on children's and adolescents' physical activity, investigated the effects of key decisions researchers must make when using accelerometers with children and adolescents, and investigated the influence of mothers' and fathers' support on children's physical activity and mothers', fathers', family, siblings' and peers' support on adolescents' physical activity. Within the context of the behavioural epidemiology framework, this research furthers scientific understanding of accelerometer use in young people (Phase II of the behavioural epidemiology framework) and the factors that influence young people's physical activity (Phase III).

This chapter summarises the main findings reported within the thesis, contextualises the importance of these findings, highlights areas for future research and provides general conclusions. A summary of the main findings, and strengths and limitations from each study are presented in Table 6.1.

6.1 Parental influences on physical activity in youth: Systematic reviews

Several authors have reviewed research on parental correlates of young people's physical activity and have produced mixed results. The main limitations with all previous reviews have been:

- the grouping together of all types and intensities of physical activity regardless of what physical activity the individual studies actually measured. In a recent review of reviews (157) it was noted that it would be helpful from the point of view of public health policy to be able to identify the correlates of different types of physical activity.
- a predominant focus on cross-sectional data which is limited by data being collected at a single time point.
- the exclusion of qualitative research.

Identifying correlates of different types of physical activity is important because young people's physical activity takes place in different contexts. For example, young people may participate in organised physical activity or in games, play and other recreational activities in their leisure time which are performed in formal and informal settings and the relative importance of correlates of young people's physical activity in these contexts may vary dependent on characteristics of the activities taking place (253). Furthermore, it is important to examine longitudinal data in addition to cross-sectional data as they can clarify temporal relationships between correlates and physical activity and also assess the long-term relationship between parental correlates and young people's physical activity. Qualitative research on the other hand may provide a richness of detail and a different perspective than that found within quantitative research. The aim of the reviews presented in Chapter 2 was to update and build on the current literature by addressing the limitations associated with previous reviews.

Key findings from Chapter 2.1 were that for children, parents play an important role in MVPA, overall physical activity and leisure-time physical activity through direct involvement and being active role models and in organised physical activity through a combination of methods such as modelling, transport and encouragement. For adolescents, parents' physical activity level, attitudes towards physical activity, transport and encouragement are important for them to be physically active. Cross-sectional findings therefore suggest that to facilitate activity in children parents need to be actively involved in physical activity themselves and directly involved in physical activity with their child. For more organised physical activity however, children require their parents to provide broader support such as transport, financial assistance, and encouragement as well as being active role models of physical activity which was reinforced by longitudinal findings. In adolescents, cross-sectional evidence was less clear but suggestive of parental influence still being important throughout teenage years and longitudinal research specifically identified fathers' level of physical activity as important for overall physical activity. Such findings are important because they suggest that parental influences vary by activity type/intensity which has important implications for interventions (Phase IV).

It is difficult to compare and contrast these results with previous reviews because of the breakdown of activity type/intensity in Chapter 2.1, however in general previous reviews (79, 205) have failed to demonstrate significant positive associations between parental influence and young people's physical activity. It appears though that when you differentiate between types of physical activity positive relationships emerge between mother and father activity levels, involvement and support and young people's physical activity as demonstrated in Chapter 2.1.

Support for the findings in Chapter 2.1 can also be found in Chapter 2.2, where children and adolescents reported that parents' physical activity behaviour, encouragement and logistic support influenced their physical activity behaviour. Although the qualitative research did not provide the richness of detail that was expected, some important findings emerged that were not evident in the quantitative research. For example, it was found that for children, parents restricted activity levels because of safety concerns whereas for adolescents, parents restricted physical activity by promoting academic activities in favour of physical activities. A further key finding was that there were differences in the type of parental influence by high versus low socioeconomic groups which was not examined in Chapter 2.1, with parents from high socioeconomic groups being directly involved in activities with their children, being active role models and providing transport and financial assistance. Parents from low socioeconomic groups relied on more verbal forms of encouragement to influence their children's activity levels. One explanation could be that low SES families rely more on verbal encouragement due to financial constraints on transport, sports equipment and enrolment in sports club, which families of middle/high SES may not face.

Explanations for the relationship between parents' behaviour and children's physical activity include social reinforcement and role modelling, central concepts in Bandura's (14) social cognitive theory. Social cognitive theory points to the importance of a supportive environment to performing, establishing and maintaining a pattern of regular physical activity. Reinforcements provided by parents (directly and through modelling) may explain the mechanisms through which parents influence children's and adolescents' participation in physical activity.

Together, findings from the quantitative and qualitative research (Chapter 2) lend support to the view that parents need to be involved in their child's physical activity in a variety of ways if their child is to lead a physically active lifestyle. Furthermore, parental influence can have both a negative and a positive influence on young people's physical activity levels. In the context of this thesis, these systematic reviews identified areas for future research which informed the direction of later chapters.

6.2 Measurement issues associated with accelerometer use in children and adolescents

The case for focusing on the measurement of physical activity (Phase II) is underpinned by several factors: (a) the long-held recognition that valid and reliable measures are an important research priority within physical activity epidemiology; (b) it has become increasingly evident that the development and refinement of physical activity assessment techniques are critical for the continued advancement of the field (121, 260); (c) accurate assessments are needed to better test theories of physical activity or to determine if a particular behavioural intervention was successful in changing behaviour; and (d) if there is considerable error in the assessment, the power to detect change is reduced and large sample sizes are required to test these relationships. Clearly, advances in measurement technique would improve our ability to more effectively study, predict and promote physical activity behaviour (262).

During the planning phase of this thesis, it was clear that an objective measurement technique would be required to provide an accurate estimate of children's and adolescents' physical activity. Accelerometers were the preferred option given that they are minimally intrusive, small, lightweight and able to record several days or weeks of physical activity data. This made them ideal for use with young people of all ages. However, in using accelerometers it soon became evident that they were not simple 'plug and play' devices. Very rich data can be obtained from an accelerometer, but making the most of this tool required a thorough understanding of the relevant literature to enable careful planning of the research design, data analysis, and interpretation. Therefore, before progressing with the analysis of accelerometer data from Chapters 4 and 5 it was important to determine the most appropriate processing decisions to use. Chapter 3 investigated the effects of key decisions researchers must make when using

accelerometers with children and adolescents. More specifically Chapter 3.1 examined the effect of epoch length, a pre-data collection decision, on physical activity intensity in children and adolescents. Chapter 3.2 examined the impact of accelerometer post-data collection processing decision rules, such as cut-points, and non-wear period, on children's and adolescents' physical activity. Chapter 3 makes an important contribution to the literature because the impact of these decisions on accelerometer output has not been widely explored in children and no studies had been conducted using an adolescent sample.

Much of the research conducted with children and adolescents has used 60 second epochs. The use of 60 second epochs may be inappropriate when measuring young people's physical activity because of the spontaneous and intermittent nature of their activity and may result in an underestimation of moderate and vigorous physical activity. The purpose of Chapter 3.1 was to investigate the effect of different epoch lengths (5s, 15s, 30s, 60s) on derived levels of physical activity in both a child and adolescent sample to determine which epoch length would best reflect the nature of young people's physical activity. A key finding in Chapter 3.1 was that using a 5 second epoch would be more effective than longer epochs in detecting short bouts of physical activity which are commonly displayed by young people. Support for this conclusion can be found in a recently published study in preschool children (251) which concluded that using a shorter epoch might be better adapted to preschool children's physical activity patterns. It appears therefore, that there is now evidence suggesting that a short epoch is preferable in all ages of young people from preschool age to adolescence and with the recent advances in accelerometer storage capacity there is no reason why researchers cannot select a short epoch for example, 5 seconds, to monitor activity levels in young people. Furthermore, it was suggested by Corder and colleagues (47) that the epoch length used should ideally be as short as possible, because data can always be reintegrated into a longer time frame but not vice versa.

In the absence of a single accepted protocol for processing accelerometer data, researchers have not consistently applied the same processing rules, making it difficult to compare physical activity data across studies. The purpose of Chapter 3.2 was to investigate the impact of applying different processing rules to the same dataset on (a)

participant numbers; (b) time in different intensities of physical activity; and (c) percentage of participants achieving the recommended guidelines for moderate-to-vigorous physical activity. A key finding from Chapter 3.2 was that the number of hours that constitute a valid day, the cut-points employed and indicators of non wear time had significant effects on time spent in the different physical activity intensities suggesting that caution should be taken when comparing studies employing different processing decisions. Furthermore, in agreement with previous research (151, 186, 249), substantial differences were found in the percentage of participants reaching physical activity guidelines depending on the cut-point applied in both the child (3-100%) and adolescent (18-98%) samples and considerable lack of agreement was found between cut-points from different researchers. The difference in compliance to physical activity guidelines due to choice of cut-points makes it difficult to draw conclusions about the activity patterns in young people and compare results across studies.

A recent study examined the impact of different accelerometer thresholds (sample-specific thresholds, published thresholds and individualised activity-related time equivalent) on various health outcomes. Stone, Rowlands, & Eston (225) demonstrated that choice of threshold did not impact on relationships detected between activity and various health outcomes in boys. This indicates that studies investigating relationships between activity and health outcomes such as BMI, waist circumference, blood pressure and VO_{2peak} may be comparable even where different thresholds have been employed. It is important to note however that thresholds used in this study ranged between 2910 and 9630. This is at least a small step forward in accelerometer measurement but it is also important to reach consensus on cut-points to enable comparability between activity prevalence studies and progress the field.

Findings from Chapter 3 regarding epoch length and post-data collection processing decision were used to inform accelerometer use in Chapters 4 and 5.

6.3 Social support and young people's physical activity: the role of parents, family, siblings and peers

In relation to physical activity behavioural epidemiology, the primary goal of correlates research is to describe and understand the factors that influence physical activity

behaviour. Research on the correlates of physical activity (Phase III of the behavioural epidemiology framework) has increased in recent years and while considerable progress has been made, it has still proven difficult to accurately predict physical activity behaviours (262). Physical activity correlates research is compounded by measurement challenges and if the assessment of physical activity is weak, then it becomes more difficult to predict physical activity to any appreciable extent. With this in mind, and as already mentioned in the previous section, accelerometers were chosen to provide an accurate estimate of children's and adolescents' physical activity. Furthermore, it was evident from the systematic review in Chapter 2.1 that there was a need for more studies employing objective measures of physical activity.

Social sources that impact upon children's and adolescents' physical activity have been frequently studied but the ways in which mothers and fathers differ in their provision of support for physical activity is relatively unexplored. Furthermore, the majority of studies examining parental influence and children's physical activity have been conducted in the US, assessed parent support using single item questions and measured physical activity using self-report methods. For Chapter 4 it was decided that only mother and father activity support would be assessed and would be reported by parents. This decision was made based on several factors: (a) using self-report measures with children <10 years of age is problematic; (b) parents would be unable to accurately report influence from other sources such as peers; and (c) developmental psychologists suggest that it is not until adolescence when children spend increasing amounts of time with friends that peers begin to influence activity (37, 70).

A key finding in Chapter 4 was that fathers' explicit modelling such as the father being regularly active, enjoying being active and being active with child, was positively associated with MVPA and VPA in boys only. Such findings are important because they suggest that fathers are an important influence for boys aged 7-10 years, which offers a potentially useful avenue for intervention. For girls however, no associations were found with mothers' or fathers' activity support. In support of this, previous investigations (245, 246) employing accelerometers also reported that modelling from mothers and fathers was not associated with girls' MVPA suggesting that influences other than parents may influence their physical activity.

Some researchers have questioned the importance of parents on adolescents' physical activity, suggesting that the influence of peers and the wider social environment become more important (160). In agreement with this, a key finding from Chapter 5 was that adolescents perceived more activity support from their peers compared to family, parents and siblings. However, it was also found that although parents' influence appeared to lessen in regards to modelling of active behaviour, with young adolescents perceiving greater amounts of explicit modelling than older adolescents, the amount of perceived logistic support provided by parents remained similar for younger and older adolescents. These declining levels of explicit modelling likely reflect developmental declines in the time children spend with their parents and in opportunities for joint physical activity with the family. However, findings for logistic support suggest that as adolescents get older they still require parents to transport them to places to be active and provide financial assistance.

In the adolescent sample, it was decided that physical activity would be measured by self report and objective measures because self report measures had been shown to be valid and reliable in this age group. Furthermore, it has been suggested that the correlates of physical activity may differ as a function of the method used to measure physical activity. It was important to investigate this issue because if the correlates did differ it would limit the generalisation of the findings obtained with the use of one or the other method (65). A key finding in Chapter 5 was that univariate and multivariate associations between social support sources and adolescents' physical activity differed by physical activity measurement technique. Support for this finding can be found in Chapter 2.1 and suggestions are provided in Chapter 2.1 and Chapter 5 for these inconsistencies. Key findings from multivariate analyses were that when controlling for gender and age peer support significantly predicted objective MVPA and father logistic support and parent reported mother logistic support were significant predictors of self-reported MVPA. In support of this several investigators (25, 51, 67, 219) have also demonstrated that adolescents who reported greater amounts of peer support also displayed greater levels of self-reported physical activity. However, Prochaska and colleagues (178) found no associations between peer support and objectively measured physical activity. With respect to logistic support, a previous study utilising the same support questionnaire found that logistic support and explicit modelling from parents

were associated with adolescent physical activity. In a recent longitudinal study, Davison and Jago (53) found that girls who maintained physical activity had parents who reported stable levels of logistic support from 9 to 15 years and girls who did not maintain physical activity had parents who reported declines in logistic support. Together with previous research, findings demonstrate that peer support and logistic support provided by mothers or fathers have some influence over adolescents' physical activity.

6.4 Implications for interventions (Phase IV)

Identification of the factors influencing physical activity among young people is a prerequisite for design of effective interventions. Findings throughout Chapters 2, 4 and 5 have important implications for interventions designed to increase physical activity among children and adolescents. Chapter 2 demonstrates that parents influence their child's activity in a variety of ways which suggests that intervention programmes need to incorporate parents and educate them on how they can best support their child to be active and parents must be made aware of how their actions (e.g., the amount of encouragement they give their child, taking part in physical activity with their child and providing transport for their child to be active) can influence their child's participation in physical activity. For example, parents could be educated about the importance of physical activity for both themselves and their children, encouraged to act as role models through their own participation, participate in activities with their children and not just command them to be active, work with their children to find activities that they enjoy and provide transport to places where their children can be active. Chapter 4 specifically identifies fathers' physical activity behaviour as important for boys' activity levels. This suggests that a possible intervention strategy for low-active boys aged 7-10 years might be to promote opportunities for fathers and sons to be active together (e.g., discounted sessions at local leisure facilities for fathers and sons), or to target the fathers' physical activity levels to increase physical activity in low-active boys. Chapter 5 identifies peers and logistic support provided by parents as important influences on objective and self-reported physical activity. This suggests that there may be benefit in encouraging adolescents to participate in physical activity with their peers and educating young people on how they can verbally (e.g., encouragement, praise) and physically (doing activity with) encourage physical activity with friends. Programmes

could be created for adolescents that partner them with other peers to participate in physical activities, creating a system of social support. Furthermore, physical education class could be used as an opportunity to create an environment of peer support for physical activity. Moreover, parents could help foster support within the peer network by identifying activities that their children's friends enjoy, organising activities that can include a friend, or facilitating the ability for their children to spend time with their friends while doing something active. Finally, findings from Chapters 2 and 5 point to the importance of logistic support therefore to increase physical activity parents need to be aware of the importance of providing logistic support and efforts could be made to encourage parents to transport their child to places where he/she can be active, enrol their child in physical activities and watch their child participating in physical activity. However, as identified from Chapter 2.2 it may be difficult for parents from low-socioeconomic groups to provide logistic support due to financial constraints on transport, sports equipment and enrolment in clubs, issues which parents form middle/high socioeconomic groups may not face.

6.5 Limitations

When interpreting the results of this thesis the following limitations should be considered. The limitations will be presented under study design, sample and physical activity measurement.

Study Design

The studies in this thesis employed a cross-sectional design which does not allow for causality to be examined. Although it is assumed that support from significant others leads to higher levels of physical activity, it is also possible that children and adolescents who are already active elicit activity support from significant others. A longitudinal study would have enabled causality to be determined.

Sample

Chapters 4 and 5 contained relatively small sample sizes due to compliance issues with accelerometer wear time (82% and 60% for 3 days of monitoring for children and adolescents respectively) and poor return rate of support questionnaires from parents in Chapter 4 (65% return rate). The children who took part in the research were very keen

to wear the accelerometer, the adolescents however, were much more of a challenge which is reflected in the compliance percentage. Furthermore, in the adolescent sample 35.5% of pupils refused to wear the accelerometer. Wearing the accelerometer on a belt may have been seen as 'uncool' in the secondary school pupils. It was also a challenge to get the young people to return the accelerometers in some schools and in both the child and adolescent sample some accelerometers were never returned (n = 14, ~£3,000). To increase compliance in adolescent samples the accelerometer could be worn on a clip rather than a belt and monetary incentives that change with the number of days worn could be provided.

The generalisability of the results is limited because participants in Chapters 3, 4 and 5 were predominantly white British (95% in the child and adolescent samples) and of higher socioeconomic status (71%, adolescent sample only), thus findings should not be generalised beyond this population. Very little is known about the impact of support from significant others (e.g., parent, peers) on physical activity among minority youth and youth from lower socioeconomic groups. Therefore, there is a need to focus future research on these groups of young people.

It is important to note that the samples in Chapters 4 and 5 were limited to children and adolescents who had both mothers and fathers support data. Given the changes in current family dynamics, it is very important to determine which forms of social support are dominant in the parent-child interrelations within single-parent families. For example, it is possible that single parents may have less free time to devote to their children's physical activity participation than do two-parent families, or even the forms of parental social support may be different for single-parent families.

Social Support and Physical Activity Measurement

In Chapter 4 activity-related social support was reported by parents and not the child which is acknowledged as a limitation because it may be more important to get the child's perception of their parents' supportive behaviour. It has been shown that there is low agreement between child and parent reports with regard to parental behaviour (101). Parents were chosen to report their social support because using questionnaires with children < 10 years has been shown to be problematic.

Physical activity measurement is an inherent challenge with young people and while accelerometers can provide objectivity they are not without limitations. Accelerometers are unable to measure common physical activity such as swimming and cycling that young people participate in which can result in an underestimation of physical activity level. Furthermore, accelerometers have an inability to detect upper body movement and locomotion on a gradient which again may result in an underestimation of physical activity.

Chapter 3.1 recommends a 5 second epoch for use with young people, however a major limitation of this study along with Chapter 3.2 was the lack of a criterion measure of physical activity intensity to allow for the determination of which epoch and processing rules produced the most accurate estimate of physical activity. Identification of the most accurate epoch length and processing rules would allow the field to move toward a uniform approach to accelerometer data collection and reduction.

A final limitation is the use of 5 second epochs along with Freedson et al's cutpoints in Chapters 4 and 5. This is because when determining cutpoints for different physical activity intensities, Freedson and colleagues used a 60 second epoch and at present there is no evidence to support the validity of epoch adjusted cutpoints.

Table 6.1 Summary of findings, strengths and limitations from individual studies.

Chapter	Purpose	Methods	Findings	Strengths	Limitations
2.1	To review cross-sectional and longitudinal research on parental influences on different types and intensities of physical activity in children and adolescents	Systematic quantitative review 41 papers (65 independent samples) in children, aged 6-11 years; 60 papers (104 independent samples) in adolescents, aged 12-18 years	• In children parents play an important role in MVPA, overall physical activity and leisure-time physical activity through direct involvement and being active role models and in organised physical activity through a combination of methods such as modelling, transport and encouragement. • In adolescents, parents' physical activity level, attitudes towards physical activity, transport and encouragement are important for them to be physically active. • Longitudinal data demonstrated that overall support predicted children's organised physical activity over time and fathers' physical activity predicted adolescents' overall physical activity.	• Systematic approach adopted and the summary of 96 published papers • The clear definitions of parental influence variables • Types and intensities of physical activity separated • Examined and reported results separately for children and adolescents	• Only published papers written in English were reviewed • The review focused on the consistency of reported associations and did not assess strength of associations
2.2	To review published	Systematic qualitative review	• Parental influence in young people's physical activity is diverse, ranging from verbal	• First study to review qualitative literature	• Small number of qualitative studies

	qualitative research studies which have examined parental influences on children's and adolescents' physical activity	12 papers including a total of 789 boys and girls aged between 6-18 years.	encouragement, providing transportation and money for clubs, co-participation and modelling of physically active behaviour. • The way in which parents encourage their children to be active differs according to socioeconomic background. • Children from middle and high SES schools reported proactive methods by parents, and children from low SES schools restricted to verbal encouragement. • Parents can also have a negative impact on their child's physical activity by restricting after school participation and by girls perceiving encouragement as 'nagging'.	in this area.	• Richness of detail was not evident in studies • Did not consider the influence of other family members and peers • Did not include parent perceptions
3.1	To investigate the effect of different epoch lengths (5s, 15s, 30s, 60s) on derived levels of physical activity in	Cross-sectional study involving 311 children aged 7-11 years of age and 234 adolescents aged 12-16 years of age who were asked to wear an	• A significant epoch effect was seen for time spent in MVPA, MPA, VPA, LPA and rest in the child sample. • Time spent in all of these physical activity intensities, at all epoch lengths significantly differed from each other.	• Large sample size compared to previous studies in children • First study to examine the effect of	• Studies have used 60 second epochs when determining cutpoints for different physical activity intensities

	both a child and adolescent sample.	accelerometer during waking hours for 7 days.	• For the adolescent sample, a significant epoch effect was seen for time spent in VPA, LPA and rest. • Time spent in all of these physical activity intensities (VPA, LPA and rest), at all epoch lengths significantly differed from each other. • In the child sample bias was close to zero and 95% limits of agreement were small between the 5 and 15s, 15 and 30s and the 30 and 60s epoch lengths for MVPA, MPA, VPA, LPA and rest. • In the adolescent sample, bias was close to zero and 95% limits of agreement were small between the 5 and 15s, 5 and 30s and 15 and 30 s epoch lengths for MVPA, MPA, VPA, LPA and rest.	epoch length in an adolescent sample	and at present there is no evidence to support the validity of epoch-adjusted cutpoints • Lack of a criterion measure of physical activity intensity to allow for determination of which epoch length produced the most accurate estimate of physical activity
3.2	To investigate the impact of applying different decision	Cross-sectional study involving 311 children aged 7-11 years of age and	Effect on sample size • The decision rule of any 3 days being required as the minimum number of days used in the	• Inclusion of both children and adolescents	• Lack of a criterion measure of physical activity

	rules to a child and adolescent accelerometer data set	234 adolescents aged 12-16 years of age who were asked to wear an accelerometer during waking hours for 7 days.	analysis and holding all other rules constant, resulted in the greatest number of participants being retained for the child and adolescent samples (82.3% and 60.3% respectively). Day length • Altering the number of wearing hours (8, 9, or 10) required to constitute a valid day had a significant effect on the recorded hours of physical activity. • In the child sample significant differences were demonstrated in MVPA, MPA, light PA and rest between hours constituting a valid day. • In the adolescent sample no significant differences by hours constituting a valid day were observed for any intensity of physical activity. Non Wear Period • Significant differences were found between all number of zeros in both the child and adolescent samples (p<0.05), with 30 minutes	• Large sample compared to other studies • Provides insight into the comparability of studies employing different decision rules and cut-points	intensity to allow for determination of which cut-point produced the most accurate estimate of physical activity

			of continuous zeros resulting in the greatest time spent in rest Number of days • Changing the number of days required for analysis in both the child and adolescent samples did not have a significant effect on recorded hours of MVPA, MPA, VPA, light PA and rest Cutpoints • There is considerable variance in recorded time in MVPA when different published cut-points are applied to both the child and adolescent data sets • The percentage of participants meeting the physical activity guidelines ranged from 3-100% in the child sample and 18-98% in the adolescent sample depending on the cut-point applied		
4	To explore mothers' and	Children wore an accelerometer for 7 days	• No significant gender differences in the mean level of activity support were identified for any	• Few studies have examined activity-	• Cross-sectional design which does

	fathers' activity-related support and examine its effect on objectively measured physical activity using a sample of children	and a total of 117 children (54 boys and 63 girls 7 – 10 years of age) provided 3 days of usable accelerometer data. Mothers and fathers completed an activity support questionnaire.	source of support • For boys mothers reported significantly higher levels of support for limiting sedentary behaviour than fathers • For girls mothers reported significantly higher levels of logistic support and limiting sedentary behaviour than fathers • Explicit modelling was significantly associated with MVPA and VPA for boys No significant differences in the mean level of activity support were found for any source of support for boys or girls in the high and low active groups • The combined level of support from mothers and fathers was not related to activity level in boys or girls	related parenting practices using a UK sample and employing objective measures of physical activity • The use of an objective measure of physical activity • Reporting paternal and maternal supportive behaviour separately • Employing a questionnaire that assessed a broad range of parenting practices	not allow causality to be examined • Only included children with data from both mother and father which resulted in a fairly small sample size
5	To examine gender and age differences	261 adolescents aged 12-16 years (53% boys) wore an	• Adolescents perceived more support from their peers compared to other sources	• Use of valid and reliable instruments	• Cross-sectional design

	in five sources of social support (family, mother, father, siblings and peers) and their relationship with both self-reported and objectively measured physical activity among adolescents	accelerometer for 7 days, completed a 3-day physical activity recall and completed a questionnaire assessing family, mother, father, sibling and peer support for physical activity. Parents also completed a support questionnaire.	• Boys perceived more peer support than girls • Younger adolescents perceived greater amounts of family support, explicit modelling and limiting sedentary behaviour from both mother and father than older adolescents however logistic support appeared constant throughout adolescence • Univariate associations between sources of social support and adolescents' physical activity differed by gender, age and measurement technique • Multivariate analyses, controlling for gender and age, demonstrated that peer support was a significant predictor of objective MVPA and father logistic support and parent reported mother logistic support were significant predictors of self-reported MVPA	to assess physical activity and activity support • Multidimensional measure of support • Separating mother and father sources of support • Inclusion of five sources of support	• Participants were predominantly White and middle/upper socioeconomic status therefore limiting the generalisability of results

MVPA: Moderate-to-vigorous physical activity; MPA: Moderate physical activity; VPA: Vigorous physical activity; LPA: Light physical activity

6.6 Future directions

Findings presented in this thesis have important implications for future research and practice involving young people's physical activity. These have been organised into research priorities within phase II and III of the behavioural epidemiology framework applied to physical activity.

Phase II: Develop methods for accurately assessing physical activity behaviour

Assessing physical activity in young people is notoriously difficult and without accurate measures of physical activity behaviour it is difficult to demonstrate strong associations with other variables (Phase III). Technological advances have facilitated the development of accelerometers, which have the potential to overcome many of the problems associated with self-report measures while providing robust and detailed physical activity information (75). The rich information provided by accelerometers makes them an invaluable tool to understand the complex nature of physical activity behaviour (75). To date however, there is no standardised method for cleaning, analysing and reporting accelerometer data (63) which hampers comparison between studies and it is obvious that there is a need for standardisation.

Epoch length

To further understanding on epoch length and to determine the most accurate epoch length to use with young people it is necessary to compare accelerometer estimates by epoch length against a criterion standard such as direct observation. To date, one study (135) has investigated this and demonstrated that a 5-second epoch along with employing Freedson et al (82) age specific cut-points (MVPA $\geq$ 4 METs) yielded similar mean estimates of MVPA compared with a direct observation criterion standard. Although this study goes someway to making progress in this field, physical activity was only assessed for 30 minutes during a physical education class in small sample of children (n = 32). Furthermore, the criterion method used (C-SOFIT) was not capable of storing time series data i.e., it only provided an output of the aggregate total time in independently coded behaviours for each participant. Therefore, to further understanding it will be necessary to compare intensity classification at the epoch level from synchronised time series data for both criterion data and accelerometer-predicted values. Future research should use criterion methods, which allow for storage of time series data at or above the storage frequency of the minimum epoch length under

consideration. This will enable researchers to determine the most accurate epoch length to use with children and adolescents.

Research priorities on epoch length identified from Chapter 3.1

- Future criterion comparisons with criterion and accelerometer data collected during longer periods of free-living are required.
- Future research using even shorter epoch lengths (e.g., 1 second) could produce more accurate estimates of time in MVPA relative to a criterion standard of observation.
- Future research should establish validity of epoch-adjusted activity count cut-points for data collection at shorter epoch lengths.
- Clarification of the biological significance of differences in estimates of MVPA according to differing epochs is warranted.

Quantifying physical activity

In general, accelerometer-based approaches to quantifying physical activity 'calibrate' the accelerometer by simultaneously recording accelerometer output and some physiological variable (e.g., METs) in a laboratory setting. The relationship between theses variables is then determined using linear regression, and ranges of accelerometer output corresponding to different levels of physical activity are established. The end point of these ranges (cut-points) are then applied to data collected in the field to estimate the minutes per day spent above a certain intensity threshold (176). Several researchers have published cut-points but thresholds for moderate and vigorous physical activity vary. Chapter 3.2 demonstrated considerable variance in recorded time in MVPA when different published cut-points were applied to both the child and adolescent data sets. However, these different equations pose a problem for researchers because no single regression line is able to accurately predict energy expenditure or time spent in different categories, across a wide range of activities. In addition, all of these equations assume a linear relationship between counts per minute and energy expenditure (50). This approach to analysing accelerometer data also has an associated intrinsic measurement error - it is unable to distinguish two activities that produce similar total acceleration over time but have different energy costs (e.g., walking at a given speed over a level surface (approximately 3 METs) versus walking at that same

speed over an inclined surface (approximately 6 METs). The deficiency of the cut-point approach stems from the fact that the cut-point approach only uses the mean counts per minute to classify the intensity of physical activity (176). Furthermore, this approach does not value the richness of accelerometer data.

New developments in data processing offer promise for resolving some of the underlying challenges. The accuracy of physical activity estimates may be enhanced by using pattern recognition or 'machine learning' approaches to the processing of data from accelerometers. These new pattern recognition approaches (e.g., quadratic discriminant analysis, hidden Markov modelling, artificial neural network modelling) make it possible to detect underlying patterns in movement and thereby offer considerable promise for a more precise estimation of energy expenditure through the application of activity-specific regression equations or through identification of specific activities using multiple features of the accelerometer signal. This information is important because it may improve assessment of activity patterns and intensity which might prove valuable for health outcomes research (Phase I), measurement (Phase II) and correlates studies (Phase III). Recently several investigators have successfully employed various types of pattern recognition methods to identify activity type (50, 220). These methods identify activity types by evaluating attributes of the acceleration signal measured in portions of defined length (segments). A segment of the acceleration signal includes a certain number of data points determined by the sampling frequency of the signal and by the time length of the segment. Given a certain sampling frequency, the longer the segment size, the more samples are considered in calculating attributes (features) of the acceleration. Acceleration features are used to classify the type of activity performed in a certain time interval. The use of short segments for the calculation of the acceleration features would improve the ability to correctly recognise short activities and to measure activity duration, supposing that the classification performances are constant regardless of the segment size (33). These pattern recognition methods have performed substantially better than the traditional cut-point method in quantifying minutes spent at given intensity levels based on activities studied in the investigations (50) and have successfully identified various activities. For example, Pober and colleagues (176) compared quadratic discriminant analysis (QDA) and hidden Markov model (HMM) and demonstrated that on average QDA and HMM were able to correctly identify specific activities from the accelerometer data in 70.9% and

80.8% respectively of the seconds for which data were recorded. More recently, Staudenmayer and colleagues (220) demonstrated that artificial neural network (ANN) correctly classified activity type 88.8% of the time. Activity types in this study were low-level activities, locomotion, vigorous sports, and household activities/other activities.

Another novel method for identifying activities was presented at the recent American Public Health Association meeting by Intille and colleagues (108). They reported on the use of new wireless accelerometers that communicate with mobile phones and permit the detection of a wide variety of physical activities at the same moment they are happening. In one experiment an overall accuracy of 75% on 51 different physical activities was obtained and if activity types of different intensities are clustered (i.e., walking 2mph and walking 3mph are clustered as walking), overall activity type detection accuracy increased to 91%.

These novel approaches for processing accelerometer data are promising and show that activity types can be successfully identified and activity METs estimated. However, if these more sophisticated approaches to data processing are to be widely adopted by physical activity researchers, the methods must apply to commonly used accelerometers, and individuals with limited computation and statistical background should be able to use these methods. Furthermore, although these advances in data processing show promise, researchers are publishing various approaches to pattern recognition methods and the field does not want to be in the same position as it is currently with cut-points where different cut-point methods result in different estimates of physical activity making comparability between studies difficult.

Research priorities on quantifying physical activity using accelerometers

- Most pattern recognition studies have been conducted with adult participants. More studies need to be conducted with other age groups who may participate in different activities to adults. The activities used in these studies should be reflective of the type and intensities of the activities undertaken by the population under investigation.
- Decision rules used in data reduction should be explicitly described by researchers.

- Attempts should be made to standardise criteria, based on the available evidence, in order to allow comparison across studies.
- Identification of the most accurate prediction equation would allow the field to move toward a uniform approach to accelerometer data reduction.

Phase III: Identify factors that influence levels of physical activity

Findings from the quantitative systematic review presented in Chapter 2 demonstrate that parents influence children's and adolescents' physical activity when physical activity is measured by self-report. In agreement with this, qualitative studies (Chapter 2.2) also demonstrated that parents influence physical activity of children and adolescents in a variety of ways. However, Chapter 2.1 demonstrated that when objectively measured physical activity is analysed separately no positive relationships are evident between parental influence and young people's physical activity. This finding supports the work of Ferreira et al (79) and Prochaska et al (178) who found clear discrepancies between correlates of objectively measured and self-reported physical activity. Chapters 4 and 5 also demonstrate few significant associations between objectively measured MVPA and sources of social support. One possible explanation for the lack of associations found may be because objective measures of physical activity are able to detect incidental physical activity throughout the day that may not be influenced by parents. Furthermore with objective measures, average minutes per day spent in MVPA, MPA and VPA are most commonly reported and it may be more important to examine specific segments of the day rather than including all physical activity accumulated throughout each day. For example, parents may have a more direct influence on early evening physical activity rather than overall MVPA. The internal clock mechanism in accelerometers allows activity levels during specific time periods (e.g., after school) to be assessed.

Among social support studies however, little attention has been directed toward activities undertaken at specific time periods or segments of a school day (e.g., after-school activity, lunchtime activity, before school as part of active transportation). The importance of support from parents, siblings and peers is likely to be dependent on the location, period of the day, and context of the physical activity examined. Only one study was located that examined the relative importance of encouragement from various sources (i.e., friends, parents, older siblings/cousins, schools) on segments of the day

(104) but physical activity was measured using self-report. Results demonstrated that peer encouragement was a key influence of activity during lunchtime, while both parent and peer encouragement influenced frequency of after-school activity. This makes sense given that children and adolescents spend a substantial part of the day at school away from the parents. Parents may have more influence on the early evening and weekend physical activity of their children. Therefore, to progress parental correlates research using objective measures of physical activity we should maybe turn our attention away from examining overall physical activity levels or average accumulated MVPA, MPA and VPA to examine specific segments of the day (e.g., after school period or weekends) in which young people spend the majority of their time with parents or friends. Examining specific segments of the day is possible with accelerometers. It may then be found that positive relationships emerge between objective measures of physical activity and social support.

Research priorities identified from chapters of this thesis

- Very little is known about the impact of parent and peer support on physical activity among minority youth and youth from lower socioeconomic groups. Therefore, there is a need to focus future research on these groups of young people.
- Given the changes in current family dynamics, it is very important to determine which forms of social support are dominant in the parent-child interrelations within single-parent families. For example, it is possible that single parents may have less free time to devote to their children's physical activity participation than do two-parent families, or even the forms of parental social support may be different for single-parent families.
- Given that the parents' ability to provide a high level of logistic support is likely to be affected by lifestyle issues such as their work patterns or socioeconomic status, there is a need to understand the factors that influence the provision of logistic support and develop innovative approaches to facilitate the provision of support when maintenance becomes difficult.
- Although a number of longitudinal studies have now emerged in this area more are required to determine change in activity over time and clarify temporal relationships between correlates and physical activity.

6.7 Summary

Despite the health benefits associated with regular physical activity only a small percentage of young people are meeting the physical activity recommendations. There is a need to further understanding of the factors that influence physical activity behaviour in young people to inform intervention programmes. This thesis demonstrated that parents play a key role in their child's physical activity through a variety of avenues such as modelling active behaviour, being directly involved in physical activity with their child and providing logistical support i.e., transportation and financial assistance. In adolescence support for physical activity provided by peers also appears to be important in shaping physical activity behaviour. Targeting such facets of the social environment offers a potentially useful avenue for interventions designed to increase physical activity.

An overarching theme in this thesis was the issue of physical activity measurement in young people. Assessing physical activity in young people is difficult and although objective measurement techniques such as accelerometers have the potential to overcome many of the limitations associated with self-report methods, it has been demonstrated in this thesis that there are a number of challenges with accelerometer use particularly in the area of processing data. The rich information provided by accelerometers makes them an invaluable tool to understand the complex nature of young people's physical activity behaviour but further work needs to be conducted on standardising methods for cleaning, analysing and reporting accelerometer data.

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Appendices

Appendix 1

Journal publications relating to work detailed in this thesis

Pediatric Exercise Science, 2010, 22, 105-113

Activity-Related Parenting Practices and Children's Objectively Measured Physical Activity

Charlotte L. Edwardson and Trish Gorely
Loughborough University

This study examined the relationship between activity-related parenting practices and children's objectively measured physical activity (PA) in 117 UK children (mean age 8.3 ± 0.95). No significant gender differences in the mean level of activity support were identified although it was found that mothers and fathers favored different activity-related parenting practices. Mothers provided higher levels of limiting sedentary behavior for both boys and girls compared with fathers as well as higher levels of logistic support for girls than fathers. Results showed that for boys, paternal explicit modeling was significantly associated with MVPA ($r = .31$) and VPA ($r = .37$). Overall, mothers and fathers favored different activity-related parenting practices when encouraging their children to be active and explicit modeling from fathers appears to be important in shaping physical activity in boys.

Physical activity surveys from several countries indicate that many children are not achieving the established guidelines for physical activity (7,11,13,22). In the UK 30% of boys and 51% of girls 7–10 years of age do not achieve the recommendation of moderate intensity physical activity for 60 min daily (11). These data demonstrate the need to increase physical activity levels within this age group and a first step in this process is to identify the correlates of physical activity among children.

A large number of correlates have been identified in the literature that may influence children's physical activity levels. These correlates include demographic, psychological, social, and environmental factors (14,18,21,23,26). Social sources that impact upon children's and adolescent's physical activity have been frequently studied. The family has been considered an important agent of socialisation as children spend the majority of their time within the context of the family during the formative years (16). Families teach skills and inculcate beliefs that can help to shape important attitudes and behaviors associated with physical activity (17). More specifically, parents may exert significant social influence over children's physical activity through encouraging them to be active, being active with their children, providing transportation and funding for activity and by serving as role models for physical activity. Encouragement of activity (21), parental participation

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Epoch Length and Its Effect on Physical Activity Intensity

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ABSTRACT

EDWARDSON, C. L. and T. GORELY. Epoch Length and Its Effect on Physical Activity Intensity. *Med. Sci. Sports Exerc.*, Vol. 42, No. 5, pp. 00–00, 2010. **Background**: Researchers have begun to investigate the issue of epoch length on children's physical activity using small sample sizes, and to date, no studies have been conducted in adolescents. **Purpose**: The purpose of this study was to investigate the effect of different epoch lengths (5, 15, 30, and 60 s) on derived levels of physical activity in both a child and an adolescent sample. **Methods**: Three hundred and eleven children aged 7–11 yr and 234 adolescents aged 12–16 yr were asked to wear an accelerometer during waking hours for 7 d. The epoch was set at 5 s, and when data were downloaded, the activity counts were then reintegrated into 15-, 30-, and 60-s epochs. **Results**: A significant epoch effect was seen for time spent in vigorous physical activity, light physical activity, and rest in the child and adolescent samples and moderate-to-vigorous and moderate physical activities in the child sample only. The Bland–Altman analysis showed reasonable agreement on moderate-to-vigorous, moderate, vigorous, and light physical activities and rest between 5- and 15-, 5- and 30-, and 30- and 60-s epochs in the child sample and between 5- and 15-, 5- and 30-, and 15- and 30-s epochs in the adolescent sample. **Conclusions**: A short epoch is strongly recommended for child and adolescent samples to obtain a "real" picture of children's physical activity behavior and to prevent accumulation of counts reflecting the average activity level when longer epochs are used. Activity prevalence studies using epoch lengths of 5 and 60 s in a child or an adolescent sample should not be compared nor should 15- and 60- and 30- and 60-s epochs in an adolescent sample. **Key Words:** CHILDREN, ADOLESCENTS, ACCELEROMETER, OBJECTIVE MEASUREMENT

Over the past decade, accelerometers have increased in popularity as an objective measure of physical activity to be used in free-living studies. Accelerometers measure the acceleration and the deceleration of body movement and provide a direct assessment of the frequency, intensity, and duration of physical activity (26). Accelerometers use rapid sampling of accelerometer counts over a preset sampling period (e.g., 5 s) called an epoch.

Much of the research conducted with children and adolescents has used 60-s epochs (3). This is mainly because in the past, accelerometers were only capable of storing data collected using epoch lengths of <60 s for a limited number of days, and ≥7 d has been suggested as the most appropriate length for measuring physical activity objectively in children and adolescents (24). However, researchers have described children's physical activity as spontaneous and intermittent (5), with the majority of physical activity bouts lasting between 3 and 22 s (4,5). The use of 60-s epochs may therefore be inappropriate when measuring young people's physical activity and may result in an underestimation of moderate and vigorous physical activities (MPA and VPA, respectively) (25). This is possible because if a child alternates between vigorous and light physical activities (VPA and LPA, respectively) within a given minute, the accumulation of counts for that minute will only reflect the average activity level during that period resulting in a smoothing effect (22). Total volume of activity accumulated per day is not affected by epoch length; epoch length only becomes an issue when physical activity intensity is the outcome of interest.

Recent advances in accelerometer storage capacity have meant that researchers can select an epoch length of <60 s while still being able to measure physical activity for ≥7 d. Therefore, recent research measuring young people's physical activity is using a variety of different epoch lengths (16,19,21), and it is unclear how these various epoch lengths affect the recorded time spent in physical activity. Other decisions that researchers have to make regarding the number of hours that constitute a valid day, defining nonwearing time, deciding on the minimum number of days to be used in the analysis, and extracting moderate-to-vigorous physical activity (MVPA) by applying cut points to the data have also varied across studies and some have been shown to

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Appendix 2

Parent Information Pack

This was used to collect the data that is presented in Chapters 3 and 4

GreatFun2Run Study Information

Background Information

There is much interest in the activity levels of children and young people, especially because of the increasing levels of overweight and obesity. To promote physical activity in young people Great 2 Run have developed an exciting physical activity and health initiative called GreatFun2Run. The school your son/daughter attends has signed up to take part in this programme. The Institute of Youth Sport at Loughborough University is evaluating the GreatFun2Run programme. This information sheet outlines what the evaluation involves and asks you to indicate whether you are willing for your child to take part in the evaluation.

Screening

- Prior to your child taking part we would ask you to complete a health questionnaire about them. This is to make sure your child has no health problems which would prevent them from participating in the study
- On the day of the assessments your child will be asked if they are in good health

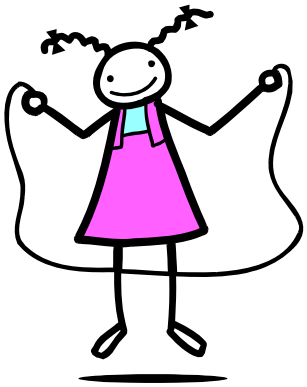
What will your child be asked to do:

During a school day your child will take part in a number of activities. These will be spread across several hours to prevent overload.

- Multi stage shuttle test – to measure fitness
- Height and weight
- Skinfold and circumference measurements – to measure the amount of fat in your child's body
- Complete a questionnaire about physical activity
- Complete a questionnaire about their views on physical activity
- Complete a questionnaire about the food they eat

In addition your child will be asked to:

- Wear a pedometer (step-counter) every day for one week
- Some children will be asked to also wear an activity logger (accelerometer) during the same week



When will these assessments take place:

The assessments will take place 3 times: November/December 2005, May/June 2006, September/October 2006.

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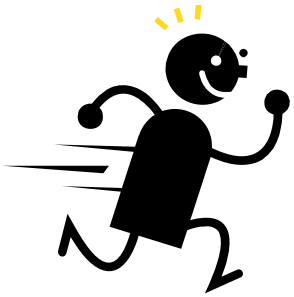
More on some of the assessments

Multi Stage Shuttle Test

This test involves running over a 20m distance. Your child will need to run in time to an audio signal (a 'bleep') which indicates when they should be at the end of each 20m. They will need to turn at the end of the 20m then begin the next 20m. They will be required to keep time to the 'bleeps' until they can no longer do so. The speed at which the 20m distance should be run increases every 60s. It will take between 5 and 10 minutes to compete the test.



Physical activity assessment

1. Pedometers (step-counter) are small devices worn on a belt around the waist. They measure the total number of steps taken. At the start of each school day and in the morning at weekends your son/daughter will be asked to record the total number of steps taken and reset the pedometer (a single button push). The pedometer does not interfere with normal daily activities.

2. Accelerometers are small lightweight physical activity loggers that give a measure of time spent being active and how hard someone is working while being active. Like the pedometer it is worn above the hip and is attached with clip to a waist belt. Aside from remembering to put the accelerometer on and off there is no further demand made upon the wearer. They do not interfere with the normal activities of the child.

A pedometer and accelerometer can be comfortably worn at the same time.

What you as a parent will be asked to do:

- Complete the health screening questionnaire on behalf of your child
- Complete a brief questionnaire covering demographics, your child's activity, and parent support for physical activity. This will take between 15 and 20 minutes.

Benefit of the Study

The aim of this study is to try and see if the GreatFun2Run programme increases physical activity in primary school aged children

Possible risks and discomfort:

None of the assessments should cause discomfort to your child. However, they will be encouraged to stop the multi stage shuttle test if it becomes uncomfortable for them.

Important notes:

- Although these assessments take place at school it is not compulsory for your child to take part
- Your child can withdraw from all or part of the study at any time without giving a reason
- All staff working on the project have been trained in the measurements involved
- All lead staff have police clearance to work with children. Police clearance has been sought for all other staff
- All information will be stored anonymously
- No individual child or school will be named in any report or research publication

Contact details:

If you have any further questions please contact Dr. Mary Nevill (01509) 226315 or m.e.nevill@lboro.ac.uk.

What to do now:

If you are willing for your son or daughter to take part in the study please complete and return the attached informed consent and health screen to the school.

Appendix 3

Parent consent form

This was used to collect the data that is presented in Chapter 3 and 4

Parent/Guardian Consent

- I have been given the opportunity to ask questions (please contact Dr Mary Nevill if you have any questions, see below) and I understand what is required from my child.

I have seen the information sheet and fully understand what the tests entail:

Tests

*Multi stage shuttle test *Height and weight *Skinfold and circumference measurements *Nutrition and physical activity questionnaires *Physical activity monitoring by pedometer and/or accelerometer *Psychological questionnaires

- I give permission for my child (please print your child's name) to be involved in the GreatFun2Run evaluation project. _____

- I understand my child can withdraw at any time and/or can choose to only do part of the testing.

- Parent/guardian's signature _____

- Parent/guardian's name (please print) _____

- Does your child take any medication? Yes ☐ No ☐
  If yes, please explain:

- Does your child have a medical condition? Yes ☐ No ☐
  If yes, please explain:

Direct line for Dr Mary Nevill: 01509 226315
Email address for Dr Mary Nevill: M.E.Nevill@lboro.ac.uk

Appendix 4

Reminder posters for primary school children

These were used to collect the data that is presented in Chapters 3 and 4

ARE YOU WEARING YOUR ACTIVITY MONITOR?

Appendix 5

Parent Questionnaire Cover Letter

This was used for the data collected in Chapter 4

School of Sport and Exercise Sciences
Loughborough University,
Loughborough LE11 3TU

Nov 2005

Dear Parent / Guardian / Care-Giver

Thank you for agreeing to let your child participate in the evaluation of the "GreatFun2Run" programme. We have completed the first round of assessments in their school and your child will be wearing a step counter this week. You don't have to do anything with this except remind your child to wear it every day. They will have brought home a guidance sheet for wearing it.

You may recall that as part of the assessment there was a short questionnaire for parents/guardians to complete. The questionnaire enclosed will provide us with some very important information, therefore we would appreciate it very much if you would complete the questionnaire and return it to the school by Thursday Dec 8.

If you have any questions please contact Dr. Mary Nevill (01509) 226315 or m.e.nevill@lboro.ac.uk.

Many thanks for your time and cooperation.

Warm Regards

Mary Nevill

Appendix 6

The Activity Support Scale

Completed by parents and used in both the child and adolescent support studies (Chapters 4 and 5)

Activity support I

I am the child's (please circle):
mother father grandmother grandfather
step-mother step-father other (please state) _____

Please read each statement and circle a response to indicate how much you agree or disagree with the statement.

		Strongly Disagree	Disagree	Agree	Strongly Agree
1.	I enjoy exercise and physical activity	1	2	3	4
2.	I limit how long my child plays video or computer games (including gameboys©).	1	2	3	4
3.	I often organise family outings that involve physical activity (e.g., going for a walk or a bike ride, going swimming).	1	2	3	4
4.	I frequently exercise or do something active with my child.	1	2	3	4
5.	I go out of my way to enrol my child in sports and other activities that get him/her to be physically active (e.g. after school programmes, programmes at the Leisure Centre).	1	2	3	4
6.	I exercise or am physically active on a regular basis.	1	2	3	4
7.	I often take my child to places where he/she can be active (e.g., parks, playgrounds, sport games or practices).	1	2	3	4
8.	My child can only watch a few programmes on TV each day.	1	2	3	4
9.	I often watch my child participate in sporting activities (e.g., watch your child perform at a cricket game or a dance recital).	1	2	3	4
10.	I tell my child to go outside and do something active if he/she has been doing indoor activities for a long time.	1	2	3	4
11.	I use my behaviour to encourage my child to be physically active.	1	2	3	4
12.	I limit how long my child can use the computer for things other than homework.	1	2	3	4

Activity support II

I am the child's (please circle):
mother father grandmother grandfather
step-mother step-father other (please state) _____

Please read each statement and circle a response to show how much you agree or disagree with the statement.

		Strongly Disagree	Disagree	Agree	Strongly Agree
1.	I enjoy exercise and physical activity	1	2	3	4
2.	I limit how long my child plays video or computer games (including gameboys©).	1	2	3	4
3.	I often organise family outings that involve physical activity (e.g., going for a walk or a bike ride, going swimming).	1	2	3	4
4.	I frequently exercise or do something active with my child.	1	2	3	4
5.	I go out of my way to enrol my child in sports and other activities that get him/her to be physically active (e.g. after school programmes, programmes at the Leisure Centre).	1	2	3	4
6.	I exercise or am physically active on a regular basis.	1	2	3	4
7.	I often take my child to places where he/she can be active (e.g., parks, playgrounds, sport games or practices).	1	2	3	4
8.	My child can only watch a few programmes on TV each day.	1	2	3	4
9.	I often watch my child participate in sporting activities (e.g., watch your child perform at a cricket game or a dance recital).	1	2	3	4
10.	I tell my child to go outside and do something active if he/she has been doing indoor activities for a long time.	1	2	3	4
11.	I use my behaviour to encourage my child to be physically active.	1	2	3	4
12.	I limit how long my child can use the computer for things other than homework.	1	2	3	4

Appendix 7

Head Teacher Study Information

This was used to collect the data that is presented in Chapter 5

School of Sport and Exercise Sciences
Loughborough University,
Loughborough LE11 3TU

Loughborough University

Participant Information Sheet for Head Teachers

A study investigating family influences on young people's physical activity, diet and sedentary behaviours

Promoting healthy eating and preventing declines in physical activity levels among young people have become public health priorities due to the increase in childhood overweight and obesity. To attempt to tackle the issue of overweight and obesity, a greater understanding of the determinants of certain behaviours is needed. The family has been identified as a critical force in the general socialisation of young people and as a prominent element of the social environment where behaviours are enacted and learnt. Research students at Loughborough University have designed a study to examine the influence of certain family variables on young people's physical activity, diet and sedentary behaviours.

For the study to elicit meaningful data, we need to recruit a number of schools to participate. We write to invite your school to take part in the study.

Being involved in the study will involve the following:

1. 2-3 classes from each year group being involved in the study, which will take place from November through to January.

   For the study a team of researchers would visit your school and carry out the assessments listed below. If it is possible these would be conducted in two lessons one week apart using whole class groups to minimise disruption to you. The questionnaire will take approximately 35 minutes to complete, and the other measures will take about 30 minutes to explain and demonstrate.

   The pupil assessments involved are:
   - Complete a questionnaire about themselves (e.g. gender, age etc.), about their family (parent support and parenting styles), about their diet and about their physical activity.

In addition to the questionnaire, pupils will be asked to:

- Wear an accelerometer (activity logger) every day for a week
- Keep a time-budget diary of sedentary behaviours for the 3-hours immediately after school for 3 school days and for the whole day on one weekend day.

The accelerometer and time budget diaries require limited input from the school except to remind the pupils to keep wearing the accelerometer and complete the diary (further information about these measures is given below).

Although conducted at the school it will not be compulsory for students to take part in the study or complete the study. Students can withdraw at anytime from the study.

2. Through the children a questionnaire would be sent home to be completed by parents/guardians. The questionnaire covers demographics, parent support for physical activity and parenting styles.

Study staff:
All staff working on the study have been trained in the measurements involved and the team have experience working with young people in schools using the measures involved. All staff working on the project have Criminal Record Bureau clearance.

What happens to the information:
All information collected will be stored anonymously. No individual school or pupil will be identifiable in any report or research publication.

Contact details:
If you have any further questions please contact Andy Atkin (01509) 228450 or A.Atkin@lboro.ac.uk. Or Dr Trish Gorely (01509) 226321 or p.j.Gorely@lboro.ac.uk.

If you are willing to for your pupils to take part in this study please complete the attached informed consent.

Thank you for your time and consideration.

Further information about the measures to be used:

Physical activity assessment:

Accelerometers are small lightweight physical activity loggers that give a measure of time spent being active and how hard someone is working while being active. The accelerometer is worn above the hip and is attached with a clip to a waist belt. Aside from remembering to put the accelerometer on and off there is no further demand made upon the wearer. They do not interfere with the normal activities of the wearer.

Food Intake:

Your child will be asked to fill in some simple food frequency questions. The foods that we will be asking about are breakfast, fruit and vegetables and snacks.

Sedentary behaviours:

Time budget diaries will be used to gather data on your child's sedentary behaviours from the time they finish school to when they eat their evening meal (approximately 3 hours), and for the whole day on one weekend day. Young people will record their actions, location and who they are with.

A study investigating family influences on young people's physical activity, diet and sedentary behaviours

INFORMED CONSENT FORM
(to be completed after Participant information Sheet has been read)

The purpose and details of this study have been explained to me. I understand that this study is designed to further scientific knowledge and that all procedures have been approved by the Loughborough University Ethical Advisory Committee.

I have read and understood the information sheet and this consent form.

I have had an opportunity to ask questions about the participation of my pupils in this study.

I understand that I, my staff and my pupils are under no obligation to take part in this study.

I understand that my pupils have the right to withdraw from this study at any stage for any reason, and that I or they will not be required to explain reasons for withdrawing.

I understand that all the information my pupils provide will be treated in strict confidence.

I agree for my pupils to participate in this study.

Your name _____

Your signature _____

Signature of investigator _____

Date _____

Appendix 8

Parent Consent Pack

This was used to collect the data that is presented in Chapter 5

School of Sport and Exercise Sciences
Loughborough University,
Loughborough LE11 3TU

Loughborough University

September 2007

Dear Parent / Guardian / Care-Giver

Research staff and students from Loughborough University are carrying out a study, looking at influences on young people's (aged 12-14 years) physical activity, diet and sedentary behaviours, in the Leicestershire area. [Loughborough University is one of the UK's leading Higher Education institutions for teaching and research in sport and exercise sciences].

In order to investigate influences on young people's physical activity, diet and sedentary behaviours, young people will be asked to complete a simple questionnaire and diary and wear an accelerometer for a week, and parents will be asked to complete a simple questionnaire.

The enclosed pack contains information detailing the study's aims and measures that will be used. We would really like your son/daughter to be part of this study. To find out more about what this would involve please read the attached information carefully and if you DO NOT want your child to participate in the study please return the consent form to the school.

In this pack you should find:

a. An information sheet, explaining in greater detail, the purpose and requirements of the study.
b. An informed consent form which MUST be signed by you and returned to the school if you DO NOT want your child to participate in the study.

If you have any questions please contact Natalie Pearson (07773165524), N.Pearson@lboro.ac.uk or Dr Trish Gorely (01509 226321), p.j.gorely@lboro.ac.uk

Kind regards,

Natalie Pearson

Study Information

Background Information

There is much interest in the physical activity, dietary and sedentary behaviours of young people, especially because of the increasing levels of overweight and obesity. Researchers from Loughborough University have designed a study to try and understand why young people behave the way they do. The school your son/daughter attends has signed up to take part in this study. This information sheet outlines what the study involves and asks whether you are willing for your child to participate.

What your child will be asked to do:

During one double lesson your child will:

- Complete a questionnaire about:
  - Physical activity
  - The food they eat
  - Their family

In addition your child will be asked to:

- Wear an activity logger (accelerometer) every day for one week
- Keep a diary of sedentary behaviours for the three hours immediately after school for 3 school days.

When will this study take place:

The questionnaire will be completed on one school day in September. The activity monitors and diaries will be collected from the school one week later.

More about the study

Physical activity assessment:

Accelerometers are small lightweight physical activity loggers that give a measure of time spent being active and how hard someone is working while being active. The accelerometer is worn above the hip and is attached with a clip to a waist belt. Aside from remembering to put the accelerometer on and off there is no further demand made upon the wearer. They do not interfere with the normal activities of the wearer.

Food Intake:

Your child will be asked to fill in some simple food frequency questions. The foods that we will be asking about are breakfast, fruit and vegetables and snacks.

Sedentary behaviours:

Time budget diaries will be used to gather data on your child's sedentary behaviours from the time they finish school to when they eat their evening meal (approximately 3 hours). Young people will record their actions, location and who they are with.

What you as a parent will be asked to do:

- Complete a brief questionnaire covering demographics, parenting styles and parental support for physical activity. This will take between 10 and 15 minutes.

Important notes:

- Although these assessments take place at school it is NOT compulsory for your child to take part
- Your child can withdraw from all or part of the study at anytime without giving a reason
- All staff working on the study have been trained in the measurements involved
- All staff have Criminal Records Bureau (CRB) clearance
- All information will be stored anonymously
- No individual child will be named in any report or research publication

What to do now:

If you are NOT willing for your child to take part in the study please complete and return the attached consent form to the school.

Contact details:

If you have any further questions please contact Natalie Pearson (07773165524) or N.Pearson@lboro.ac.uk

Or Dr Trish Gorely (01509 226321), p.j.gorely@lboro.ac.uk

Parent / Guardian Consent

- I have been given the opportunity to ask questions (please contact Natalie Pearson or Dr. Trish Gorely if you have any questions) and I understand what is required from my child.

I have seen the information sheet and fully understand what the study* entails:

Study:
*Physical activity questions, *food intake questions, * family questions, *physical activity monitoring by accelerometer, * sedentary behaviour monitoring by time-budget diaries.

I understand that my child can withdraw at anytime and/or can choose to only do part of the testing.

I do not want my child (please print child's name) to participate in this study:

_____

Parent / guardian's signature

_____

Parent / guardian's name

_____

Direct line for Natalie Pearson	07773165524
Email address for Natalie Pearson	N.Pearson@lboro.ac.uk
Direct line for Dr Trish Gorely	01509 226321
Email address for Dr Trish Gorely	p.j.gorely@lboro.ac.uk

Appendix 9

The Activity Support Scale

This was completed by adolescents for Chapter 5

YOUR FAMILY: For these questions, think about your family in general (including your parents and your brothers and sisters).

Statement	Strongly disagree	Disagree	Agree	Strongly agree
1. My family and I do active things together (for example, going on bike rides, hiking, ice skating, going for walks).	**1**	**2**	**3**	**4**
2. Physical activity is central to our family life.	**1**	**2**	**3**	**4**
3. People in my family are physically active.	**1**	**2**	**3**	**4**

YOUR BROTHER OR YOUR SISTER: For these questions, think about your sibling (brother or sister) who is most active and who influences you the most in terms of physical activity. If you only have one sibling, then think of that person. If you don't have a brother or a sister then leave these questions blank, check this box ☐

Statement	Strongly disagree	Disagree	Agree	Strongly agree
1. My sibling often plays sport or does something active.	1	2	3	4
2. My sibling thinks it is important to be physically active.	1	2	3	4
3. My sibling and I like to do active things together (e.g., play sports, swim, roller blade).	1	2	3	4
4. My sibling's participation in sports or other physical activities motivates me to be active.	1	2	3	4
5. I am interested in physical activity because of my sibling.	1	2	3	4

YOUR MOTHER: For these questions, think about your mother or your stepmother (whoever you spend more time with). If you don't live with your mother or your stepmother, then leave these questions blank, check this box ☐

Statement	Strongly disagree	Disagree	Agree	Strongly agree
1. My mother often exercises or does something active.	1	2	3	4
2. My mother and I do active things together (for example, walking, aerobics, sports).	1	2	3	4
3. My mother limits how much television I can watch.	1	2	3	4
4. My mother enjoys physical activity.	1	2	3	4
5. My mother drives (or takes) me to places where I can be physically active (for example, sport practices).	1	2	3	4
6. My mother limits how long I play video/computer games.	1	2	3	4
7. My mother enrols me in sports and other physical activities.	1	2	3	4
8. My mother tries to include me when she exercises or does something active.	1	2	3	4
9. My mother watches me compete in sporting events or other physical activities.	1	2	3	4
10. My mother limits how much time I spend using the computer for things other than homework.	1	2	3	4
11. My mother tells me to go outside and do something active if I have been doing indoor activities for a long time.	1	2	3	4
12. I am motivated to be physically active because my mother is active.	1	2	3	4

YOUR FATHER: For these questions, think about your father or your stepfather (whoever you spend more time with). If you don't live with your father or your stepfather, then leave these questions blank, check this box ☐

Statement	Strongly disagree	Disagree	Agree	Strongly agree
1. My father often exercises or does something active.	1	2	3	4
2. My father and I do active things together (for example, walking, cycling).	1	2	3	4
3. My father limits how much television I can watch.	1	2	3	4
4. My father enjoys physical activity.	1	2	3	4
5. My father drives (or takes) me to places where I can be physically active (e.g. sport practices).	1	2	3	4
6. My father limits how long I play video/ computer games.	1	2	3	4
7. My father enrols me in sports and other physical activities.	1	2	3	4
8. My father tries to include me when he exercises or does something active.	1	2	3	4
9. My father watches me compete in sporting events or other physical activities.	1	2	3	4
10. My father limits how much time I spend using the computer for things other than homework.	1	2	3	4
11. My father tells me to go outside and do something active if I have been doing indoor activities for a long time.	1	2	3	4
12. I am motivated to be physically active because my father is active.	1	2	3	4

YOUR FRIENDS: For these questions, think of your closest friends.

Statement	Strongly disagree	Disagree	Agree	Strongly agree
My friends often play sport or do something active.	1	2	3	4
My friends think it is important to be physically active.	1	2	3	4
My friends and I like to do active things together.	1	2	3	4
My friends admire people who are physically active.	1	2	3	4
I am motivated to be physically active because my friends are active.	1	2	3	4

Appendix 10

3 Day Physical Activity Recall

This was completed by adolescents for Chapter 5

The purpose of this part of the questionnaire is to estimate the amount of physical activity that you have done in the **last 3 days**. Please follow the instructions below:-

1. You are going to complete the table on the next page. This asks about what you were doing every 30 minutes yesterday (Wednesday).
2. Starting at 7am yesterday (Wednesday) morning think about the main activity that you were doing.
3. Find the number of that activity from the list of activities on the next page.
4. Write this number in the column labelled 'Activity' in the table (see the example table at the bottom of the next page if you are unsure about what to do).
5. Then decide whether the activity that you did was light, moderate, hard or very hard in intensity (see examples below) and put an 'X' in the correct column on the table (see the example table at the bottom of the next page if you are unsure).
6. Repeat this for the rest of the day and then do the same for Tuesday and Monday on the tables on the following few pages.

- **Light** – Activities that involve slow, little or no movement and breathing remains normal e.g. watching tv, reading, listening to music, getting dressed, playing on the computer, eating.



- **Moderate** – Activities that involve more movement and cause you to breathe a little heavier than normal e.g. brisk walking, slow cycling, golf, swimming.



- **Hard –** Activities that cause you to breath faster and sweat e.g. jogging, football, dance.



- **Very Hard –** Activities that involve very quick movement and cause you to breathe very fast e.g. sprinting, fast cycling, aerobics.



ACTIVITY NUMBERS

Sleep / Bathing

1. Showering / bathing / getting ready
2. Sleeping

3. **Eating/Snacking**

Transportation

4. Riding in a car / bus
5. Travel by bicycling
6. Travel by walking
7. Other way of travel
   list: _____

School

8. Club (e.g. computer club)
9. Free period / breaktime
10. PE class
11. Sitting in class (lesson time)

Out of school /Spare time /Hobbies

12. Hanging around
13. Homework / Tuition
14. Music lesson / playing instrument
15. Phone / listening to music
16. Reading
17. Religious activities (e.g. church/temple)
18. Technology activities (e.g. computer games and general use, TV or videos)
19. Shopping
20. Work (e.g. p/t job, house chores, gardening)

Physical Activities and Sports

21. Aerobics / aerobic dancing
22. Badminton
23. Basketball
24. Bicycling
25. Dance
26. Football
27. Golf
28. Hockey
29. Karate / judo / martial arts
30. Netball
31. Roller-skating / Roller-blading
32. Running / Jogging
33. Rugby
34. Skateboarding
35. Softball / Rounders
36. Stationary exercise machines (e.g. cycle, ski machine, stair climber, treadmill)
37. Swimming, water exercise
38. Table tennis
39. Tennis
40. Volleyball
41. Walking
42. Wall-climbing
43. Weight / Circuit training
44. Other (list)

_____

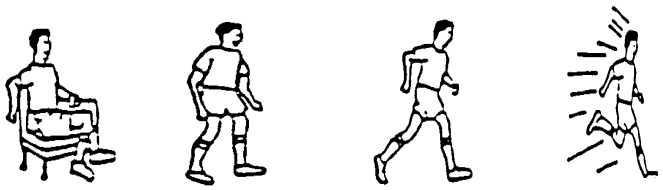
Sample activity time sheet:

The table below shows the correct way to fill the activity time sheets.
Note that only **one** intensity level is checked for each activity

	Activity	Light	Moderate	Hard	Very Hard
7.00 – 7.30	1	X			
7.30 – 8.00	3	X			
8.00 – 8.30	6		X		
8.30 – 9.00	26			X	
9.00 – 9.30	11	X			

Please complete this table for
Yesterday (Wednesday)

Put an "**X**" to mark the intensity of each activity



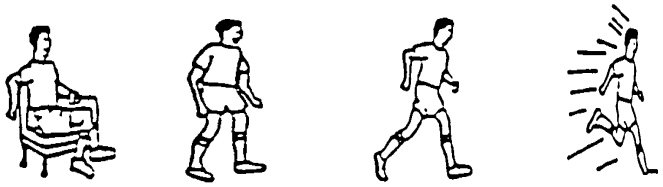
Write activity numbers in this column

		Activity	Light	Moderate	Hard	Very Hard
Before School	7.00 - 7.30					
	7.30 - 8.00					
During School	8.00 - 8.30					
	8.30 - 9.00					
	9.00 -9.30					
	9.30-10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					
Dinnertime	12.00-12.30					
	12.30 - 1.00					
During School	1.00 - 1.30					
	1.30 - 2.00					
	2.00 - 2.30					
	2.30 - 3.00					
After School	3.00 - 3.30					
	3.30 - 4.00					
	4.00 - 4.30					
	4.30 - 5.00					
Evening	5.00 - 5.30					
	5.30 - 6.00					
	6.00 - 6.30					
	6.30 - 7.00					
	7.00 - 7.30					
	7.30 - 8.00					
	8.00 - 8.30					
	8.30 - 9.00					
Night-time	9.00 - 9.30					
	9.30 - 10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					

In terms of physical activity, is this a typical day for you? Yes ☐ No ☐

Please complete this table for
Tuesday

Put an "**X**" to mark the intensity of each activity



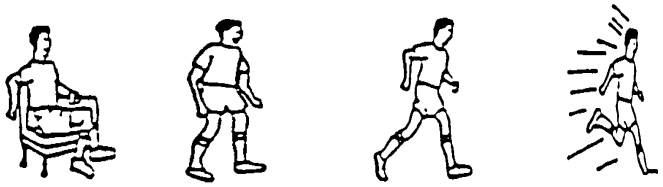
Write activity numbers in this column

		Activity	Light	Moderate	Hard	Very Hard
Before School	7.00 - 7.30					
	7.30 - 8.00					
During School	8.00 - 8.30					
	8.30 - 9.00					
	9.00 -9.30					
	9.30-10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					
Dinnertime	12.00-12.30					
	12.30 - 1.00					
During School	1.00 - 1.30					
	1.30 - 2.00					
	2.00 - 2.30					
	2.30 - 3.00					
After School	3.00 - 3.30					
	3.30 - 4.00					
	4.00 - 4.30					
	4.30 - 5.00					
	5.00 - 5.30					
	5.30 - 6.00					
Evening	6.00 - 6.30					
	6.30 - 7.00					
	7.00 - 7.30					
	7.30 - 8.00					
	8.00 - 8.30					
	8.30 - 9.00					
Night-time	9.00 - 9.30					
	9.30 - 10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					

In terms of physical activity, is this a typical day for you? Yes ☐ No ☐

Please complete this table for
Yesterday (Monday)

Put an "**X**" to mark the intensity of each activity



Write activity numbers in this column

		Activity	Light	Moderate	Hard	Very Hard
Before School	7.00 - 7.30					
	7.30 - 8.00					
During School	8.00 - 8.30					
	8.30 - 9.00					
	9.00 -9.30					
	9.30-10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					
Dinnertime	12.00-12.30					
	12.30 - 1.00					
During School	1.00 - 1.30					
	1.30 - 2.00					
	2.00 - 2.30					
	2.30 - 3.00					
After School	3.00 - 3.30					
	3.30 - 4.00					
	4.00 - 4.30					
	4.30 - 5.00					
	5.00 - 5.30					
	5.30 - 6.00					
Evening	6.00 - 6.30					
	6.30 - 7.00					
	7.00 - 7.30					
	7.30 - 8.00					
	8.00 - 8.30					
	8.30 - 9.00					
Night-time	9.00 - 9.30					
	9.30 - 10.00					
	10.00-10.30					
	10.30-11.00					
	11.00-11.30					
	11.30-12.00					

In terms of physical activity, is this a typical day for you? Yes ☐ No ☐

Appendix 11

Accelerometer instruction sheet

This was used to collect the data that is presented in Chapters 3, 4 and 5

INSTRUCTION SHEET FOR ACTIVITY MONITOR

- Wear the activity monitor everyday until we collect them from the school

- Put the activity monitor on every morning when you wake up

- Please remember to keep the belt a 'snug' fit – adjust using either tape or the pull through straps.

- Take the activity monitor off when you go to bed

- Only take the activity monitor off when: -
  - In bed
  - In the bath or shower
  - Doing watersport activities – swimming

- Do not get the activity monitor wet

- Make sure the activity monitor is the right way up.
  You should see the smiley face when you look down

- You do not need to do anything with the activity monitor just wear it

- We will collect the activity monitor from the school on **Thursday March 6th**.

Appendix 12

Cover letter for parent survey

This was used to collect the data that is presented in Chapter 5

School of Sport and Exercise Sciences
Loughborough University,
Loughborough LE11 3TU

Loughborough University

September 2007

Dear Parent / Guardian / Care-Giver,

Thank you for participating in this study. This research is important in that it will help us to better understand young people's physical activity and dietary behaviours. We are keen to learn more about the role of parents on this issue and, therefore, would be grateful if you would fill out the enclosed questionnaire. We anticipate that this will take no more than 20 minutes to complete.

Once you have completed the questionnaire, please use the paid return envelope provided. Please return the questionnaire by Friday 5th October.

Thank you again for your participation,

Kind regards,

Natalie Pearson

Note: Please be aware that your child has been asked to wear an "accelerometer" (activity monitor) for one week. This is to be worn at all times apart from during water-based activities (e.g. swimming or bathing) and whilst sleeping. Also, your child has been provided with a diary, to record their activities from 3pm until 7.30pm. Please prompt your child to complete this diary for the three days stated on the front page. The diary and activity monitor are key aspects of this research. Please encourage your son / daughter to follow the instruction carefully.

Please do not hesitate to contact the research team if you have any questions.

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