Correlates of Children's Physical Activity: A Study of Six-Year Olds

Graduate Thesis

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Trondheim, 2015

Author Note

Acknowledgements

First and foremost I would like to thank my supervisor Silje Steinsbekk. Your advice, guidance and feedback during the process of writing this paper have been invaluable. In addition, I would like to thank you for your patience and understanding, as this has been a rather lengthy process due to the emergence of several unexpected issues in my personal life. I would also like to thank my co-supervisor Lars Wichstrøm for useful advice. Lastly, I'd like to thank all the families who participated in the Trondheim Early Secure Study, as well as all the people working on the project. Without all of them, the data on which this study is based would not exist.

Abstract

Physical activity is a central component of a healthy lifestyle among young people, in addition to potentially playing a vital role in their social and mental adjustment. Lack of physical activity may contribute to the development of health problems in children, and these health problems often track into adulthood. Children's surroundings are filled with technological advances which are meant to increase efficiency and productivity, but which at the same time may reduce physical activity. Many children also have access to multiple sedentary alternatives to active play, in the form of various screen activities. Identifying factors related to physical activity in children is important because such factors can be addressed to promote higher levels of physical activity. The aim of the present study was therefore to identify child, family, and environmental correlates of objectively measured PA in a large and representative community sample of Norwegian six-year olds. Based on available research on correlates of children's physical activity, 19 factors were selected for this study, and a stepwise analysis was performed to identify those associated with children's physical activity. The results of the final analysis identified the following eight factors to be significantly related to physical activity in children: percentage of bodyfat in the child (inversely), surgency, having parents who had lived together for the past six months, total number of hours spent outside alone and together with parents, number of hours per weekday spent watching TV (inversely), time to walk to a recreational area (the shorter the time the higher the level of physical activity), and having a garden.

Keywords: children, physical activity, inactivity, health.

Despite their natural tendencies towards physical play, children in developed countries spend less time being physically active than earlier generations (Boreham & Riddoch, 2001). Physical activity (PA) is defined as any physical movement or muscular exertion which increases energy expenditure above a resting level (Allender, Cowburn, & Foster, 2006), and at the level above this is moderate-to-vigorous physical activity (MVPA) which are activities that raise energy expenditure to at least three times one's basal metabolic rate (Iannotti et al., 2009). PA is considered a central component in the maintenance of a healthy lifestyle, it is particularly important for physical health, growth and development of young people, and also plays a vital role in their social and mental adjustment (Hills, King, & Armstrong, 2007). The World Health Organization (WHO) recognize early childhood as the most important stage of development, as it is where the foundation for all future health is laid, and also where potentially life-long habits are formed (WHO, 2009). Identifying factors related to PA in children is important because such factors can be addressed to promote higher levels of PA. The aim of the present study was therefore to identify child, family, and environmental correlates of objectively measured PA in a large and representative community sample of Norwegian six-year olds.

Physical Activity and Health

PA is a central topic in discussions regarding health promotion and disease prevention, whereas physical inactivity is increasingly considered a major risk factor for morbidity in children and adolescents (Malina & Little, 2008). For children aged 5-17 years, the WHO recommends at least 60 minutes of MVPA daily (WHO, 2009). Evidence from observational studies further indicates a dose-response relationship between health and PA: the more PA a child undertakes the greater the health benefits they achieve (Janssen & Leblanc, 2010). Although estimates of PA vary, many report insufficient activity levels. A global prevalence estimate, using data from 105 countries show that more than 80% of 13-15

year olds failed to meet the WHO recommendation for 60min of MVPA per day (Hallal et al., 2012). In a large international study of students aged 11-15 from all four European regions as well as North America, it was reported that on average, children in none of the regions were sufficiently active to meet the recommended minimum of 60 minutes a day of MVPA (Iannotti et al., 2009). In Canada, recent data show that only 7% of youth aged 6-19 years participate in 60 minutes of MVPA per day (Tremblay et al., 2011), and in the US, it is estimated that children spend as little as 12 minutes a day in vigorous physical activity (Ebbeling, Pawlak, & Ludwig, 2002). In comparison with their counterparts 50 years ago, children today expend an average of approximately 600 kcal less per day (Boreham & Riddoch, 2001). There is an increasing agreement among experts that changes in environment rather than biology is the driving force behind this change in activity levels (Hill, Wyatt, Reed, & Peters, 2003). In developed countries, technological advances which in principle are meant to benefit us by increasing efficiency and productivity, are for many rendering PA almost obsolete as the amount of physical exertion needed to complete daily necessary tasks are reduced to an absolute minimum (Hill et al., 2003). In addition to extended use of motorized transport and manual labour-saving devices, sedentary activities in the form of screen based media use such as TV, mobile phones and various internet activities are becoming increasingly popular, especially among children and youth (Roberts & Foehr, 2008; Sisson et al., 2009). The increasing levels of physical inactivity is generally becoming such a major challenge to people's health that it is now recognized as a global epidemic (Allender et al., 2006), one that is estimated to cause a staggering 600 000 annual deaths in the European region alone (WHO, 2009). Notably though, PA and inactivity are not mutually exclusive, but are considered distinctly separate behaviours, so high levels of PA in a child, does not automatically predict low levels of sedentary behaviour and vice versa, and high

levels of both can coexist in one child (Biddle, Gorley, Marshall, Murday, & Cameron, 2004).

Consequences of insufficient PA

Evidence from a review suggest that sedentary behaviours, defined as any behaviour which maintains energy expenditure at a level close to that when one is resting (Iannotti et al., 2009), directly influence metabolism, bone mineral content and vascular health, and that extended doses of time spent being sedentary without vigorous PA, results in substantially elevated cardiometabolic risk (Tremblay, Colley, Saunders, Healy, & Owen, 2010). These findings are corroborated by the results from a systematic review conducted on youth aged 5-17, which indicate that increased sedentary behaviour, is associated with increased risk for cardiovascular disease (CVD) and metabolic syndrome, which is a coexistence of multiple CVD and diabetes risk factors (Steele, Brage, Corder, Wareham, & Ekelund, 2008). Sedentary behaviours have also been linked to unfavourably body compositions, decreased fitness, lower self-esteem and decreased academic achievements in children and youth (Malina & Little, 2008; Tremblay et al., 2011). The disease which causes the most deaths in Western societies is CVD, which is now recognized as partly a paediatric problem because although the clinical symptoms of the disease are not apparent until later in life, the onset of CVD lies in early childhood, and clustering of CVD risk factors are strongly related to low PA levels in children (Froberg & Andersen, 2005). Psychological health may also be affected, and children who are not physically active do not get to enjoy the positive social and emotional benefits of PA (Davidson & Lawson, 2006). The social and mental health legacies of low levels of PA are supported by a cohort study of more than 7000 adolescents which found that participation in less than 60 minutes of MVPA per week was associated with significantly higher levels of symptoms of anxiety and depression, withdrawal, social problems, and somatic complaints, compared to adolescents who were physically active,

defined in this study as undertaking four hours or more of MVPA per week (Kantomaa, Tammelin, Ebeling, & Taanila, 2008). Overall, insufficient PA is a key risk factor for developing a wide variety of problems and noncommunicable diseases, including but not limited to depression, anxiety, psychosocial problems, Type 2 diabetes, CVD, including stroke and coronary artery disease, hypertension (high blood pressure), asthma, and many cancers (Allender et al, 2006; WHO, 2009).

Parallel to the inactivity epidemic is the problem of obesity, which has also reached epidemic proportions, even among children (Ebbeling et al., 2002). Among European children as many as 15% of 9 year old children has clustered risk of CVD, and the majority of overweight and obese children are found in this group (Froberg & Andersen, 2005). It is also estimated that in the US, as many as 60% of children exhibit at least one modifiable adult risk factor for CVD by the age of 12 (Baranowski et al., 1992). Physical inactivity and obesity are intricately linked conditions (Malina & Little, 2008; Manson, Skerrett, Greenland, & Vanltallie, 2004), and it is therefore difficult to assess the adverse health consequences of insufficient PA without including the role of obesity. Simply stated, an increase in body weight is a result of energy imbalance: energy intake exceeds energy expenditure over a sustained period of time (Hensrud & Klein, 2006). An excess of as little as 120kcal per day (about 2dl of soft drink) would lead to a 50kg increase in body mass over a period of 10 years (Ebbeling et al., 2002), whereas increasing the daily energy expenditure by about 100kcal can be achieved by approximately 15 minutes of walking (Hill et al., 2003). PA is as such considered a vital component in weight control (WHO, 2009). Although a clear cause-effect relationship between inactivity and obesity has not been established (Metcalf et al., 2011), numerous studies have demonstrated a significant inverse relationship between PA and body mass index (BMI), such that lower PA levels are associated with increased BMI (Must & Tybor, 2005; Ruiz et al., 2009; Tremblay & Willms, 2003), and an increase in PA is

associated with reduced odds of overweight (Ruiz et al., 2009). Increased PA and decreased sedentary behaviour have also been found to be protective against weight gain in children (Must & Tybor, 2005). In addition, obesity is a comorbidity of some of the most prevalent diseases of our time, many of which are related to lifestyle and PA levels, such as type 2 diabetes and CVD (Baker, Olsen, & Sørensen, 2007; Hensrud & Klein, 2006; Strine et al., 2008).

Benefits of PA

When compared with their less active counterparts, children who undertake sufficient amounts of PA show improved motor skills (Hills et al., 2007), have better cardiovascular profiles and develop higher peak bone masses (Boreham & Riddoch, 2001). PA directly affects the circulatory system, including the heart, by altering the sensitivity of two metabolic hormones responsible for changes in fat and carbohydrate metabolism; adrenalin and insulin. These two hormones are related to most of the biological CVD risk factors, and they are both influenced by PA. PA can as a result of this reduce risk factors such as blood pressure, abdominal fat, and cholesterol fractions simultaneously (Froberg & Andersen, 2005). In a review, Steel et al. (2008) investigated the link between PA and the metabolic syndrome in children, which is defined by central obesity, raised triglyceride levels, reduced HDL-cholesterol level, hypertension and elevated fasting plasma glucose. They found several instances of PA being inversely associated with the number of metabolic risk factors, even when Body Mass Index (BMI) was controlled for, meaning that heavier children will benefit from PA even if fat mass is not reduced. This is supported by findings from a population-based study of metabolic risk in European children (Eklund et al., 2006), as well as a study on metabolic syndrome and PA in Danish children, where they also found this inverse relationship, and even concluded that the least fit children might actually have more to gain from increasing PA levels than their more fit counterparts (Brage et al., 2004). When applied

as an intervention program for children, PA has been found to favourably affect body composition, aerobic fitness and risk of CVD, even in children who are of normal weight and health (Kriemler et al., 2010). Sufficiently active children also have better mental and social health (Iannotti et al., 2009), and show improved cognitive functioning (Sibley & Etnier, 2003; Tomporowski, Lambourne, & Okumura, 2011). Additionally, PA has consistently been found to be related to improvements in self-esteem and inversely related to depression and anxiety (more PA predicts lower levels of depression and anxiety) among youth (Calfas & Taylor, 1994; Hong et al., 2009; Rothon et al., 2010; Wiles, Haase, Lawlor, Ness, & Lewis, 2012). This research make it clear that PA is important to a wide range of both physical and mental health aspects in children.

Tracking through lifespan

Generally, inactive children tend to become inactive adults, whereas physically active children grow into physically active adults (Craigie, Lake, Kelly, Adamson & Mathers, 2011; Steele et al., 2008). Behaviours of a sedentary nature in childhood can be reinforcing, which makes them more likely to facilitate a habitually sedentary lifestyle as they grow older (Hills et al., 2007), thus potentially turning into lifelong habits, with accompanying adverse health problems. This highlights the importance of identifying factors associated with PA early in life, as it can be viewed as a starting point for future PA behaviours. There are generally fewer detectable markers of disease due to poor lifestyle and lack of PA during childhood compared to adulthood (Hills et al., 2007), but risk factors of diseases which are most common in adults often have their origin in childhood lifestyle behaviour (Proctor et al., 2003), such as with CVD, where the clinical symptoms do not become apparent until adulthood, but the onset of the disease lies in early childhood (Froberg & Andersen, 2005). In support of this, a large population based cohort study of more than 270,000 subjects in Denmark report that even small amounts of weight gain in childhood will increase the risk of

CVD in adulthood (Baker et al., 2007). In addition to this, health problems with an onset early in life tend to track into adulthood (Hills et al., 2007). PA levels earlier in life has also shown to affect adult mental health, as lower levels of childhood PA have been found to be predictive of adult depression (Jacka et al., 2011). Fortunately, there is also evidence of tracking of positive health behaviours. Findings from a systematic review of 28 papers found evidence of tracking of both PA and inactivity from childhood and into adulthood (Craigie et al., 2011). For instance, adults who regularly participated in organized sports in childhood and youth were found to be five to six times as likely to be highly physically active as adults, when compared with nonparticipants (Telama, Yang, Hirvensalo, & Raitakari, 2006). The effects found in this study were strongest for those who had participated for at least 3 years, but even a short experience of sport participation in youth was found to increase the probabilities of being active as adults. And with health behaviours tracking from childhood into adulthood, it naturally follows that its correlate, the general level of fitness do as well (Steele et al., 2008). A systematic review of health-related fitness in youth found that those who had a healthier body composition in childhood were far more likely to have a healthier cardiovascular profile later in life and thereby also to have an overall lower risk of death (Ruiz et al., 2009). These findings highlights early childhood as a very important stage in life with regards to disease prevention and health promotion.

Theoretical framework and aims for the current study

Several ecological models within the behavioural sciences have been developed over the years, with a focus on understanding people's behavioural transactions with their surroundings. Glanz et al (2008) describes 13 such models, and the core concept of these are that human behaviour has many levels of influences, such as intrapersonal (biological and psychological), interpersonal (social and cultural), community, physical environmental, and public policy, and that influences on behaviour interact across these different levels. The

purpose of these ecological models is to aid in the development of interventions, and change in behaviour is thought to be more likely when interventions target multiple levels (Glanz, Rimer, & Viswanath, 2008). Based on the principle of ecological models noted above, literature divided into the following three different levels was explored with the intention of selecting factors for the current thesis: 1: Characteristics of the child and family related to PA (e.g. self-esteem, socioeconomic status), 2: Behaviours of the child and family related to PA (e.g. sports participation, amount of time parents spend outside with their child), and 3: Environmental factors related to PA. Notably, the difference between the first two categories is that the first category includes characteristics, which is here defined as factors "within" and of the child and family (e.g. percentage of bodyfat or socioeconomic status), whereas the second category includes behaviours, which reflects what the child and parents do.

When reviewing previous research in preparation of the current study, two findings emerged as consistent. Firstly, although there are hundreds of published articles on correlates of PA, the majority of them have focused on adults. Generally, the amount of research available tends to decrease along with the age of the subjects, and in the research reviewed here, only 14 (Davidson & Lawson, 2006; Grigsby-Toussaint, Chi, Fiese, & Group, S. K. P. W., 2011; Gustafson & Rhodes, 2006; Hamer, Stamatakis, & Mishra, 2009; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008; Janssen & Leblanc, 2010; LeBlanc et al., 2012; Must & Tybor, 2005; Roemmich et al., 2006; Sallis, Prochaska, & Taylor, 2000; Sibley & Etnier, 2003; Tandon et al., 2012; Van Der Horst, Paw, Twisk, & Van Mechelen, 2007; Whitt-Glover et al., 2009) articles were found to include correlates of PA in children six years and younger. Secondly, even though a wide range of correlates of PA have been identified, most studies have focused only on a narrow range of factors, often categorized as related to the environment (Davidson & Lawson, 2006; Grigsby-Toussaint et al., 2011; Roemmich et al., 2006; Sallis et al., 2009; Roemmich, Epstein, Raja, & Yin, 2007), mental

health (Biddle & Asare, 2011; Calfas & Taylor, 1994; Hong et al., 2009; Iannotti et al., 2009; Ortega, Ruiz, Castillo, & Sjostrom, 2008; Rhodes & Smith, 2006; Rothon et al., 2010; Scully, Kremer, Meade, Graham, & Dudgeon, 1998; Sibley & Etnier, 2003; Strauss, Rodzilsky, Burack, & Colin, 2001; Tomporowski et al., 2011; Wiles et al., 2012), physical health (Boreham & Riddoch, 2001; Hills et al., 2007; Froberg & Andersen, 2005; Janssen & Leblanc, 2010; Malina & Little, 2008; Metcalf et al., 2011; Must & Tybor, 2005; Ruiz et al., 2009; Steele et al., 2008; Tremblay et al., 2010; Tremblay et al., 2011; Tremblay & Willms, 2003), age and tracking (Jacka et al., 2011; Kuh & Cooper, 1992; Sallis, 1999), sedentary behaviours (Biddle et al., 2004; Robinson et al., 1993; Rosenberg et al., 2010; Taveras et al., 2007), SES and parental influence on child PA (Gustafson & Rhodes, 2006; O'Dwyer, Fairclough, Knowles, & Stratton, 2012; Mattocks et al., 2008; Tandon et al., 2012) etc. When combining the search for PA correlates from several domains, with subjects age 6 or younger, only 4 articles were found (Hinkley et al., 2008; LeBlanc et al., 2012; Van Der Horst et al., 2007; Sallis, Taylor, Dowda, Freedson, & Pate, 2002), and 3 of them were reviews. Thus, the author was only able to find one earlier study (Sallis et al., 2002) that has examined a range of child, -family and environmental correlates in young children, and knowledge is therefore lacking on the relative importance of different factors from these categories for children's level of PA. The current study therefore aims to fill this gap in the existing literature by investigating factors at each of these three levels in relation to children's PA levels.

Factors related to children's level of PA - a review of the literature

Characteristics of the child and family related to level of PA

Regarding aspects of children themselves, the overall most consistent findings related to PA seems to be age and gender. Generally, age is inversely related to PA, such that there is a decline in PA with increasing age (LeBlanc et al., 2012; Van Der Horst et al., 2007), and

this has even been found in other species, suggesting a biological basis (Sallis, 1999). Gender is also strongly related to PA, with males consistently being more active than females (LeBlanc et al., 2012; Hallal et al., 2012; Sallis et al., 2000; Van Der Horst et al., 2007). Weight has already been noted as being closely linked to PA, and heavier children tend do to be less physically active (Must & Tybor, 2005). Regarding aspects within the child itself, there is some evidence linking an extrovert personality and sensation seeking in adolescence and adulthood (De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Kuh & Cooper, 1992; LeBlanc et al., 2012; Rhodes & Smith, 2006) with higher PA levels, but there seems to be no research investigating such traits in relation to PA in childhood. Another intrapsychic aspect thought to be related to PA is self-esteem, which is viewed as an important indicator of positive mental health and well-being, and a commonly held idea is that PA is associated with the development of self-esteem (Biddle & Asare, 2011). Evidence from a review on the relationship between exercise and self-esteem in children and youth, indicate that exercise can indeed improve self-esteem (Ekeland, Heian, Hagen, Abbott, & Nordheim, 2004). Many other findings support the idea that various aspects of self-esteem is linked to PA levels in children, in terms of enhancing self-esteem through increasing PA levels (Biddle & Asare, 2011; Calfas & Taylor, 1994; Ortega et al., 2008; Strauss et al., 2001), although some have failed to find any connection between self-esteem and PA (LeBlanc et al., 2012). The weight of the parents have also been found to be related to children's PA, as overweight parents have somewhat surprisingly been found to have more active children (LeBlanc et al., 2012). With regards to parental influence, socioeconomic status (SES) and marital status of parents have also been researched in relation to children's PA levels. A review by Van Der Horst et al. (2007) found evidence that among youth, SES was inversely associated with sedentary behaviour, and another study report that children from families with lower SES are provided with more opportunities for sedentary behaviour and fewer for PA (Tandon et al., 2012),

whereas others have found no relationship between SES and children's PA (Hinkley et al., 2008; LeBlanc et al., 2012). The review by Van Der Horst et al. (2007) also concluded that single parent status is not related to children's PA levels. Based on the above noted research, the following child,- and parent characteristics were addressed as potential individual correlates of the level of PA in this study: percentage of bodyfat in the child and his/her parents, parental SES and whether or not the parents lived together for the past six months, as well as children's self-esteem. Since extraversion and sensation seeking has been tied to PA later in life, surgency was included as a child characteristic possibly affecting level of PA. Surgency is a trait aspect similar to extraversion in which a person tends to have high levels of positive affect and impulsivity, as well as a high activity level (Rothbart, Ahadi, Hershey, & Fisher, 2001).

Behaviours of the child and parents related to PA

Screen based media use, such as TV, video games, mobile phones, or various internet activities, are among the most common sedentary alternatives to active play offered to youth in our time (Roberts & Foehr, 2008; Sisson et al., 2009). Amount of time spent watching TV in relation to PA has been investigated with varying results, some have found increased TV viewing to be associated with lower levels of PA (Hamer et al., 2009, Robinson et al., 1993), whereas others have been unable to establish such a connection (Biddle et al., 2004; Taveras et al., 2007). There is also evidence that greater availability of media, especially TV, correlates with decreased PA (O'Dwyer et al., 2012), and more electronic equipment and numbers of TV's in the home. Media equipment in the child's bedroom has been particularly linked to children's screen based media use (Rosenberg et al., 2010; Tandon et al., 2012). Somewhat opposite of this is the aspect of amount of time a child spends outdoors, which is generally associated with increased levels of PA (Hinkley et al., 2008; LeBlanc et al., 2012). Child participation in organized sports has been found to increase daily energy expenditure

(Katzmarzyk & Malina, 1998), and as seen, it also predict a higher level of PA in adulthood (Telama et al., 2006). Because children rely on responsible adults to act as role models as well as providing them with guidance regarding what behaviours are good or bad, an assumption can be made that children may be more inclined to participate in PA if their parents model the desired behaviour (Hills et al., 2007). There has been some research on the impact that parents may or may not have on their children's PA levels. It has indeed been found that active parents tend to have more active children (Hinkley et al., 2008; Mattocks et al., 2008; Van Der Horst et al., 2007), but a review by Gustafson & Rhodes (2006) which included children in a wider age range found mixed results with regard to parental influence on their children's PA. Based on these findings, the following six child and parent behaviours were included in the current inquiry: child participation in organized sports, daily number of hours spent outside with parent, daily number of hours spent outside alone, hours per day watching TV, level of MVPA in the mother, and level of MVPA in the father.

Environmental factors related to the level of PA in childhood

In recent years there's been an increasing interest in how the physical environment influence PA levels (Davidson & Lawson, 2006). Here too, the majority of studies address PA in adults, indicating that neighbourhoods which support PA (eg. presence of sidewalks and bicycle facilities) strongly contributes to increase PA levels (Sallis et al., 2009). Notably though, some research on children do exist, and a review by Davidson & Lawson (2006) report that the location of the child's home in relation to parks, playgrounds etc, as well as the availability of recreation areas are associated with PA levels. However, the findings were mixed, with a few indications that such a relationship did not exist. Results from the same review generally showed an association between the presence of sidewalks and an absence of road hazards to children's PA. The relationship between neighbourhood greenness and how much time children spent playing outside has also been investigated, and results indicate that

children who live in neighbourhoods with higher levels of greenness were more likely to engage in outdoor PA (Grigsby-Toussaint et al., 2011). Findings from two other studies support this, showing greater proportions of park areas, as well as increased proximity between houses being associated with increased PA (Roemmich et al., 2006; Roemmich et al., 2007). Based on these findings, including environmental factors seemed justified in our aim to examine a multivariate model of PA in children. The following environmental factors were included in our study: time to walk to ballpark, time to walk to playground, time to walk to other recreational area, type of home (house, apartment), density between homes, having a garden, and traffic safety in the area.

Summary and objective of the present study

The research described above show that PA is associated with many health benefits in children (Boreham & Riddoch, 2001; Hills et al., 2007; WHO, 2009), whereas insufficient amounts of PA is associated with increased risk for severe health problems (Froberg & Andersen, 2005; Steele et al., 2008; Tremblay et al., 2010). Further, the level of PA tend to track from childhood into adulthood (Aberg et al., 2012; Hills et al., 2007; Ruiz et al., 2009), underscoring the importance of identifying factors related to PA early in life. To increase children's level of PA, such factors must be addressed. This is not only important with regards to children's current health status, but would also serve as a preventive measure to avoid future health problems.

Although a considerable amount of research is available on the topic of correlates of PA in children, gaps in the current knowledge base on this subject do exist. Firstly, the majority of research has focused on older children and adolescents. Secondly, most studies have investigated a narrow range of potential correlates. Only one study (Sallis et al., 2002) was found to include a wide range of factors combined with subjects six years and younger.

Also, although there is some evidence to support a correlation between an extrovert personality and higher PA levels in adolescence and adulthood (De Moor et al., 2006; Kuh & Cooper, 1992; Rhodes & Smith, 2006; Sallis et al., 2000), to the author's knowledge, there seems to be no research available on this topic in children. In an attempt to address these shortcomings and embrace the magnitude of factors associated with PA level in children, the aim of this study was to examine a wide range of potential child, family and environmental correlates of PA in a large and representative sample of six-year olds.

The research described above illustrate that a diversity of factors play a part in influencing children's PA levels. Based on this research, it is hypothesized that 1) percentage of bodyfat in the child will be negatively associated with PA, 2) high scores on surgency and self-esteem will be positively associated with PA, 3) percentage of bodyfat in the parents will be positively associated with the child's PA, 4) living in a single-parent household will show no association with PA, 5) living with parents of higher SES will be positively associated with PA, 6) time spent watching TV will be negatively associated with PA, 7) child participation in organized sports, and amount of time spent outdoors alone and together with parents will be positively associated with PA, 8) MVPA levels in the parents will be positively associated with PA in the child, 9) living in close proximity to ballparks, playgrounds and other recreational areas will be positively associated with PA, 10) type of home (e.g. house or flat), having a garden, closer proximity between houses, and traffic safety in the area will be positively correlated with PA. The multivariate model tested is displayed in Figure 1.

Method

Recruitment and participants

Data used is based on the longitudinal study "Trondheim,- Early Secure Study (TESS)", where all children born in Trondheim, Norway in 2003 and 2004 along with their parents were invited to participate (N=3,456).The invitation to participate was given to the families when the children were scheduled for their mandatory 4-year checkup at their local health clinics. Parents who did not have a sufficient understanding of the Norwegian language to participate in interviews were excluded (n=176). The parents were informed about the study by the nurse at the health clinic, who used procedures approved by the Regional Committee for Medical and Health Research Ethics. The nurse also obtained written consent from the parents. Retesting took place two years later (T2), and the current study used data from the second wave only, because PA was not assessed at age 4. Recruitment of participants and procedure at follow-up are presented in Figure 2. Characteristics of the sample at age 6 are presented in Table 1.

Measures

Dependent variable

Child Physical Activity. The child wore an Actigraph GT3X accelerometer for seven consecutive days, 24 hours per day. Accelerometers are worn around the waist on an adjustable belt, and as acceleration occurs, the acceleration signal from the accelerometer is digitized and generates an "activity count". These counts are summed up over a predetermined time interval (e.g. 5 seconds, 10 seconds, 1 minute). The resulting activity counts can then be used to estimate amount of PA, PA intensity, or energy expenditure. Only daytime activity (06:00-23:59) was used, and only participants with a minimum of three days of recordings with a minimum of 480 minutes of activity per day were included. 10 second epochs were used, and data was processed using accelerometer analysis software (ActiGraph

LLC, Pensacola, FL, USA). MVPA was calculated as minutes per day with >2000 counts per minute.

Characteristics of the child and family

Percentage of bodyfat in the child and his/her parent was measured by bioimpedance, using a digital scale (Tanita BC418MA) which is a device that can provide body mass readings (Volgyi, Tylavsky, Lyytikainen, Suominen, Alen, & Cheng, 2008). The subjects stands with bare feet on the analyzer and holds a grip in each hand, and an algorithm which incorporates impedance, age and height is then used to estimate percentage of fat mass in the body. The height of both children and parents were measured to the nearest 0,01cm by a digital stadiometer (Heightronic QuickMedical, Model 235A).

Surgency. Surgency was measured using the short form of the Children's Behavior Questionnaire (CBQ) (Putnam & Rothbart, 2006) which is a caregiver report that provides a comprehensive assessment of temperamental behavior patterns in children aged 3-8. The short form of CBQ contains 94-items divided by 15 subscales. The questionnaire covers three main factors: negative affectivity, effortful control, and extraversion/surgency, but only the latter was included in the present inquiry due to the already established link to PA (De Moor et al., 2006; Kuh & Cooper, 1992; LeBlanc et al., 2012; Rhodes & Smith, 2006). The surgency factor consists of 4 subscales: Activity level (7 items), High-intensity pleasure (6 items), Impulsivity (6 items), and Shyness (6 items). Parents assess their child's behavior by rating statements (e.g.*" is full of energy, even in the evening"*, or "*likes rough and rowdy games"*) on a 7-point scale ranging from 1 (*extremely untrue of your child*) to 7 (*extremely true of your child*), and they are also provided with the option *Not Applicable*, if they feel they cannot rate their child on the statement provided. Structural analysis of the CBQ scales demonstrate good construct validity and adequate internal consistency, and the factor

structure remains consistent across age groups and across cultures, (Putnam, & Rothbart, 2006; Rothbart et al., 2001).

Self-esteem. The child's self-esteem was measured using the Self-Description questionnaire (SDQ-I), (Marsh, Barnes, Cairns, & Tidman, 1984). The SDQ-1 is a commonly used questionnaire demonstrating strong internal consistency (Leach, Henson, Odom, & Cagle, 2006). It is designed to measure seven components of self-concept (physical ability, physical appearance, peer relationships, parental relationships, mathematics, reading, and all school subjects) in children aged 6-11 years. 72 items are presented as statements which the respondents rate on a 5-point response scale ranging from 1 (*false*) to 5 (*true*). The general self-esteem subscale is made up of 8 items (e.g. "*in general, I like being the way I am*").

Parents living together >6months. Parents were interviewed in order to provide a dated history of family composition.

Socioeconomic status. To measure socioeconomic status, parental occupational status was derived from the widely accepted International Standard of Classification of Occupations (ISOC-88; Elias, 1997), which uses 6 categories ranging from unskilled worker to leader. In this study, data from the parent which had achieved the highest level of occupational status was used.

Behavioral factors in child and parents

Child participation in organized sports. Parents were interviewed regarding their child's participation in organized physical activities (No/Yes), number of times per week, duration, and what type of activity.

Daily number of hours spent outside with parents and alone. The attending parent made a record of how many days he/she or spouse/partner spent at least 10 minutes outside with the child on weekdays and weekends.

Daily number of hours spent outside alone. Parents were asked to estimate the total amount of time the child spent outside in minutes per day.

Screen time. Parents were interviewed regarding the amount of time their child watched TV each week and weekend. A mean value in hours per day was calculated

MVPA mother and father. Each parents reported on their own PA using the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003), which is an international questionnaire used for monitoring PA in 18-65 year-olds. Participants answers questions regarding approximately how much time they have spent engaged in various activities in the last seven days or in a usual week. There are 31 questions covering four domains of PA: work-related, transportation, housework/gardening, and leisure-time activity (including exercise and sport participation). Data is summed within each PA category to estimate total weekly time spent in each type of activity (Craig et al., 2003). To estimate total weekly PA, the reported minutes per week within each activity category is weighted using a MET (Metabolic Equivalent Task) energy expenditure assigned to each category of activity.

Environmental factors

Time to walk to ballpark, playground or other recreational area, and traffic safety in area. Parents reported on how much time they estimated they would use to travel with the child to access a ballpark, playground or other recreational area which would allow for PA and where the child could play safely away from traffic, using an eight-point scale with responses ranging from "0-2 minutes" to "more than 2 hours". The parents also reported on

their perception of how safe from traffic their child was when playing outside their house, with response options ranging from 1 ("very unsafe") to 4 ("very safe").

Type of home, density between homes, and having a garden. Parents provided information regarding what type of home they lived in, house or apartment, and whether or not they had a garden.

Results

General linear modelling (GLM) was used to examine correlates of PA in a stepwise manner. Firstly, bivariate associations between each factor and PA was examined.

Secondly, because correlates within and between ecological levels are likely to be correlated, e.g. mother's and father's PA, multivariate regression analysis were conducted to test the unique associations from factors within each of the three categories (1) characteristics of the child and family, 2) behaviors of the child and parents, and 3) environmental factors) and PA in the child. Only those factors found to be significantly related to PA in the bivariate analysis were included in the multivariate model. As a third step, those factors significantly related to PA in step two were included in a final multivariate model, thus including factors from all three categories. Because gender have been consistently found to be related to PA (Hallal et al., 2012; LeBlanc et al., 2012; Van Der Horst et al., 2007), gender was used as a co-variate in all tests. All analyses were performed in PASW Statistics 18.

Table 1 presents the results of the bivariate analysis. As can be seen, out of the 19 factors examined, the following 10 were found to be significantly related to PA: surgency, self-esteem, percentage of bodyfat in the child, parents living together for more than six months, total number of hours outside alone and with parents per day, hours per week watching TV, father's MVPA, time to walk to other recreational area, and having a garden.

Table 2 shows the results of the three separate multivariate analysis from step two. The 10 factors which were significantly related to PA in the previous bivariate analysis were placed into their respective categories: (1) characteristics of the child and family, 2) child and parent behaviors, and 3) environmental factors). Out of the 10 factors tested in this step, three factors from the child and family characteristic category were significantly related to children's PA: surgency, percentage of bodyfat in the child, and having lived with both parents for more than six months. From the category of child and family behaviors, the following three factors were also significantly related to children's PA: daily number of hours child spends outside alone and together with parents, and hours per day watching TV. And lastly, in the category of environmental factors, only two factors was significantly related to children's PA: time to walk to other recreational area and having a garden.

Table 3 displays the results from the third analysis. All factors found to be significantly related to children's PA in the previous step were included in one final multivariate analysis. As shown, all the factors included in the final model were significantly related to PA. Thus, factors from all three categories were uniquely and independently associated with children's PA.

Discussion

The main objective of this study was to identify factors associated with PA in a large and representative sample of Norwegian six-year olds. A range of factors separated in three distinct categories were explored: 1) characteristics of the child and family (surgency, self-esteem, percentage of bodyfat in the child, percentage of bodyfat in the parents, parents living together for more than six months, socioeconomic status), 2) child and parent behaviors (child participation in organized sports, total number of hours outside alone and with parents per day, hours per week watching TV, mother MVPA, father MVPA), and 3) environmental

factors (time to walk to ballpark, time to walk to playground, time to walk to other recreational area, type of home, density between homes, having a garden, traffic safety around home). Earlier studies have mainly examined a narrow range of factors in older children and adults, and the available research on the relative importance of these factors in young children is limited. Further, to the best of the author's knowledge, the current study is the first to include a personality trait as a potential correlate of PA in young children. Firstly, and in contrast to many other findings (Ebbeling et al., 2002; Hallal et al., 2012; Iannotti et al., 2009; Tremblay et al., 2011), the children in the current study were on average sufficiently active (mean daily MVPA was 64 minutes) to meet the WHO recommended 60 minutes of daily MVPA. And as hypothesized, factors from each of the three categories were independently associated with PA in our sample.

Characteristics of the child and family related to level of PA

Children's bodyweight has repeatedly been linked to PA levels (Must & Tybor, 2005), and in accordance with this the current study found percentage of bodyfat in the child to be inversely related to PA. Notably though, the current finding adds to earlier research given that the majority of studies have examined weight/BMI rather than percentage of body fat, thus not distinguishing lean tissue from fatmass and therefore being less precise. The association between PA and percentage of bodyfat is likely a result of the fact that a decrease in energy expenditure, in the form of decreased PA, will burn less calories and (unless the diet is adjusted accordingly) this will over time lead to an increase in body mass (Hill et al., 2003). However, whether the increase in percentage of bodyfat caused the decrease in PA, or the other way around can't be determined due to the cross sectional nature of this study.

Previous research has linked extrovert personality and sensation seeking in adolescence and adulthood to higher PA levels (De Moor et al., 2006; Kuh & Cooper, 1992;

Rhodes & Smith, 2006; Sallis et al., 2000), and the findings from the current study suggests that this is also true for younger children. The trait surgency, defined as a trait aspect in which a person tends to have high levels of positive affect, impulsivity, and a high activity level (Rothbart et al., 2001), thus corresponding to extraversion, was found to be significantly associated with higher PA levels. Possibly, children who are more impulsive and outgoing tend to be drawn to, or perhaps are better at seeking out, more physically active types of play. On the other hand, quiet and shy children might also be more prone to sedentary behaviours. Notably though, the causality of the relation between surgency and PA cannot be determined by the current study. However, surgency is thought to be biologically based and relatively stable across contexts (Leung et al., 2014), and it is therefore reasonable to assume that surgency affects level of PA, not the other way around.

Although there is ample evidence to support the notion that there is a link between self-esteem and PA (Biddle & Asare, 2011; Calfas & Taylor, 1994; Ekeland et al., 2004; Ortega et al., 2008; Strauss et al., 2001) in children, the current study found no such association. This is in contrast to the majority of previous findings, but is supported by the review by Sallis et al. (2000) who conclude that no such association exists. As the majority of the existing evidence is based on samples of older children and adolescents (Calfas & Taylor, 1994; Ekeland et al., 2004; Strauss et al., 2001), the association between self-esteem and PA might be age-related.

The results also show that children whose parents had been living together for more than six months were significantly more active. This contrasts evidence from a review that found no link between single parent status and child PA (Van Der Horst et al., 2007). Notably, single parent status (as used in the review by Van Der Horst et al., 2007) and having parents that have lived together for more than six months is not the same, and this difference may account for the different results. Because this study is cross sectional, the causal

pathway can't be established, but it can be speculated that that the single-parent status is more likely to affect the child's PA level than the other way around. In single-parent households the adult obviously have to take on more tasks and responsibilities as opposed to families where the work can be divided between two parents. Possible explanations for the current finding may be that single parents experience higher levels of stress, and they simply have less time and resources available to offer and support PA in their children. Since SES was found to be unrelated to children's PA, it is likely that time, rather than financial or educational restraints play a part here. If you are the only adult present, it is for instance difficult to play with your child and make dinner simultaneously. And going outside with a child often requires planning, such as finding a destination, choice of clothes, bringing food etc, and can be more challenging if you are alone. Children living with only one parent may be left to play more inside, and possibly also alone, especially if it's not regarded as safe to send the child outside on his or her own, which may lead to more sedentary forms of play, such as screen based entertainment.

Behavioural child and parental factors associated with level of PA

Sport participation was not found to be significantly related to PA levels in Norwegian six-year olds. Sports participation should not be viewed as unimportant though, as it may still provide children with other important experiences, such as socialization, improvement of skills, practice in cooperation etc. And although sport participation is not significantly related to PA at age six, it may become more important at a later stage. Such an assumption is supported by earlier findings showing that such participation both increases energy expenditure in children (Katzmarzyk & Malina, 1998) as well as predict higher levels of PA in adulthood (Telama et al., 2006).

The total number of hours the child spends outside, both alone and with his or her parents, was significantly associated with the child's PA level. This is in accordance with previous findings (Hinkley et al., 2008; LeBlanc et al., 2012). Many of the most active forms of play preferred by children at this age are contingent on being outside due to the amount of free space required to perform them, such as riding a bike, playing football, climbing trees or jumping on a trampoline etc. There are simply more and varied opportunities to be active outside, as opposed to indoors where play is limited by space, objects and furniture, and perhaps restrictions from parents. In addition, the more sedentary activities such as screen time, reading books, playing with building blocks or other toys are typically performed indoors.

The number of daily hours spent watching TV was found to be inversely related to amount of PA: the more TV-hours, the lower the level of PA. Previous findings on this subject have been mixed (Biddle et al., 2004; Hamer et al., 2009; Robinson et al., 1993; Taveras et al., 2007). Because of the cross-sectional design of the study it cannot be determined whether low levels of PA cause children to watch more TV or the other way around. Other factors such as social competence and number of friends may also explain the association, e.g. less sociable children may spend more time indoors, thus watching more TV and being less physically active. Such an assumption is in accordance with our finding that more outgoing children (surgency) have higher levels of PA, and time spent outside is associated with increased PA. Notably, time spent watching TV and low levels of PA have been found to be independently associated with psychological distress in children (Hamer et al., 2009), and along with the findings that both increased sedentary behaviours and low levels of PA is associated with increased the risk of CVD risk factors (Froberg & Andersen, 2005; Steele et al., 2008), the coexistence of high levels of TV watching and lower levels of PA in the same child warrants attention.

Parent's level of PA was not associated with children's PA in this study, neither was their percentage of body fat. The amount of time the parents spend outside with their child, on the other hand, was related to children's PA. It thus seems reasonable to assume that parents influence their children's PA more through shared experiences, encouragement and support, rather than acting as role models.

Environmental factors

Two factors in this category were significantly related to PA, having a garden and distance to recreational area (any area which would allow for PA and where the child could play safely away from traffic). The shorter the distance to a recreational area, the higher the level of PA in the child in the multivariate model. In light of the finding that time spent outdoors was positively associated with PA, both these factors can be assumed to play roughly the same role with regards to PA in children, as they both can allow for free outdoor play. The findings are in accordance with results from the study by Grigsby-Toussaint et al., (2011) who found level of neighborhood greenness to be positively correlated with child PA, as well as the review by Davidson & Lawson (2006) on the influence of physical environments on children's PA, reporting children's PA to be related to publicly provided recreational infrastructure. Notably, this review also reports other environmental attributes (e.g. traffic safety, higher population density, playgrounds etc.) to be significantly related to PA in children, factors not found to be associated with children's level of PA in this study. This latter inconsistency in the findings may reflect local or at least national attitudes and differences, such as speed limits, population density and number of busy roads, general attitudes regarding traffic safety etc.

Practical implications of the findings

One of the main goals of this study was to generate knowledge on the relative importance of a range of correlates of children's PA levels, because such knowledge can inform interventions aimed at increasing children's level of PA. The results of this study show that factors at different levels of influence (child- and parent characteristics and behaviour, environmental factors) are independently related to children's level of PA, suggesting that interventions aimed at increasing PA in children should address factors at all these levels. Notably though, the cross-sectional design of the current study does not allow for conclusions with regard to causality. Thus, although factors associated with PA have been identified, it can't be established whether these factors affect and/or are affected by children's PA level. Based on our findings, future studies should therefore identify the nature of the relationships using longitudinal designs. Nevertheless, it is worth noting some potential implications of these findings. Firstly, the link between PA and percentage of bodyfat is important in a health perspective. Percentage of bodyfat has the potential to decline as a result of interventions to increase PA, due to increased energy expenditure (Hill et al., 2003), leading to a reduction of fat mass. Importantly though, increased PA provides health benefits to children even in the absence of weight loss (Steele et al., 2008), so the focus on bodyweight should not be overestimated, but rather an increase in PA should in itself be a goal. Secondly, being the first study to report a relation between surgency and level of PA, these results suggest that special attention may be needed to provide playtime activities and equipment which would encourage more withdrawn children to be more physically active. One way of achieving this could be to simply remove some of the sedentary play alternatives, thus possibly making PA more attractive. Also, research into what type of physically active play these children would prefer could be useful.

Children living with single parents show lower levels of PA, thus future studies are needed to sort out how this association can be explained. If as assumed here, it is a matter of

the availability of time, offering some form of support, possibly community based, to single parents may be an option to increase levels of PA in this group of children. E.g. provide support in the home so that the parent gets more time to spend with the child, or offer structured activities, preferably outdoors, for these families. Educating and/or encouraging single parents both on the importance of PA, and providing specific examples on how to achieve this should also be considered an important part of any intervention. This could for instance be incorporated in the mandatory check-ups at the local child health clinics, as the health nurse knows which children live with only one parent.

Children are more active when they are outside. This has some practical implications, and perhaps the simplest one being to send children outside, ideally at a time when they would normally watch TV, thus displacing sedentary time with PA. However, given that parental time spent outside with the child is related to children's level of PA, parents should aim to take part in the outdoor play, or at least be present. Notably, the findings in this study also suggest that having access to a recreational area is of importance. This may be of particular importance to single parents, because having a garden or living in close proximity to a park area or a playground may lower the threshold, and the amount of planning needed, to spend time outside with the child, thus increasing the child's level of PA.

However, sending children outside may seem like an overly simplistic solution, and there are obviously aspects which may hinder this, such as weather conditions, availability of proper clothing for a cold or rainy day, making sure that the child has someone to play with, etc. Children will naturally spend some time indoors, but although indoor conditions don't allow for the same level of PA as you can achieve outdoors, the amount of time spent being completely sedentary, such as when watching TV, should still be kept to a minimum as such behaviours have been linked to negative health outcomes (Malina & Little, 2008; Steele et al., 2008; Tremblay et al., 2011). An alternative to sedentary screen based media use are

gaming consoles like Nintendo Wii and Xbox Kinect, which have developed interactive games where the players are required to move around to play, and although these games may not require high intensity PA, they are none the less a better alternative. Technology can as such be used to promote positive health behaviours, rather than impede it.

The finding that non-specific recreational area was significantly related to PA leaves a great deal of freedom, both financially and imaginatively, for those planning, designing and building parks, playgrounds etc. Ensuring that the physical environments our children grow up in contain plenty of recreational areas which encourage PA should therefore be considered an important aspect in matters of public health care and disease prevention.

Strengths and limitations

Because the majority of earlier research has examined older children than those included here, studying correlates of PA in a sample of young school children is considered a strength of the current inquiry. As is the range of potential correlates included, covering several levels of influence. Other strengths of this study include methods of measurement. In contrast to several large-scale studies relying on self-report (questionnaires), the current research has used accelerometers to objectively and precisely measure children's PA level, and it should also be noted that percentage of bodyfat was used, as opposed to measuring height and weight to calculate BMI, as the latter does not distinguish lean tissue from fatmass.

However, the findings should be interpreted in light of several limitations. Firstly, the cross-sectional design of the study does not allow for conclusions with regard to causality between level of PA and the factors examined. This also leaves us with the possibility that the factors which were not found significant at age six, may become significant at a later point in time. The inclusion of the factors from this study in a longitudinal study would therefore be

very useful in determining causal relationships as well as identifying potential differences in determinants of PA at different ages. Another limitation is that although this study included a wide variety of factors, naturally, it did not include all factors which could possibly influence PA in children. There are likely many other aspects contributing to differences in PA levels, such as diet, cultural background or race, differences between schools, etc. Also, this study used TV as a measurement of screen activity, but the emergence of many portable and easy-to-use touch screen devices, such as pads and mobile phones, may also be a contributing factor to increased sedentariness among children, and research into if and how these new devices affect PA levels should be a priority. Future research should also focus on how to motivate children, and their parents, to be more active, and how to effectively incorporate PA into the lives of children, with particular attention to screen based media use.

Summary and conclusions

The current study aimed to examine a wide range of child, family and environmental factors related to PA in a large and representative community sample of Norwegian six-year olds. Out of the 19 factors tested, we found the following eight to be significantly related to PA when tested in a multivariate model: surgency, percentage of bodyfat in the child (inversely), having lived with both parents for more than six months, daily number of hours child spends outside alone and together with parents, hours per day watching TV (inversely), living in close proximity to a recreational area which allows for PA, and having a garden. This study offers important insight into factors associated with PA in children, and also provides suggestions to practical application of the findings. Overall, the findings indicate displacing time normally spent watching TV with outside playtime, preferably with their parents, as a simple, yet effective way of increasing children's PA. This may be of special importance for children who are shy and withdrawn, those with higher percentage of bodyfat, as well as those living with single parents. These findings additionally highlight the

importance of publicly provided recreational areas which encourage PA. Given the many physical, mental and social health benefits associated with PA (Calfas & Taylor, 1994; Hong et al., 2009; Iannotti et al., 2009; Kriemler et al., 2010; Rothon et al., 2010; Sibley & Etnier, 2003; Tomporowski et al., 2011; WHO, 2009; Wiles et al., 2012) combined with the tendency for PA levels to track from childhood into adulthood (Aberg et al., 2012; Hills et al., 2007; Ruiz et al., 2009), providing ample amounts of recreational areas should be considered an important part of ensuring the health of both current and future generations. Notably, future longitudinal studies are needed to test the assumptions provided here.

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Table 1

Characteristics of the sample

Sample characteristics	%
Gender of child	
Male	49.8
Female	50.2
Gender of parent informant	
Male	18.9
Female	81.1
Ethnic origin of biological mother	
Norwegian	93.0
Western	6.7
Other countries	0.3
Ethnic origin of biological father	
Norwegian	93.0
Western	6.3
Other countries	0.7
Parents living together (>6 months)	85.7
Socioeconomic status of parent (highest)	
Leader	12.5
Professional, higher level	36.7
Professional, lower level	36.2
Formally skilled worker	14.1
Unskilled worker	0.6

Table 2

Bivariate analysis of children's level of PA and three categories of correlates (characteristics of the child and family, behaviours of the child and family, environmental factors)

Factors	B	95% CI	*p*
Characteristics of the child and family			
Percentage of bodyfat in child	-5.79	[-10.3, -1.27]	.01
Surgency	46.45	[25.17, 67.74]	.00
Self-Esteem	2.35	[.36, 4.34]	.02
Percentage of bodyfat in parents	-.60	[-1.78, .58]	.32
Parents living together >6months	46.54	[17.59, 75.50]	.00
Socioeconomic status	-5.83	[-22.39, 10.74]	.49
Behavioural variables			
Child participation in organized sports	26.88	[-5.62, 59.38]	.11
Daily nr of hours outside with parents	42.05	[23.63, 60.48]	.00
Daily nr of hours child spend outside	33.53	[24.18, 42.88]	.00
Hours per day watching TV	-2.98	[-4.07, -1.89]	.00
Mother's MVPA	.25	[-.02, .51]	.07
Father's MVPA	.44	[.07, .81]	.02
Environmental variables			
Time to walk to ballpark	5.63	[-4.59, 15.85]	.28
Time to walk to playground	.56	[-8.12, 9.24]	.90
Time to walk to other recreational area	-13.81	[-25.40, -2.23]	.02
Type of home (house, apartment)	-5.96	[-16.20, 4.28]	.25
Density between homes	-9.12	[-23.81, 5.58]	.22

Having a garden	62.13	[19.02, 105.23]	.01
Traffic safety around home	4.87	[-14.53, 24.27]	.62

Note. Gender was adjusted for in all tests.

Table 3

Multivariate regression analysis of children's' level of PA within 3 separate categories of factors (characteristics of the child and family, behaviours of the child and family, environmental factors)

Factors	B	95% CI	*p*
Characteristics of the child and family			
Percentage of bodyfat in child	-5.64	[-10.32, -.95]	.02
Surgency	51.35	[26.81, 75.89]	.00
Self-Esteem	2.02	[-.25, 4.28]	.08
Parents living together >6months	43.59	[11.04, 76.14]	.01
Behavioural variables			
Daily nr of hours outside with parents	26.57	[1.92, 51.22]	.03
Daily nr of hours child spend outside	28.47	[15.43, 41.52]	.00
Hours per day watching TV	-3.42	[-4.66, -2.18]	.00
Father's MVPA	.31	[-.06, .69]	.10
Environmental variables			
Time to walk to other recreational area	-13.68	[-25.21, -2.15]	.02
Having a garden	-63.48	[-106.46, -20,49]	.00

Note. Gender was adjusted for in all tests.

Table 4

Final multivariate regression analysis combining all factors significantly related to children's PA from previous analysis

Factors	B	95% CI	*p*
Characteristics of the child and family			
Percentage of bodyfat in child	-6.45	[-11.96, -.95]	.02
Surgency	43.30	[18.53, 68.08]	.00
Parents living together >6months	36.23	[1.51, 70.94]	.04
Behavioural variables			
Daily nr of hours outside with parents	24.77	[2.35, 47.20]	.03
Daily nr of hours child spend outside	28.00	[14.80, 41.20]	.00
Hours per day watching TV	-3.90	[-5.01, -2.79]	.00
Environmental variables			
Time to walk to other recreational area	-15.63	[-29.26, -2.00]	.03
Having a garden	-45.68	[-91.86, .49]	.05

Note. Gender was adjusted for in all tests.

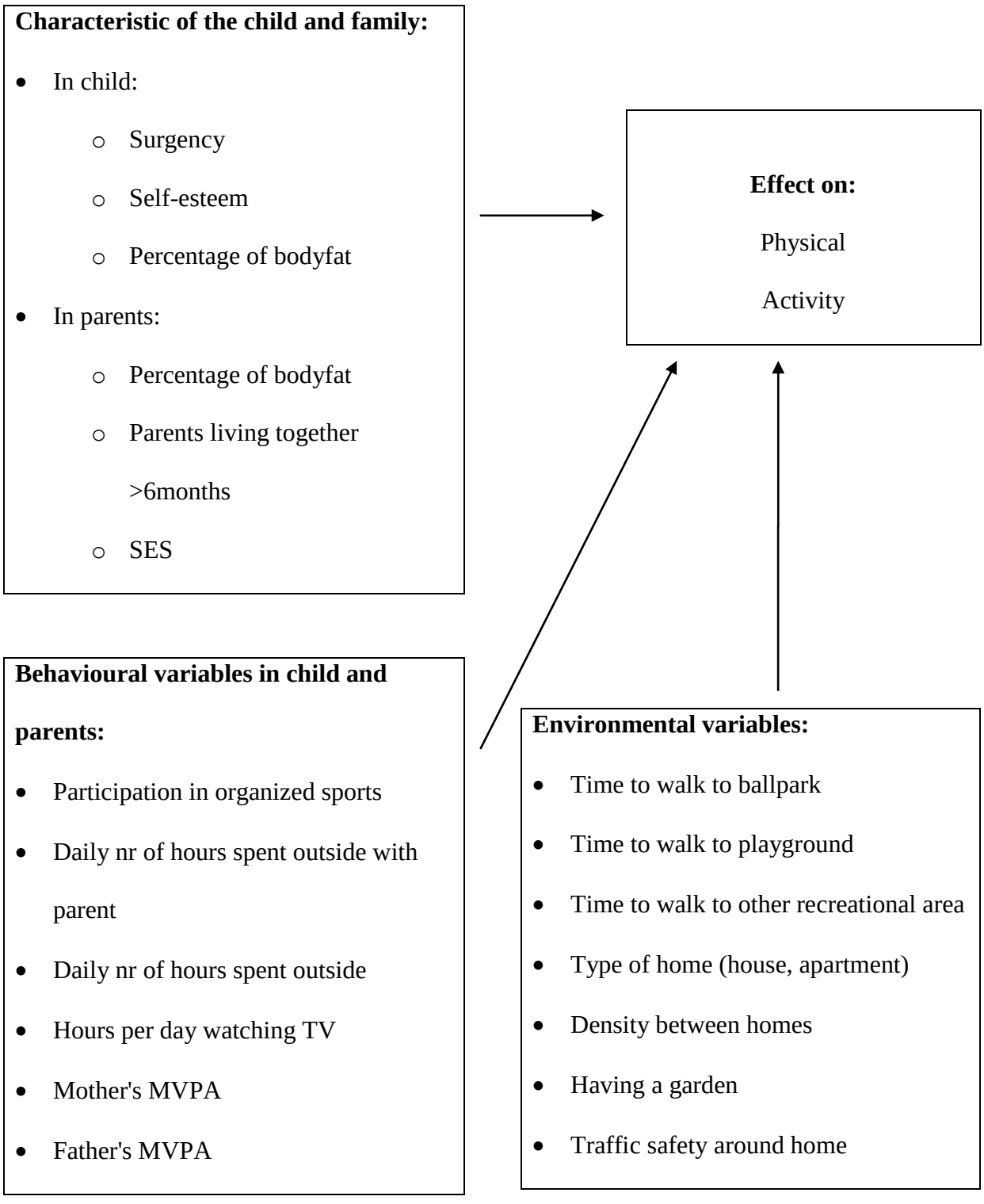

Figure 1. Conceptual theoretical framework illustrating the variables in the current study

Note. Gender was adjusted for in all tests.

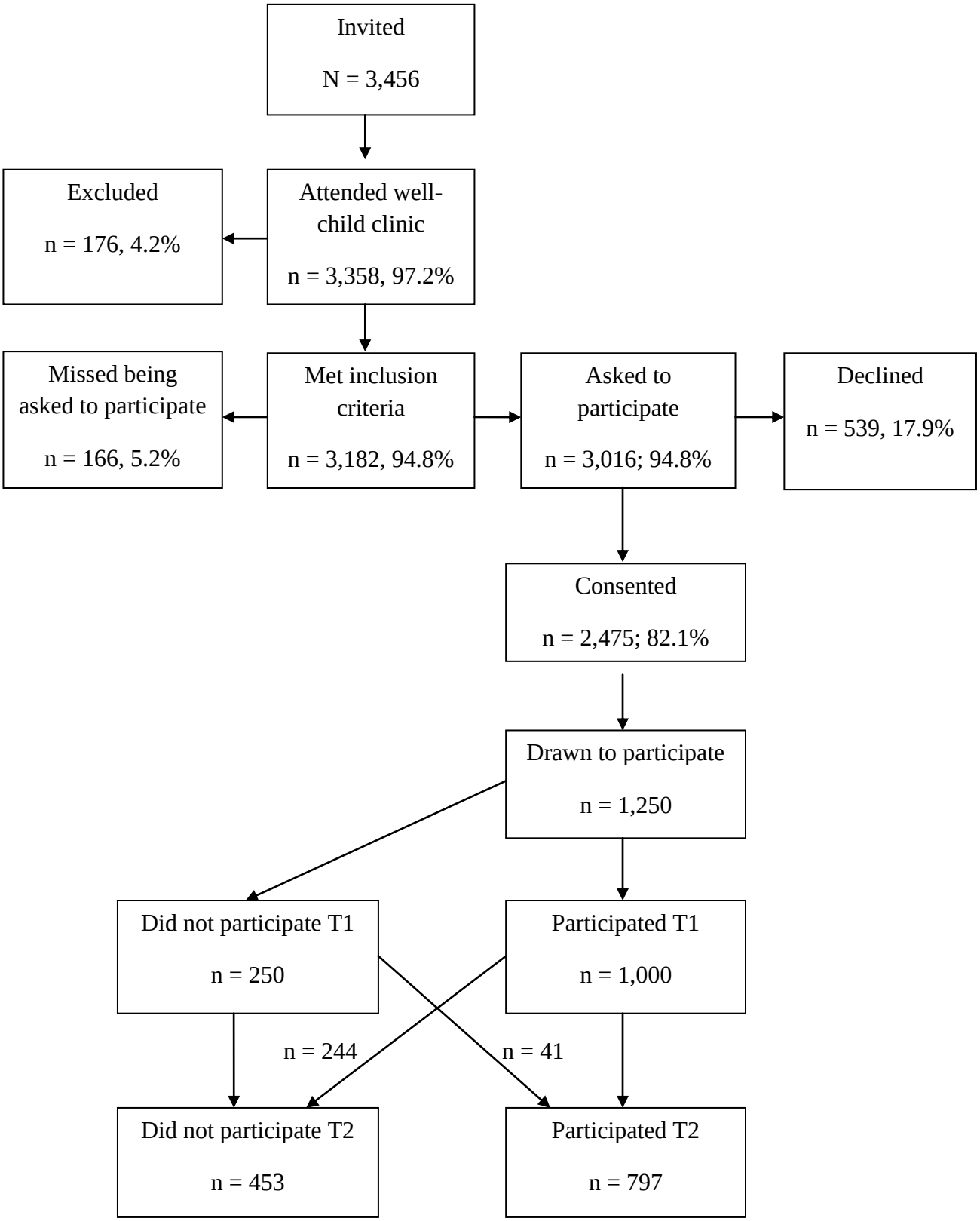

Figure 2. Sample recruitment and procedure