

Marko Kantomaa

THE ROLE OF PHYSICAL
ACTIVITY ON EMOTIONAL
AND BEHAVIOURAL
PROBLEMS, SELF-RATED
HEALTH AND EDUCATIONAL
ATTAINMENT AMONG
ADOLESCENTS

FACULTY OF MEDICINE,
INSTITUTE OF HEALTH SCIENCES,
UNIVERSITY OF OULU;
FINNISH INSTITUTE OF OCCUPATIONAL HEALTH, OULU



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MARKO KANTOMAA

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Abstract

Physical activity provides important physical health benefits for young people. However, the information on physical activity in association with various social, educational and mental health factors among adolescents is scarce. This study aimed to evaluate how physical activity is related to adolescents' emotional and behavioural problems, self-rated health, educational attainment and parental socio-economic position, and how these factors interrelate with each other.

The study population consisted of the Northern Finland Birth Cohort 1986 (N = 9432). Data on physical activity, emotional and behavioural problems, self-rated health, educational attainment and parental socio-economic position at age 15–16 years was collected by postal inquiries in 2001–2002. Logistic regression models were used to study the associations between these factors.

High parental socio-economic position was associated with being physically active among adolescents. Physical inactivity was related to emotional, social, thought and attention problems, and rule-breaking behaviour. Physical inactivity, emotional, behavioural and social problems, and low parental socio-economic position were related to poor self-rated health. In addition, higher levels of physical activity, fewer behavioural problems, and higher parental socio-economic position were associated with high self-perceived academic performance and future plans for higher education.

Physical inactivity during adolescence is associated with several emotional and behavioural problems, and poor self-rated health, whereas being physically active is related to higher educational attainment. Developmentally appropriate and enjoyable physical activity could have an important role in enhancing adolescents' health, well-being, and educational attainment.

Keywords: adolescent, behavioural symptoms, education, exercise, self-rated health, socioeconomic factors

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Tiivistelmä

Liikunta edistää lasten ja nuorten fyysistä terveyttä. Liikunnan yhteyksistä sosiaalisiin tekijöihin, nuorten koulumenestykseen ja mielenterveyteen on kuitenkin vähän tietoa. Tämän tutkimuksen tavoitteena oli selvittää liikunnan yhteyksiä nuorten tunne-elämän ja käyttäytymisen häiriöihin, koettuun terveyteen ja koulumenestykseen. Lisäksi selvitettiin liikunnan, terveyteen ja koulutukseen liittyvien tekijöiden, sekä perheen sosioekonomisen aseman keskinäisiä suhteita.

Tutkimusaineistona oli Pohjois-Suomen syntymäkohortti 1986 (N = 9432). Liikunta-aktiivisuus, perheen sosioekonominen asema, tunne-elämän ja käyttäytymisen häiriöiden esiintyvyys, koettu terveys ja koulumenestys selvitettiin postikyselyllä 15–16-vuotiaana vuosina 2001–2002. Muuttujien välisiä yhteyksiä testattiin logistisella regressioanalyysillä.

Vanhempien korkea sosioekonominen asema oli yhteydessä nuorten liikunnalliseen aktiivisuuteen. Vähäinen liikunnan harrastaminen liittyi tunne-elämän häiriöihin, sosiaalisiin ongelmiin, ajatus- ja tarkkaavuushäiriöihin sekä sosiaaliseen käytöshäiriöön. Vähäinen liikunta, tunne-elämän ja käyttäytymisen häiriöt sekä vanhempien alhainen sosioekonominen asema liittyivät huonoon koettuun terveyteen. Lisäksi liikunnallinen aktiivisuus, vähäiset käyttäytymisen häiriöt sekä vanhempien korkea sosioekonominen asema olivat toisistaan riippumatta yhteydessä nuorten hyvään koulumenestykseen ja opintosuunnitelmiin.

Tämän tutkimuksen tulokset osoittavat, että vähäinen liikunta on yhteydessä nuorten tunne-elämän ja käyttäytymisen häiriöihin sekä huonoon koettuun terveyteen, kun taas liikunnallinen aktiivisuus liittyy hyvään koulumenestykseen. On mahdollista, että monipuolisen, ikä- ja kehitystasolle sopivan liikunnan avulla voidaan edistää nuorten terveyttä ja hyvinvointia sekä koulutuksellisia edellytyksiä.

Asiasanat: koettu terveys, koulutus, käyttäytymishäiriöt, liikunta, nuoret, sosioekonominen asema, tunne-elämän häiriöt

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Helsinki, December 2009

Marko Kantomaa

Abbreviations

ANOVA	analysis of variance
BMI	body mass index, kg/m ²
CI	confidence interval
EBP	emotional and behavioural problems (in appendix 2 table 1)
EP	educational performance (in appendix 4 table 1)
GPA	grade point average (in appendix 4 table 1)
LSD	Fisher's least significant difference
MVPA	moderate-to-vigorous intensity physical activity
NFBC 1986	Northern Finland Birth Cohort 1986
OECD	Organisation for Economic Co-operation and Development
OR	odds ratio
<i>p</i> , <i>p</i> -value	significance probability
PA	physical activity (in appendices)
SD	standard deviation (in appendix 2 table 1)
SEP	socio-economic position (in appendix 1 table 1)
SRH	self-rated health (in appendix 3 table 1)
YSR	Youth Self-Report (Achenbach 2001)

List of original publications

This thesis is based on the following original publications, which are referred to in the text by the Roman numerals I–IV.

- I Kantomaa MT, Tammelin TH, Näyhä S & Taanila AM (2007) Adolescents' physical activity in relation to family income and parents' education. *Prev Med* 44(5): 410–415.
- II Kantomaa MT, Tammelin T, Ebeling H & Taanila A (2008) Emotional and behavioral problems in relation to physical activity in youth. *Med Sci Sports Exerc* 40(10): 1749–1756.
- III Kantomaa MT, Tammelin TH, Ebeling HE & Taanila AM (2009) Physical activity, emotional and behavioural problems, and self-rated health among adolescents. Manuscript.
- IV Kantomaa MT, Tammelin TH, Demakakos P, Ebeling HE & Taanila AM (2009) Physical activity, emotional and behavioural problems, maternal education and self-reported educational performance of adolescents. *Health Educ Res Sep* 17. In press.

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1 Introduction

Physical activity provides important health benefits for adolescents, including increased physical fitness, reduced body fatness, favourable cardiovascular and metabolic disease risk profiles, enhanced bone health, and reduced symptoms of depression and anxiety (Physical Activity Guidelines Advisory Committee 2008). Physical activity is also beneficial to cognition and brain function, which, in turn, may have positive effects on learning and academic performance (Hillman *et al.* 2008).

Despite the known benefits of physical activity on health and future life opportunities, recent evidence consistently demonstrates that a majority of adolescents do not meet current physical activity and public health recommendations of at least 60 minutes per day of moderate or vigorous intensity activity on at least five days per week (Eaton *et al.* 2006, Fogelholm *et al.* 2007, Physical Activity Guidelines Advisory Committee 2008, Tammelin *et al.* 2007, Whitt-Glover *et al.* 2009).

Since many chronic diseases and other adverse life chances have their roots in childhood and adolescence (Kuh & Ben-Shlomo 2004), the question of inequalities in young people's health behaviours, health and education is critical. Physical activity could have a significant role in enhancing adolescents' health, educational attainment and other life chances. In order to promote adolescents' health and well-being through physical activity, it is essential to understand determinants and outcomes of adolescents' physical activity and sedentary behaviours such as socio-economic conditions, health status and educational attainment.

Data from the Northern Finland Birth Cohort 1986 study was used to evaluate how physical activity is associated with emotional and behavioural problems, self-rated health and educational attainment among adolescents. The associations between parental socio-economic position and adolescents' physical activity, educational attainment and self-rated health were also examined. In addition, we evaluated adolescents' emotional and behavioural problems in relation to educational attainment and self-rated health.

2 Review of the literature

2.1 Physical activity in adolescence

Physical activity is most often defined in the context of energy expenditure as any bodily movement produced by the contraction of skeletal muscle that substantially increases energy expenditure over the resting level (U.S. Department of Health and Human Services 1996). The dose or volume of physical activity can be calculated from the frequency, duration (time), intensity and type of physical activity. Although physical activity is often evaluated in terms of energy expenditure, it can also be seen as a form of biological and cultural behaviour: energy is expended in active behaviours that occur in different forms and cultural contexts, including free play, house work, school physical education and organized sports (Malina 2001).

The current physical activity recommendations for young people state that adolescents should do one hour or more of physical activity daily, most of which should be of either moderate or vigorous intensity, including aerobic and muscle- and bone-strengthening activities (U.S. Department of Health and Human Services 2008). The recommendations emphasize the need to encourage children and adolescents to participate in physical activities that are appropriate for their age, enjoyable, and offer variety.

Many young people, however, fail to meet the current physical activity and public health recommendations (Eaton *et al.* 2006, Physical Activity Guidelines Advisory Committee 2008, Whitt-Glover *et al.* 2009). In Finland, it has been estimated that about 50% of boys and 40% of girls are sufficiently active, with 20% of boys and 25% of girls reporting very little or almost no physical activity at all (Fogelholm *et al.* 2007, Tammelin *et al.* 2007). Moreover, any changes in the various indices of physical activity for adolescents have been small and inconsistent over the past decade (Physical Activity Guidelines Advisory Committee 2008).

In the present study we concentrate on the amount and types of daily moderate-to-vigorous intensity physical activity (MVPA). MVPA refers to a level of effort in which a person should experience an increase in breathing or heart rate within the range of some increase to a large increase (U.S. Department of Health and Human Services 2008). Examples of MVPA in young people are brisk

walking, skateboarding, rollerblading, active games involving running and chasing, bicycle riding, and sports such as soccer, ice hockey and swimming.

2.2 Life course perspective on social determinants of health

Health and well-being follow a social gradient: the higher the social position, the better the health (Marmot & Wilkinson 2006). The social gradient in health is not confined to those living in adverse socio-economic circumstances, but it runs from the top to the bottom of society, with every level down the social hierarchy having less good standards of health than the one above (Marmot & Wilkinson 2006). Moreover, the social gradient is not confined to adult populations; social inequalities also adversely affect the health and development of young people (Wadsworth & Butterworth 2006). Furthermore, social inequalities in health are not restricted to 'poor' countries, and are visible in wealthy and egalitarian nations like the Nordic countries (Huisman *et al.* 2004, Martikainen *et al.* 2007, Merlo *et al.* 2003).

In their framework of social determinants of health (Figure 1) Brunner and Marmot (2006) provide a public health view, which emphasizes prevention of disease instead of cure. Their model links social factors to health and well-being via material, psychosocial, and behavioural pathways. Material circumstances are related to health directly, and via the social and work environment. These in turn shape psychological factors and health behaviours, including physical activity. In addition, factors such as early life experiences, culture and genetics exert influences on health.

The model of social determinants of health is congruent with the models of life course epidemiology, which present the influence of socially patterned exposures during childhood and adolescence on later health and disease risk (Ben-Shlomo & Kuh 2002, Kuh & Ben-Shlomo 2004, Kuh *et al.* 2003). Within the life course approach, the 'critical period' model suggests that an exposure during a particular time window has lasting or lifelong effects on health while the 'accumulation' model hypothesizes that environmental, social or behavioural insults may cause long-term, gradual damage to health in separate and independent ways (Figure 2, model (a)), or they may cluster together in socially patterned ways (Figure 2, model (b)). Risk factors at different life stages may also accumulate over time because of 'chains of risk' where one adverse exposure leads to another with independent 'additive' effect (Figure 2, model (c)) or

through the final link in the chain that has any marked effect (Figure 2, model (d)) (Kuh *et al.* 2003).

By emphasizing an interdisciplinary view, as well as the cumulative and interactive roles of early life physical and social exposures on later health outcomes, these models of life course epidemiology, together with social determinants of health, offer a fruitful framework for investigating the role of physical activity on adolescents' emotional and behavioural problems, self-rated health and educational attainment.

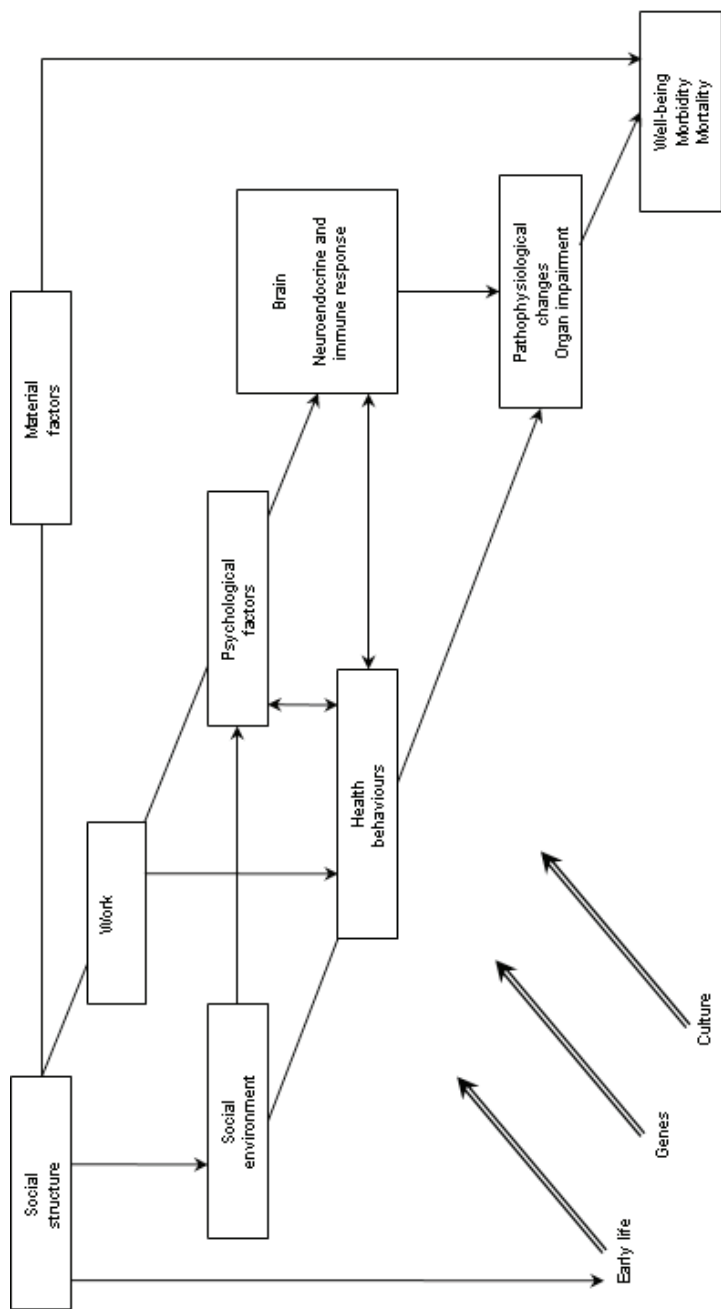


Fig. 1. A model describing social determinants of health. The model links social structure to health and well-being via material, psychosocial, and behavioural pathways. Modified from Brunner & Marmot (2006).

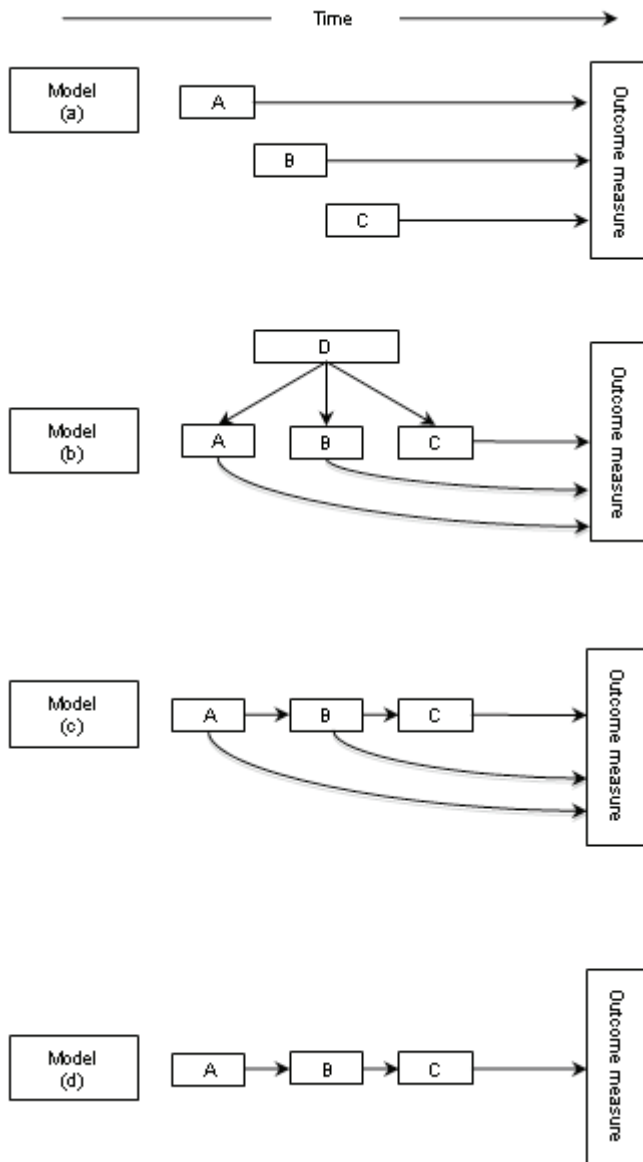


Fig. 2. Life course models. Modified from Kuh *et al.* (2003).

2.3 Socio-economic position and adolescents' physical activity

The concept of 'socio-economic position' is here used to mean the social and economic factors that influence the position individuals or groups hold within the multiple-stratified structure of a society (Krieger *et al.* 1997, Lynch & Kaplan 2000). Occupation, education and income are the most traditional indicators of socio-economic position and have proved very useful in describing and evaluating health inequalities (Elo 2009, Galobardes *et al.* 2007). In the present study, the mother's and father's education and annual family income are used as proximal measures of parental socio-economic position, because they were hypothesized to represent diverse dimensions (e.g. socio-economic, psychological, cultural and material) of social position in association with adolescents' physical activity.

Recent reviews and cross-national studies on parental socio-economic position and adolescents' physical activity have reported inconsistent results (Borraccino *et al.* 2009, Ferreira *et al.* 2007, Sallis *et al.* 2000). However, this mainly applies to studies in which parental socio-economic position has been defined as a composite of parent's education and income levels or occupational status (Ferreira *et al.* 2007). Those studies in which the specific association between parental education and family income have been analysed separately from each other and from parent's occupational status, have revealed statistically significant associations with physical activity among adolescents (Ferreira *et al.* 2007, Sallis *et al.* 2000). Studies of the association between parental socio-economic position (parental education and/or income) and adolescents' physical activity are summarized in Appendix 1.

These studies show that family income is positively associated with overall physical activity among adolescents (Gordon-Larsen *et al.* 2000, Lasheras *et al.* 2001, Lee & Cubbin 2002, Lowry *et al.* 1996). A higher level of family income is also related to active participation in structured physical activity outside school (Wagner *et al.* 2004) and compliance with physical activity guidelines (Butcher *et al.* 2008). Similarly, parental education is positively associated with adolescents' physical activity (Chen *et al.* 2007, Lasheras *et al.* 2001, La Torre *et al.* 2006, Piko & Keresztes 2008, Singh *et al.* 2008) and physical activity guideline compliance (Butcher *et al.* 2008), irrespective of the measurement level (household or individual). It is noteworthy that maternal education seems to be a fairly strong predictor of physical activity and inactivity patterns (Gordon-Larsen *et al.* 2000, Murphey *et al.* 2004, Piko & Fitzpatrick 2007). However, diverging results have also been reported, indicating that parental education and family

income are not related to physical activity in youth (Gomez *et al.* 2004, Higgins *et al.* 2003, Saxena *et al.* 2002).

Although the number of studies of socio-economic position and physical activity among adolescents is increasing, relevant research with high quality study designs and representative population samples is limited. Studies using multiple measures of parental socio-economic position are especially scarce (Appendix 1). Moreover, much of the earlier research has obtained the relevant information on parental social position from adolescents themselves, which may be biased since few young people know their parents' income or can adequately describe their education or occupation (Currie *et al.* 1997).

2.4 Physical activity and mental health

'Mental health is defined as a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community' (WHO 2007). Approximately half of all mental disorders begin before the age of 14 years (Kessler *et al.* 2005a). It has been estimated that the worldwide prevalence of mental disorders or problems in children and adolescents is around 20%, with similar types of disorders being reported across cultures (Kessler *et al.* 2005b, Roberts *et al.* 1998, Verhulst *et al.* 1997, Vollebergh *et al.* 2006, WHO 2001).

Physical activity during childhood and adolescence exerts a beneficial effect on several mental health outcomes (Physical Activity Guidelines Advisory Committee 2008). Studies on physical activity and emotional and behavioural problems among adolescents are summarized in Appendix 2. Regular physical activity is inversely related to emotional problems (Abu-Omar *et al.* 2004, Kirkcaldy *et al.* 2002, Larun *et al.* 2006, Sagatun *et al.* 2007, Steptoe & Butler 1996, Tao *et al.* 2007), social problems (Sagatun *et al.* 2007) and psychotic symptoms (Tao *et al.* 2007). Sports participation is negatively associated with emotional (Desha *et al.* 2007, Donaldson & Ronan 2006, Pastor *et al.* 2003), social (Donaldson & Ronan 2006), and behavioural problems (Donaldson & Ronan 2006). Studies also indicate a positive association between physical activity and self-esteem and self-concept (Dishman *et al.* 2006, Ekeland *et al.* 2004, Sagatun *et al.* 2007). In follow-up studies, it has been reported that a natural increase occurring in physical activity across time during adolescent years is inversely associated with a change in depressive symptoms (Motl *et al.* 2004) and

that physical activity in adolescence is consistently related to psychological well-being in adulthood (Sacker & Cable 2006).

There is also some evidence of a dose-response relationship between the level of physical activity and mental health among adolescents and young adults (Abu-Omar *et al.* 2004). However, although both physical activity and mental health problems in adolescence differ by gender, results are rarely reported separately for boys and girls (Sagatun *et al.* 2007). Hence, relatively little is known about the dose-response relationship between physical activity and various mental health outcomes, and whether these associations vary according to gender (Sagatun *et al.* 2007).

Previous studies notwithstanding, high quality studies on physical activity and mental health problems among young people are scarce (Donaldson & Ronan 2006, Motl *et al.* 2004, Paluska & Schwenk 2000). To date only a few cohort studies using general population samples have been published (Motl *et al.* 2004, Physical Activity Guidelines Advisory Committee 2008). Most of the earlier studies have focused on emotional problems, primarily depression and anxiety, but only a few have examined behavioural or social problems and even fewer have viewed the phenomenon in a broad sense, including both internalizing and externalizing syndromes (Donaldson & Ronan 2006, Paluska & Schwenk 2000). Furthermore, many previous studies have measured mental health problems using methods originally developed for adults, without establishing their validity among adolescents (Motl *et al.* 2004).

2.5 Explaining adolescents' self-rated health

One of the most commonly used measures of perceived health status consists of a single Likert scale question querying respondents' overall health (Wade *et al.* 2000). This measure of self-rated health has consistently been found to be a valid measure of physical health status among adults (Idler & Benyamini 1997, Moller *et al.* 1996). Even in young populations, self-rated health is strongly linked to mortality (Breiblik *et al.* 2008) and is a good predictor of future illness, independent of clinical health status (Bjorner *et al.* 1996). In addition, self-rated health has been shown to be one of the best predictors of the use of health-care services in adults (Bierman *et al.* 1999).

Health is conceptualised during childhood and adolescence, and young people typically define health in a broad and global way (Breiblik *et al.* 2009, Wade & Vingilis 1999). Adolescents tend to use psychosocial health variables as a

frame of reference for their perceived health, partly due to the psychosocial and biological changes of puberty (Piko *et al.* 1997). Children and adolescents, in general, have low rates of serious physical morbidity (Breidablik *et al.* 2009). However, self-rated health declines during early adolescence, especially among girls, and a fairly large number of adolescents report subjective health problems and health concerns (Haugland *et al.* 2001). Furthermore, many of the most prevalent diseases of our time have their roots in childhood or adolescence (Eder 1990).

Prior research suggests that subjective health problems are of great importance for disability in modern societies (Bjorner *et al.* 1996, Idler & Benyamini 1997, Overland *et al.* 2006). Self-rated overall health is an important construct of subjective health problems, reflecting essential elements of adolescents' perceived health that are rarely captured by other health measures (Johnson & Wang 2008). Although self-rated health is a widely examined measure of health status in adults, relatively little is known about factors that contribute independently to self-rated health in adolescents. The way in which self-rated health is constructed and influenced during adolescence is an important research question, which needs to be answered in order to enhance adolescent health and positive attitudes towards life, as well as self-perception and coping with negative emotions.

2.5.1 Physical activity and self-rated health

In adults exercise and physical activity are associated with good self-rated health (Abu-Omar & Rutten 2008, Abu-Omar *et al.* 2004, Sodergren *et al.* 2008). Even though much less is known about the relation between physical activity and self-rated health among young people, there is some evidence of the level of physical activity being a significant contributor to self-rated health in adolescence (Breidablik *et al.* 2008, Mikolajczyk *et al.* 2008, Piko 2007, Piko & Keresztes 2007). Previous studies of physical activity and self-rated health among adolescents are summarized in Appendix 3. It has been suggested that adolescents may use health-related behaviours such as physical activity as a frame of reference for their self-rated health (Dowdell & Santucci 2004, Goodwin *et al.* 2006). According to types of association, Pastor *et al.* (2003) have suggested that sports participation was associated with perceived health both directly and indirectly by decreasing smoking and alcohol consumption, feelings of depression and psycho physiological symptoms, and by increasing perceived physical fitness.

However, the association between physical activity and self-rated health in adolescents may differ according to sex and the level of physical activity, the influence being stronger among males and likewise among more active persons (Piko 2000). According to the results of previous studies, research on physical activity and self-rated health in adolescents with large unselected population samples and high quality study designs are needed in order to clarify their association.

2.5.2 Emotional and behavioural problems in relation to self-rated health

In adults, self-rated health reflects physical health problems and functional ability as well as social and mental well-being (Fylkesnes & Forde 1992, Uden & Elofsson 2001). In their study Uden and Elofsson (2001) reported that lower social and mental well-being and somatic conditions in women and worse coping abilities in men were associated with poor self-rated health, irrespective of current physical health.

Among adolescents, psychosocial functioning may be a major factor shaping a young person's appraisal of perceived health status (Vingilis & Wade 2000), poor self-rated health being related, for example, to feelings of loneliness, shyness and hopelessness (Page & Suwanteerangkul 2009). In adolescents there is evidence relating depression, anxiety, conduct disorders, aggression and anger to various subjective health complaints (Egger *et al.* 1999, Fekkes *et al.* 2004, Kumpulainen *et al.* 1998). Psychosomatic symptoms like headache, backache, nervousness and sleeping problems are also significantly related to health perceptions among young people (Erginoz *et al.* 2004, Milligan *et al.* 1997, Piko *et al.* 1997). Piko and Keresztes (2007) and Piko (2007) reported that psychosomatic symptoms, depression and anger were associated with poor overall health status among adolescents. In contrast satisfaction with life seems to be an important protective factor against poor self-rated health (Piko 2007).

However, only a limited number of studies have examined the association between mental health problems and overall health status in adolescents using a valid single item measure of self-rated health (Piko 2007, Piko & Keresztes 2007). Most previous studies have not directly asked adolescents to rate their perceived health, but have measured various subjective health complaints or symptoms, which are thought to reflect adolescents' overall health status (Egger *et al.* 1999, Fekkes *et al.* 2004, Kumpulainen *et al.* 1998). Even fewer have used wide scale

measures of mental health problems, including both emotional and behavioural problems in the analyses.

2.5.3 Socio-economic position and self-rated health

Lower socio-economic position is consistently associated with worse self-rated health among adults (Chittleborough *et al.* 2009, Lopez 2004, Zimmer *et al.* 2000). However, socio-economic inequalities in adolescent health have been little studied until recently (Currie *et al.* 2008). Nevertheless, some recent studies suggest that poor self-rated health is more prevalent among adolescents with low socio-economic background across countries (Currie *et al.* 2008). Previous studies have reported inverse associations between various measures of parental socio-economic position and adolescents' self-rated health, including income (Goodman 1999, Newacheck *et al.* 2003, Wade *et al.* 2000), the Family Affluence Scale (FAS) (Torsheim *et al.* 2004, Torsheim *et al.* 2006), occupational status (Goodman 1999), and the level of education (Goodman 1999). However, the methods and measures used to evaluate the association between parental socio-economic position and adolescents' self-rated health in previous studies vary, making it difficult to compare the results and draw consistent conclusions.

There is some evidence of the existence of social gradients in several aspects of adolescent self-rated health status, which refer to graded effect of class on self-rated health and other health outcomes (Starfield 2008, Starfield *et al.* 2002). However, the existence of social gradient in self-rated health during adolescence is not evident, with some studies concluding that it is less uniformly visible in adolescence than in childhood or adulthood (West 1997). It has also been suggested that subjective perceptions of social positions based on the socio-economic hierarchy predict adolescents' global health ratings, even when adjusting for the sociodemographic factors which shape them (Goodman *et al.* 2007). Furthermore, the relationship between perceived socio-economic position and health is less consistent among young people compared to older age groups, which suggests that developmental differences in subjective evaluations of socio-economic position may influence adolescents' health (Goodman *et al.* 2007).

2.6 Explaining adolescents' educational attainment

Education can be thought of as the transmission of the values and accumulated knowledge of a society. In this sense it is equivalent to what

social scientists term socialization or enculturation. Children -- are born without culture. Education is designed to guide them in learning a culture, molding their behaviour in the ways of adulthood, and directing them toward their eventual role in society. (Encyclopaedia Britannica Education 2009)

According to Brezinka (1994) the term 'education' is understood as the action through which people attempt to improve one or more person's psychic dispositional structures in some respect, preserve those components viewed as valuable and prevent others that seem to be inappropriate. It is suggested that the aim of education is to aid an individual in his/her development as a member of society, and more broadly, to preserve and/or develop the framework of society (Shafritz *et al.* 1988, Staff 1996). In the present study, 'education' is considered as the system of formal education, which takes place in schools and other educational institutions. Educational attainment is defined in terms of self-perceived overall academic performance and educational plans after basic education.

There is strong evidence in epidemiological literature that education is a key predictor of life opportunities, both within the economic and social sphere and with respect to subjective outcomes such as happiness and perceived quality of life (Campbell 1981, Ross & Mirowsky 2003, Ross & Van Willigen 1997). People who have not completed secondary school have lower levels of income, experience less stability at home and at work, and are more likely to require public assistance than those who have completed secondary education (Coley 1995, Schwartz 1995). Well-educated people also enjoy better health than the poorly educated, and a low level of education is associated with, for example, high rates of many infectious and chronic non-infectious diseases, poor self-reported health and shorter life expectancy (Chandola *et al.* 2006, Freudenberg & Ruglis 2007, Molla *et al.* 2004). The less schooling people have, the higher their levels of risky health behaviours such as smoking or physical inactivity (Lantz *et al.* 1998). Considering the importance of educational attainment for future opportunities in adulthood, it is critical to get more information on the factors associated with educational attainment during earlier life phases. Knowing more about the factors associated with educational attainment in adolescence is essential in understanding the pathways and mechanisms through which education is associated with health and other life opportunities in later life. This knowledge is also crucial in supporting people's educational trajectories and lifelong learning.

2.6.1 Physical activity and educational attainment

Physical activity may reduce stress, alter mood states, affect arousal and attention, and perhaps as a result, improve school achievement (Paluska & Schwenk 2000, Taras 2005). Physical activity may also improve social skills that might result in academic outcomes: children and adolescents who learn to co-operate, share, and abide by the rules of group physical activities are likely to feel more connected to their school and community (Taras 2005). Moreover, testing physical abilities in individual activities may encourage adolescents to challenge themselves in social and academic circumstances (Taras 2005).

Physical activity is positively related to cognitive performance across all ages (Hillman *et al.* 2008, Sibley & Etnier 2003, Tomporowski *et al.* 2008). In their recent review, Hillman and colleagues (2008) concluded that physical activity, especially aerobic fitness training, can have a positive effect on multiple aspects of brain function and cognition. Although the number of studies on physical activity is larger for older adults than for other age groups, the data suggest that physical activity can have beneficial effects on cognitive performance throughout the lifespan, even for individuals with neurodegenerative diseases (Hillman *et al.* 2008).

Despite the previous studies of physical activity in association with cognition and brain function, studies of physical activity in relation to actual academic performance are scarce. These studies are summarized in Appendix 4. Previous studies have reported that the level of physical activity is associated with scores of grade point average among adolescents (Fisher *et al.* 1996, Pate *et al.* 1996, Sigfusdottir *et al.* 2007). However, some studies have concluded that only high levels of physical activity are positively associated with overall grade score (Coe *et al.* 2006, Field *et al.* 2001, Nelson & Gordon-Larsen 2006). The evidence for the association between sports involvement and academic performance among adolescents is inconsistent with previous studies reporting either positive (Aaron & Gallagher 2003, Nelson & Gordon-Larsen 2006) or no effect (Fisher *et al.* 1996, Sanders *et al.* 2000) of participation in organised sports on school outcomes. Moreover, relatively few studies have explored the relationship between physical activity and educational performance/plans through high quality designs with large, unselected and nationally representative study samples. Most previous studies summarized in Appendix 4 were North America or United Kingdom based, and none of them were conducted in Scandinavian countries.

2.6.2 Emotional and behavioural problems in relation to educational attainment

Psychiatric conditions in adolescence are associated with diminished probabilities of successfully making important educational transitions such as high school completion, college entrance conditional on high school graduation, and college completion conditional on college entrance (Kessler *et al.* 1995, Miech *et al.* 1999). Adolescents who report emotional distress are also more likely to experience academic failure (Needham *et al.* 2004). In the United States, over half the adolescents who fail to complete secondary education have a diagnosable psychiatric disorder, and the proportion of failure to complete school that is attributable to psychiatric disorder has been estimated to be 46% (Stoep *et al.* 2003).

Mental health problems operate to weaken adolescents' school connectedness, decrease their ability to do well in school, and dampen their aspiration for pursuing higher education (Jin *et al.* 2008). Haas and Fosse (2008) have suggested three possible mechanisms for the association between adolescent (mental) health and educational attainment: 1) poor health may be proxy for disadvantaged parental socio-economic position, 2) poor health may be linked to poor educational outcomes through its effect on academic performance and cognitive development and 3) poor health may operate through poor psychosocial adjustment with peers and school. Poor childhood/adolescent (mental) health can also be accompanied by decreased physical functioning, which in turn might limit athletic and other social activities of the adolescent and in this way hinder peer interaction and the development of social relationships (Haas & Fosse 2008). This can adversely impact self-esteem and contribute to social isolation. The net effect of mental health problems and poor psychosocial functioning could be to weaken commitment to school and learning, for example by estranging the adolescent from the school environment (Haas & Fosse 2008).

Results from several longitudinal studies show that associations with educational attainment may differ according to types of mental health problems. Behavioural problems (problems with control, attention, and conduct) appear to be more important for primary and high school termination, while emotional problems (depression and anxiety) play a stronger role in college entrance and completion (Kessler *et al.* 1995). However, only a few studies have explored mental health problems in association with educational performance on a wider scale, including not only emotional, but also behavioural and social problems in

the same study setting. Even fewer have examined future educational plans as an outcome measure.

2.6.3 Socio-economic position and educational attainment

Research consistently shows an association between parents' socio-economic position and adolescents' school performance, with adolescents of higher socio-economic position showing higher levels of academic achievement than their counterparts from lower socio-economic backgrounds (OECD 2001, OECD 2003, OECD 2006). Young people from low socio-economic positions are more likely to have lower retention rates, lower higher education participation rates, are less likely to study specialized mathematics and science subjects, are more likely to have difficulties with their studies and display negative attitudes to school, and have less successful school to labour market transitions (Considine & Zappala 2002). Similar associations have been reported between pupils' socio-economic position and reading, spelling, and mathematics skills (Duru-Bellat 2004, Keeves 1995).

Previous studies have reported the effects of parental education on adolescents' academic achievement both at subject (e.g. mathematics, science and reading) and common grade level (Hanushek & Luque 2003, Lekholm & Cliffordson 2008, Smith *et al.* 2003). Low parental education is also related to a risk of school failure (Livaditis *et al.* 2003), school liking and self-perceived school performance (Stanley *et al.* 2008) among adolescents. However, it has also been reported that parental education is not predictive of adolescent self-reported school performance (Gonzales *et al.* 1996). Furthermore, some studies have suggested that rather than having a direct effect on adolescent academic achievement, parental education has a positive indirect effect on achievement, e.g. through pupil prior achievement and academic self-concept (Alomar 2006, Schmitt *et al.* 1999).

The association between parental socio-economic position and adolescent educational attainment remains somewhat inconsistent and needs further clarification. For example, it has been suggested that the overall effects of socio-economic background on educational outcomes are declining in industrialised countries (Marks & McMillan 2003). Furthermore, it has been reported that even within a group with considerable economic disadvantages, socio-economic status, as reflected by the level of parental education, is a key predictor of student school performance (Considine & Zappala 2002). This supports the notion that the

‘social’ and the ‘economic’ components of the socio-economic position may have different and independent influences on educational outcomes.

2.7 Summary of the literature and justification for this study

Physical activity provides important health benefits for adolescents (Physical Activity Guidelines Advisory Committee 2008). Physical activity is also beneficial to adolescents’ cognition and brain function, which, in turn, may have positive effects on learning and academic performance (Hillman *et al.* 2008). Despite the well-known benefits of physical activity on health and future life opportunities, the majority of adolescents do not meet current physical activity and public health recommendations (Eaton *et al.* 2006, Fogelholm *et al.* 2007, Physical Activity Guidelines Advisory Committee 2008, Tammelin *et al.* 2007, Whitt-Glover *et al.* 2009).

In order to promote the health and well-being of adolescents through physical activity, more detailed information is needed on social determinants of adolescents’ physical activity and sedentary behaviours. According to previous studies, a higher level of family income (Butcher *et al.* 2008, Gordon-Larsen *et al.* 2000, Lasheras *et al.* 2001, Lee & Cubbin 2002, Lowry *et al.* 1996, Wagner *et al.* 2004) and parental education (Chen *et al.* 2007, Gordon-Larsen *et al.* 2000, Lasheras *et al.* 2001, La Torre *et al.* 2006, McVeigh *et al.* 2004, Murphey *et al.* 2004, Piko 2007, Piko & Keresztes 2008, Singh *et al.* 2008) are positively associated with physical activity among adolescents. However, studies with large and representative population samples and with multiple measures of parental socio-economic position are few. Furthermore, many of the earlier studies have obtained the relevant information on parental social position from adolescents, instead of from parents themselves.

More information is also needed on health and educational outcomes of physical activity. Most of the studies of adolescents’ physical activity and mental health problems, for example, have examined only emotional problems, presenting limited evidence for social and behavioural problems (Donaldson & Ronan 2006, Paluska & Schwenk 2000). Many previous studies have also used a measure of mental health problems originally developed for adults, without establishing its validity among adolescents (Motl *et al.* 2004). Only a few studies have examined physical activity in association with overall self-rated health, reporting mainly positive association (Breibablik *et al.* 2008, Mikolajczyk *et al.* 2008, Piko & Keresztes 2007). However, the association may differ according to

sex and the level of physical activity, calling for a further investigation on the association between physical activity and self-rated health among adolescents (Piko 2000). Similarly, there is some evidence for the beneficial effect of physical activity on cognition and brain function, but studies of physical activity and actual educational attainment are scarce and the results are inconsistent (Coe *et al.* 2006, Sigfusdottir *et al.* 2007, Vindfeld *et al.* 2009).

Finally, a more holistic perspective is needed on determinants and outcomes of adolescents' physical activity than that in the extant literature. Instead of searching for distinct determinants and/or outcomes, these factors should be seen as larger constructs of adolescents' behavioural patterns and lifestyles, and analysed together, taking into account social conditions. Although there are several studies reporting bivariate associations between parental socio-economic position and adolescents' physical activity, emotional and behavioural problems, self-rated health and educational attainment (Breibablik *et al.* 2008, Breslau *et al.* 2008, Fekkes *et al.* 2004, Goodman 1999, OECD 2001, Sigfusdottir *et al.* 2007, Wade *et al.* 2000), no study so far has synthesized these factors into one study and evaluated interrelationships between these factors.

Altogether, research with large and representative population samples, high quality study designs and valid measures of key variables together with innovative theoretical frameworks are needed to strengthen the existing evidence, and to produce novel views for the role of physical activity on adolescents' health and educational attainment. The present study tries to rise to this challenge by evaluating the associations between adolescents' physical activity, emotional and behavioural problems, self-rated health and educational attainment in the light of life-course approach and social conditions with a large unselected population sample, the Northern Finland Birth Cohort 1986.

3 Aims of the study

This study aims to evaluate the role of physical activity on adolescents' emotional and behavioural problems, self-rated health and educational attainment in the light of social conditions. The defined aims by the original publications (I–IV) are:

1. To evaluate how family income and parental education are associated with physical activity and TV watching among adolescents, and how participation in different types of physical activity is modified by the adolescents' social background (I).
2. To examine how the level of physical activity is associated with various types of self-reported emotional and behavioural problems among adolescents (II).
3. To study how physical activity, emotional and behavioural problems and parental socio-economic position are related to adolescents' self-rated overall health (III).
4. To study how physical activity, emotional and behavioural problems, and parental socio-economic position are associated with the academic performance of adolescents (IV).

The main associations evaluated in the present study are presented in Figure 3.

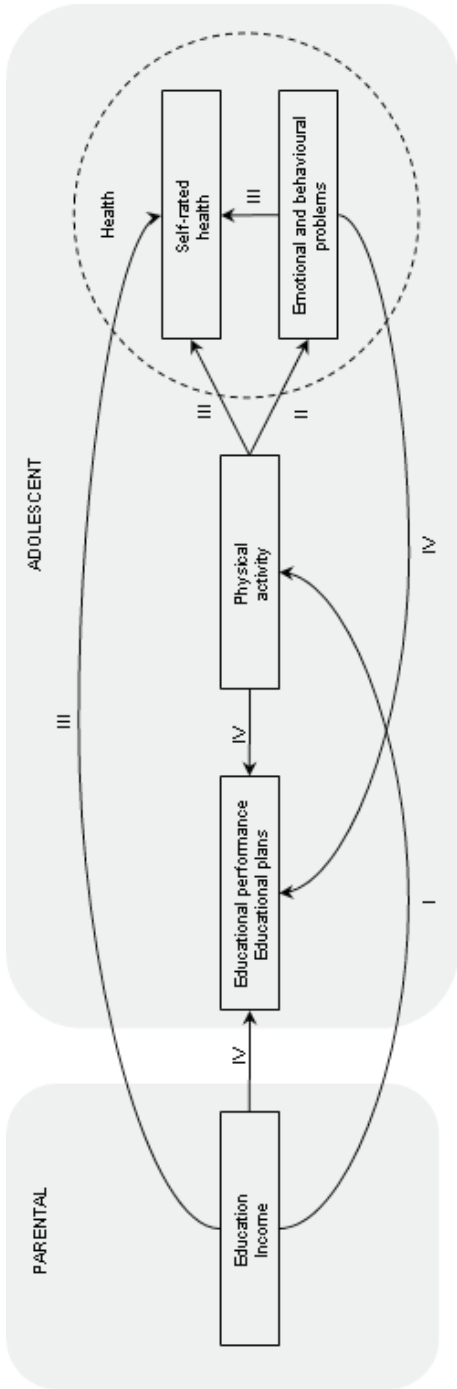


Fig. 3. The associations between parental socio-economic position, adolescents' educational attainment, physical activity and health outcomes evaluated in the present study. Original publications are presented as I-IV.

4 Materials and methods

4.1 Study population and data collection

The study population consisted of a prospective mother-child birth cohort, the Northern Finland Birth Cohort 1986 (NFBC 1986), which at the baseline comprised 9432 infants who were born alive and whose expected date of birth was between 1 July, 1985 and 30 June 1986 in the two northernmost provinces of Finland, Oulu and Lapland (Jarvelin *et al.* 1997, Jarvelin *et al.* 1993, Taanila *et al.* 2004). The data collection started during the pregnancy of the mothers and the follow-up surveys were carried out at age 7–8 years (1992–1994) and 15–16 years (2001–2002). NFBC 1986 is part of the longitudinal research program called Well-being and Health: The Northern Finland Birth Cohort Studies, which aims to promote the health and well-being of the population. The program is internationally well-known and is funded by bodies including The Academy of Finland, European Union, National Institutes of Health (US), The Wellcome Trust (UK) and The Nordic Academy for Advanced Study (NorFA).

When the cohort members were 15–16 years old, all 9215 of them who were alive and whose addresses were known were sent a postal questionnaire at the same time, in April 2001. The postal inquiry included questions about adolescents' physical activity, sedentary behaviours, mental health, educational attainment and self-rated health. The response rate was 80% (N = 7344, 3559 boys and 3785 girls). At the same time their parents were sent a questionnaire in a separate envelope, including questions about parents' education, family income, family type, place of residence and parents' level of physical activity. The response rate in parents' questionnaire was 76% (N = 6985, 3495 boys and 3490 girls). The study population and data collection are presented in Figure 4.

To study the association between parental socio-economic position and adolescents' physical activity, those 5457 adolescents (2760 boys and 2697 girls) were included whose family income and level of physical activity were reported. To study the relationships between physical activity, mental health, educational attainment and self-rated health, the study population was restricted to those 7002 adolescents (3355 boys and 3647 girls), who completed the Youth Self-Report (YSR) questionnaire assessing their emotional and behavioural problems. Individuals were excluded from the analyses if the YSR questionnaire data were missing for more than eight items (not including open-ended and socially

desirable items, 15 items in total), and if there was more than one answer missing on any of the eight subscales. Otherwise, the missing values were replaced by the mean value of the items on that particular scale for that particular individual. The study samples in original publications I–IV are described in Table 1.

Table 1. Study designs and samples in the original publications I–IV.

Original publication	Study design and sample
I	Questionnaire-based survey: 5457 adolescents (boys 2760 and girls 2697), who responded to postal questionnaire about their physical activity and whose parents responded to the question about family income at age 15–16 years
II–IV	Questionnaire-based survey: 7002 adolescents (3355 boys and 3647 girls), who responded to postal questionnaire about their emotional and behavioural problems at age 15–16 years

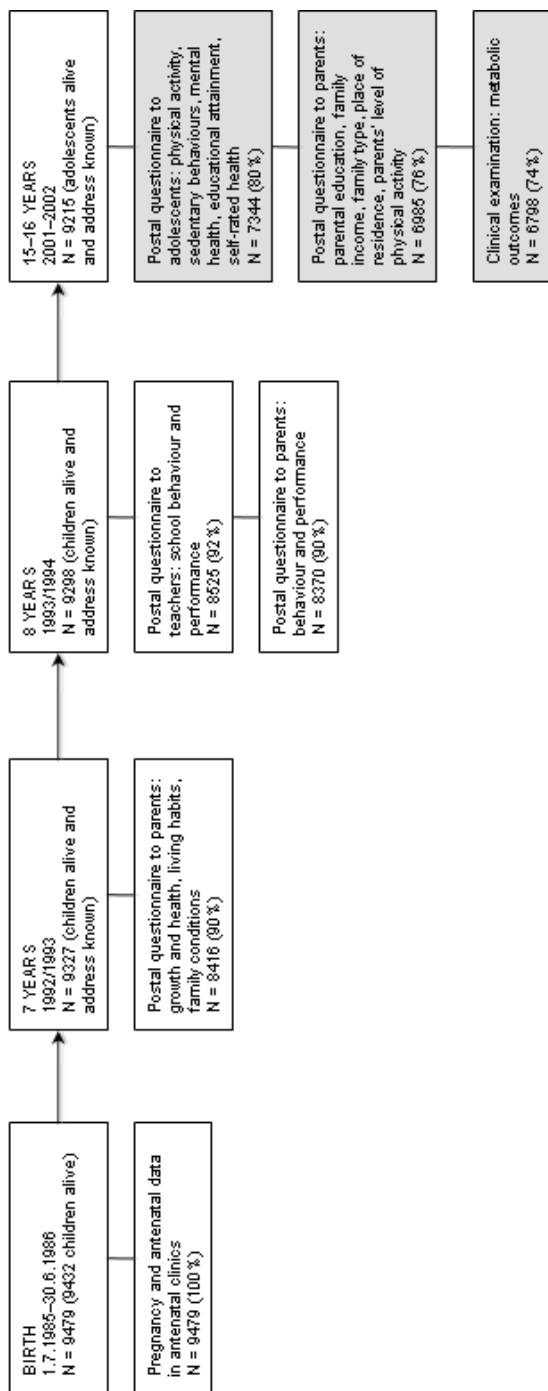


Fig. 4. Study population and data collection of the Northern Finland Birth Cohort 1986 from 1985 to 2002. The boxes in grey represent the databases and variables used in the present study.

4.1.1 Representativeness of the study samples

The characteristics of the different study samples were compared to evaluate their representativeness (Appendix 5). The study samples used in the original publications I (N = 5457) and II–IV (N = 7002) were compared to the original population samples at baseline and at the 15–16 years postal questionnaire survey. The selection criteria for the original study samples are presented in Table 1.

No difference was observed in the amount of physical activity between adolescents in the original 15–16 years postal questionnaire sample (N = 7344) and adolescents in the samples used in the present study. Neither were there significant differences in the level of mothers' education between the original 15–16-years postal questionnaire sample and the present study samples. However, mothers' level of education was somewhat lower in the baseline sample than in the other population samples; in the baseline sample (N = 9479) only 7% of mothers had a tertiary/higher education degree, compared to 13% in the other samples.

4.1.2 Study variables

The study variables are presented in Table 2. The variable may be used as an outcome variable, an explanatory variable or a confounding variable in different publications.

Table 2. The outcome, explanatory and confounding variables used in the original publications (I–IV).

Variables and their categorization	Outcome variable	Explanatory variable	Confounding variable
Physical activity			
Moderate-to-vigorous intensity physical activity outside school hours	I	II, III, IV	III, IV
Membership in a sports club	I		
Participation in different types of sports	I		
Time spent watching TV	I		
Emotional and behavioural problems	II	III, IV	III, IV
Self-rated health	III		
Educational attainment			
Overall academic performance	IV		
Educational plans	IV		
Other variables			
Annual family income		I	II
Mother's education		I, III, IV	II, III, IV
Father's education		I	II
Change in family type			I, II, IV
Place of residence			I
Mother's level of physical activity			I
Father's level of physical activity			I
Adolescents' obesity level			II

4.1.3 Physical activity

Moderate-to-vigorous intensity physical activity (MVPA). At the age of 15–16 years, the adolescents were asked about their participation in MVPA outside school hours. The amount of MVPA was evaluated by asking ‘How many hours a week altogether do you participate in brisk physical activity outside school hours?’ In the questionnaire, the term *brisk* was defined as physical activity causing at least some sweating and getting out of breath. The response alternatives were not at all, about half an hour a week, about 1 hour a week, 2–3 hours a week, 4–6 hours a week and 7 hours or more a week. Adolescents were classified into three groups according to their weekly participation in MVPA: 1) active (four hours or more of MVPA), 2) moderately active (two to three hours of MVPA) and 3) inactive (one hour or less of MVPA). The test-retest reliability of this question has been reported to be very good, intraclass correlation coefficient being 0.83 among

Finnish adolescents aged 15–16 years (Tammelin *et al.* 2007). The validity of this question has been reported as acceptable, when tested against aerobic fitness among Australian adolescents (Booth *et al.* 2001).

Membership in a sports club. The participants were also asked whether they were members in a sports club and did they participate in the training sessions organised by the club. The adolescents were categorized as *active sports club members* if they were members in a sports club and participated in the training sessions.

Participation in different types of physical activity. The participants reported how often they participated in different types of physical activity during the previous year in the season, which was suitable for those activities. The listed activities were walking, jogging, cycling, cross-country skiing, swimming, soccer, ice hockey, floorball, rinkball or bandy, Finnish baseball, basketball, volleyball, ice-skating, figure skating, track and field, horseback riding, aerobics, gymnastics, dancing, gym training (in Finland, gym training mainly includes weight training but may also include some endurance exercises), downhill skiing or snowboarding, roller-skating or skateboarding, badminton, tennis, orienteering running, judo or karate or wrestling, and golf. Those who participated in a certain sport once a week or more often were classified as *active participants* in that particular sport. These activities were selected into the questionnaire as they were reported being the most popular sports among Finnish young people in 1997–1998 (Nurmela & Pehkonen 1998).

Time spent watching TV. The adolescents were also asked how many hours per day, on average, they spent watching TV outside school hours. Time spent watching TV was classified as 1) less than 1.5 hours (the top quartile), 2) 1.5 hours or more but less than 3.5 hours and 3) 3.5 hours or more per day (the bottom quartile).

4.1.4 Emotional and behavioural problems

Emotional and behavioural problems at the age of 15–16 years were assessed using the Finnish version of the Youth Self-Report (YSR), which is a widely used questionnaire designed to assess emotional and behavioural problems among adolescents aged 11–18 years (Achenbach & Rescorla 2001). The YSR consists of 105 symptom/behaviour items and eight syndrome scales): 1) anxious/depressed symptoms (13 statements, e.g. ‘I cry a lot’, ‘I am afraid of going to school’ and ‘I feel worthless or inferior’), 2) withdrawn/depressed

symptoms (8 statements, e.g. ‘I would rather be alone than with others’, ‘I refuse to talk’ and ‘I am too shy or timid’), 3) somatic complaints (10 statements, e.g. ‘I have nightmares’, ‘I feel dizzy or light headed’ and ‘I feel overtired without good reason’), 4) social problems (11 statements, e.g. ‘I’m too dependent on adults’, ‘I feel lonely’ and ‘I don’t get along with other kids’), 5) thought problems (12 statements, e.g. ‘I can’t get my mind off certain thoughts’, ‘I deliberately try to hurt or kill myself’ and ‘I sleep less than most kids’), 6) attention problems (9 statements, e.g. ‘I act too young for my age’, ‘I have trouble sitting still’ and ‘I daydream a lot’), 7) rule-breaking behaviour (15 statements, e.g. ‘I break rules at home, school or elsewhere’, ‘I lie or cheat’ and ‘I run away from home’) and 8) aggressive behaviour (17 statements, e.g. ‘I argue a lot’, ‘I am mean to others’ and ‘I try to get a lot of attention’).

Participants assessed whether each statement was true or not for them for the period of the preceding 6 months. The response scale was: not true (score 0), somewhat or sometimes true (score 1), and very true or often true (score 2). The YSR item scores were summed to obtain a summary score for each subscale. Syndrome scales 1–3 (anxious/depressed, withdrawn/depressed and somatic complaints) comprise the *internalizing scale* (hereafter referred to as ‘*emotional problems*’), scales 7 and 8 (rule-breaking and aggressive behaviour) comprise the *externalizing scale* (hereafter referred to as ‘*behavioural problems*’), while scales 4–6 (social, thought and attention problems) are not part of either internalizing or externalizing scales and are called ‘*other syndromes*’. In this thesis we used the original summary scores in which the problems were grouped into normal, borderline and clinical range groups based on recommended cut-off points (approximately the 84th through 90th percentiles) (Achenbach & Rescorla 2001). For further analyses the YSR variables were dichotomized by combining borderline range and clinical range groups into one group, which is hereafter referred to as ‘problem range’. The YSR questionnaire has been established as a reliable data collection method in epidemiological research in Scandinavia (Berg-Nielsen *et al.* 2003, Broberg *et al.* 2001, Heyerdahl *et al.* 2004) and in Finland (Helstela & Sourander 2001). The reliability and validity of the YSR are documented by Achenbach and Rescorla (2001).

4.1.5 Self-rated health

Self-rated overall health was measured using question about how healthy the adolescents felt at that moment. Respondents were asked to rate their health in

general on a five-point scale: 1) very poor, 2) poor, 3) fair, 4) good and 5) very good. For analytical purposes and for the reason that our main focus was on very good and good self-rated health status, the adolescents were dichotomized into two groups according to their self-rated health: 1) good (very good or good self-rated health) and 2) poor (fair, poor or very poor self-rated health). This single-item measure of general health status has been used widely in previous research and has been consistently found to be an independent predictor of mortality and a reasonable measure of objective health status (Idler & Benyamini 1997, Singh-Manoux *et al.* 2006, Singh-Manoux *et al.* 2007).

4.1.6 Educational attainment

Overall academic performance. Adolescents were asked to rate their performance in Finnish language, general subjects (such as history and religion), mathematics and natural sciences (such as biology, chemistry and physics) compared to their peers. The response alternatives were: above average, average, below average and bottom. Responses were coded according to the following scheme: above average = 4, average = 3, below average = 2 and bottom = 1. Grades for the four subjects were summed to calculate a summary score of self-perceived *overall academic performance*. The range of the summary score was from 4 (all bottom) to 16 (all above average). For analytic purposes, the academic performance summary score was dichotomized around the 30th percentile of the summary score (summary score = 14) so that those scoring 14–16 were classified as having ‘high academic performance’ and those scoring 4–13 were classified as having ‘average or lower academic performance’. This cut-off point was chosen because it distinguishes adolescents' ratings of their performance in all four subjects (Finnish, general subjects, mathematics and natural sciences) as ‘above average’ from those rating their performance as ‘average or lower’.

Educational plans. Educational plans at the age of 15–16 years were measured by asking what plans adolescents had for continuing school after basic education. The response alternatives were: upper secondary school and polytechnic or university, upper secondary school and vocational school, upper secondary school only, vocational education, will not continue education and do not know yet. The adolescents were dichotomized into two groups according to their educational plans: 1) higher education (adolescents aiming to continue their education to upper secondary school and polytechnic or university level) and 2) lower level education (all other options).

4.1.7 Socio-economic position

Annual family income and parental education were used as proximal measures of parental socio-economic position.

Annual family income. Family income was obtained from the parents' questionnaire. To enable comparison of households of different sizes and structures, household consumption units (OECD scale) were calculated by assigning the first adult in the household a value of 1.0, with additional adults (>17 years) receiving 0.7 and each child (≤ 17 years) 0.5 (OECD 1982, United Nations 1977). The families were classified into quartiles based on their annual income per consumption unit: 1) less than EUR 9200, 2) EUR 9200–13 599, 3) EUR 13 600–18 599, and 4) more than EUR 18 600 per year.

Parental education. Mother's and father's highest level of education was also ascertained from the parents. The variable was categorized according to educational level categories used by the International Standard Classification of Education (ISCED) (Statistics Finland 2001) and the Finnish National Board of Education (The Finnish National Board of Education 2009). The original educational levels were 1) less than nine years of primary education, 2) basic education, 3) matriculation examination, 4) vocational course, 5) vocational education, 6) vocational college, 7) polytechnic, 8) university and 9) other or degree not finished. These nine educational groups were merged to form the four larger categories of 1) basic education, lasting nine years or less (original levels 1–2); 2) upper secondary education, lasting 10–12 years (original levels 3–6); 3) tertiary/higher education, lasting ≥ 13 years (original levels 7–8) and 4) other or degree not finished (original level 9). The last category (other or unfinished degree) included relatively heterogeneous educational backgrounds, like parents who have just started higher education studies and others with almost finished higher education degree.

4.1.8 Other variables

Family type. Information on family type was obtained from questionnaires filled out by mothers during pregnancy and postal questionnaires sent to parents when the child was aged 7–8 and 15–16 years. Family type was divided into four categories: 1) always two-parent family, the child lives with his/her biological parents who are married or cohabiting; 2) single-parent family, the child lives with his/her biological parent who is divorced, separated, or widowed; 3)

reconstructed family, the child lives in a family where his/her biological parent is divorced, separated, or widowed but now have a new spouse or partner, or in which the mother had been single at the time of the child's birth but has later married or began cohabiting and 4) always one-parent family, the child lives in a family where the mother has never married or cohabited.

Place of residence. Place of residence was also obtained from the parents' questionnaire and coded according to the Finnish Regional Research Classification of Municipalities in 2000 into 1) urban (urban municipalities), 2) semi-urban (rural municipalities close to urban areas) and 3) rural municipalities (core rural municipalities and sparsely populated rural municipalities) (Keranen *et al.* 2000).

Parents' level of physical activity. Parents' level of physical activity was based on a question asking about the frequency of participation in brisk physical activity (causing at least some sweating and getting out of breath) during leisure-time. Parents were classified into three groups: 1) active (exercising briskly twice a week or more often), 2) moderately active (exercising briskly once a week) and 3) inactive (exercising briskly less than once a week).

Obesity level. Body weight and height were both self-reported in the postal inquiry and measured in the health examination at 15–16 years. Self-reported body weight and height were used for those who failed to attend the health examination. Body mass index (BMI) was calculated as weight divided by the square of their height (kg/m^2). Overweight was defined as BMI between the 85th and 95th percentiles of the study population (24.20–28.16 kg/m^2 among boys and 24.13–27.70 kg/m^2 among girls) and obesity as BMI above the 95th percentile (≥ 28.18 kg/m^2 among boys and ≥ 27.70 kg/m^2 among girls) (Whitaker *et al.* 1997).

4.2 Statistical methods

The basic analyses included frequency counts and relative distributions. Bivariate cross-sectional associations were tested separately for boys and girls by cross-tabulation with chi-square test and by logistic regression. In the logistic regression analyses odds ratios (OR) and their 95% confidence intervals (95% CI) were calculated for the explanatory variables. ANOVA with Fisher's least significant difference (LSD) post hoc analysis was used to compare the mean scores of emotional and behavioural problems for the level of physical activity (original publication II). Multivariable cross-sectional analyses were also performed separately for boys and girls using logistic regression. According to self-rated

health (original publication III), multivariable analyses were conducted also in subsamples of adolescent (adolescents with one or several types of emotional and behavioural problems, and adolescents from low socio-economic background), considered as 'risk groups' for poor self-rated health, based on crude multivariable analyses. The results are presented with odds ratios and 95% confidence intervals. In the multivariable models the variables were adjusted for all explanatory variables and for annual family income, parents' education, family type, place of residence, parents' level of physical activity and obesity level, depending on the independent and the dependent variables (Table 2). The data were analysed using SPSS Software, versions 12.0 and 16.0.

4.3 Ethical considerations and personal involvement

The NFBC 1986 study conformed to the principles of the Declaration of Helsinki. The participants took part voluntarily and signed their informed consent, which was also obtained from their parents. The research protocol was approved by the Ethics Committee of the University Hospital of Oulu.

The author of this thesis has participated in the NFBC 1986 study as a researcher since 2004. He has participated in designing the use of statistical methods and he has conducted all the statistical analyses in the four original publications and this thesis. All presentations of methods, presentations of results and report writing for the original publications and this thesis have been done by the author.

5 Results

5.1 Characteristics of adolescents in the Northern Finland Birth Cohort 1986

Boys were physically more active than girls ($p < 0.001$); 46% of boys as compared with 29% of girls were classified as physically active, 23% of boys and 30% of girls were moderately active, and 31% of boys and 41% of girls were physically inactive (Table 3). Boys (28%) were also more often active members of sports clubs than girls (20%) ($p < 0.001$). 25% of boys watched TV more than 3.5 hours a day, compared with 22% of girls ($p = 0.001$).

Thirty percent of boys and 29% of girls were classified as having high overall academic performance (Table 3). In addition, 32% of boys and 43% of girls were planning to continue to upper secondary school and to polytechnic or university after secondary school. Girls more often than boys reported poor self-rated health ($p = 0.001$), 17% of girls and 15% of boys rated their current health as poor. About 14% of adolescents had a highly educated mother (Table 3).

The prevalence of self-reported mental health problems was substantially higher for girls than boys (Table 4). Among boys, the prevalence of emotional and behavioural problems varied between 1.6% and 8.6%, thought problems being the rarest and rule-breaking behaviour the most common syndrome. Similarly among girls, thought problems were the rarest (4.1%) and rule-breaking behaviour was the most common (15.6%) syndrome (Table 4).

Table 3. Sample characteristics and gender comparison of boys (N = 3355) and girls (N = 3647) in the Northern Finland Birth Cohort 1986.

Variables	Boys (%)	Girls (%)	p-value ^a
Physical activity level ^b			
Active	45.5	29.0	
Moderately active	23.4	30.0	
Inactive	31.0	40.9	<0.001
Membership in a sports club			
No	67.9	74.9	
Yes, but does not attend training sessions	3.6	5.1	
Yes, and attends training sessions	28.4	20.0	<0.001
Watching TV (h/day)			
<1.5	22.7	24.9	
1.5-3.5	52.0	53.4	
>3.5	25.3	21.7	0.001
Overall academic performance			
High	30.2	28.9	
Average or lower	69.8	71.1	0.247
Educational plans			
Higher education	32.2	43.0	
Lower level education	67.8	57.0	<0.001
Self-rated health			
Good	85.4	82.6	
Poor	14.6	17.4	0.001
Mother's education			
I Tertiary/higher	13.5	12.5	
II Upper secondary	65.6	67.1	
III Basic (≤ 9 years)	9.7	9.1	
IV Other or unfinished degree	11.3	11.3	0.515

^a Pearson chi-square test for gender difference.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

Table 4. Prevalence and gender comparison of emotional and behavioural problems among adolescents in the Northern Finland Birth Cohort 1986.

Variables	Boys (%)	Girls (%)	p-value ^a
Emotional problems			
Anxious/depressed			
Problem range	3.0	5.7	
Normal range	97.0	94.3	<0.001
Withdrawn/depressed			
Problem range	6.4	7.5	
Normal range	93.6	92.5	0.079
Somatic complaints			
Problem range	5.0	15.1	
Normal range	95.0	84.9	<0.001
Behavioural problems			
Rule-breaking behaviour			
Problem range	8.6	15.6	
Normal range	91.4	84.4	<0.001
Aggressive behaviour			
Problem range	7.3	8.9	
Normal range	92.7	91.1	0.018
Other problems			
Social problems			
Problem range	2.9	4.3	
Normal range	97.1	95.7	0.002
Thought problems			
Problem range	1.6	4.1	
Normal range	98.4	95.9	<0.001
Attention problems			
Problem range	3.2	7.5	
Normal range	96.8	92.5	<0.001

^a Pearson chi-square test for gender difference.

5.2 Socio-economic position in relation to adolescents' physical activity (I)

High family income was initially associated with high physical activity level among boys (OR 1.55, 95% CI 1.19–2.02) and girls (OR 1.57, 95% CI 1.18–2.08), but did not remain significant once allowance was made for parents' level of education (Table 5). Both mother's high educational level (among boys: OR 1.82, 95% CI 1.06–3.12) (among girls: OR 1.98, 95% CI 1.08–3.66) and father's high

educational level (among boys: OR 1.58, 95% CI 1.02–2.43) (among girls: OR 1.70, 95% CI 1.07–2.70) were independently associated with being physically active.

Family income was positively associated with being an active sports club member among both boys (OR 2.43, 95% CI 1.74–3.40) and girls (OR 2.67, 95% CI 1.81–3.94) after adjustments for parents' education, family type, place of residence, and parents' level of physical activity (Table 6). Father's education was positively related to sports club membership among boys (OR 2.05, 95% CI 1.27–3.31) and girls (OR 1.91, 95% CI 1.09–3.36), but the association between mother's education and sports club membership did not remain statistically significant in the adjusted analyses (Table 6).

Parents' educational level was inversely associated with time spent watching TV for adolescents (Table 7). Boys with highly educated fathers were 44% (OR 0.56, 95% CI 0.33–0.95) less likely to watch TV more than 3.5 hours a day compared to boys with fathers having a basic education. The association appeared to be even stronger among girls (OR 0.35, 95% CI 0.20–0.61). Regarding mother's education, the findings were similar among girls (OR 0.55, 95% CI 0.31–0.98), but among boys the association was not statistically significant.

Differing from the original publication I, in this study, *p*-test for trend was used instead of Pearson chi-square test to test the statistical significance for the association between family income and types of physical activity, which changed the results slightly. Participation in different types of physical activity varied between family income groups, although most differences were minor or the associations were weak (Table 8). Participation in downhill skiing and snowboarding increased with increasing family income among both boys and girls ($p < 0.001$). Among boys, participation in golf, roller skating and tennis, and among girls, participation in aerobics and dancing was more common in the highest income group ($p < 0.001$). However, athletics, bandy, cross-country skiing, ice hockey, swimming and volleyball were more common in the lowest income group among both boys and girls (Table 8).

Table 5. Physically active adolescents by background characteristics. Multivariable regression of being physically active at age 15–16 years.

	Boys (N = 2494)			Girls (N = 2565)		
	Active Adolescents ^a (%)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)	Active Adolescents ^a (%)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
Annual family income/consumption unit (€)						
I ≥18 600	52.7	1.55 (1.19–2.02)	1.17 (0.88–1.57)	32.9	1.57 (1.18–2.08)	1.25 (0.92–1.70)
II 13 600–18 599	45.9	1.24 (0.95–1.63)	1.08 (0.82–1.43)	33.5	1.49 (1.12–1.98)	1.29 (0.95–1.74)
III 9200–13 599	46.0	1.38 (1.05–1.81)	1.27 (0.96–1.68)	26.7	0.98 (0.72–1.33)	0.92 (0.67–1.26)
IV <9200	40.1	1.00	1.00	26.9	1.00	1.00
Mother's education						
I Tertiary/higher	55.4	2.37 (1.44–3.92)	1.82 (1.06–3.12)	38.3	2.85 (1.59–5.12)	1.98 (1.08–3.66)
II Upper secondary	45.3	1.65 (1.05–2.60)	1.43 (0.90–2.29)	29.4	1.93 (1.12–3.31)	1.68 (0.97–2.93)
III Basic (≤9 years)	37.8	1.00	1.00	22.6	1.00	1.00
IV Other or unfinished degree	46.0	1.84 (1.09–3.10)	1.62 (0.95–2.78)	27.8	1.58 (0.86–2.93)	1.38 (0.74–2.60)
Father's education						
I Tertiary/higher	57.1	2.20 (1.49–3.26)	1.58 (1.02–2.43)	41.9	2.31 (1.50–3.56)	1.70 (1.07–2.70)
II Upper secondary	45.9	1.52 (1.10–2.09)	1.32 (0.95–1.84)	29.5	1.26 (0.88–1.81)	1.10 (0.76–1.59)
III Basic (≤9 years)	37.9	1.00	1.00	26.5	1.00	1.00
IV Other or unfinished degree	45.2	1.55 (0.98–2.44)	1.25 (0.78–1.99)	26.1	1.06 (0.64–1.76)	0.95 (0.56–1.61)

^a Exercised briskly for more than 4 hours a week.

^b Adjusted for all variables in the table as well as for change in family type, place of residence, and parents' level of physical activity. OR, odds ratio; 95% CI, 95% confidence interval.

Table 6. Active sports club members by background characteristics. Multivariable regression of active sports club membership at age 15–16 years.

	Boys (N = 2507)			Girls (N = 2573)		
	Active sports club members ^a (%)	Adjusted ^b		Active sports club members ^a (%)	Adjusted ^b	
		Unadjusted OR (95% CI)	OR (95% CI)		Unadjusted OR (95% CI)	OR (95% CI)
Annual family income/consumption unit (€)						
I ≥18 600	38.4	2.99 (2.19–4.08)	2.43 (1.74–3.40)	31.2	3.83 (2.66–5.52)	2.67 (1.81–3.94)
II 13 600–18 599	33.4	2.50 (1.83–3.43)	2.32 (1.67–3.21)	25.2	3.10 (2.14–4.50)	2.38 (1.62–3.49)
III 9200–13 599	27.9	2.02 (1.45–2.80)	1.94 (1.39–2.71)	17.3	1.72 (1.15–2.58)	1.57 (1.04–2.37)
IV <9200	18.2	1.00	1.00	10.7	1.00	1.00
Mother's education						
I Tertiary/higher	37.3	2.62 (1.44–4.74)	1.38 (0.73–2.62)	28.8	3.58 (1.71–7.50)	1.81 (0.83–3.94)
II Upper secondary	29.1	1.95 (1.12–3.41)	1.48 (0.83–2.63)	21.4	2.56 (1.27–5.16)	1.80 (0.87–3.72)
III Basic (≤9 years)	20.4	1.00	1.00	10.9	1.00	1.00
IV Other or unfinished degree	28.2	1.95 (1.05–3.64)	1.51 (0.79–2.89)	16.7	1.84 (0.84–4.04)	1.30 (0.58–2.91)
Father's education						
I Tertiary/higher	41.9	2.87 (1.86–4.43)	2.05 (1.27–3.31)	30.6	3.43 (2.02–5.81)	1.91 (1.09–3.36)
II Upper secondary	29.0	1.61 (1.11–2.35)	1.35 (0.92–1.99)	20.8	1.85 (1.16–2.96)	1.47 (0.91–2.39)
III Basic (≤9 years)	20.7	1.00	1.00	13.8	1.00	1.00
IV Other or unfinished degree	28.9	1.61 (0.96–2.69)	1.26 (0.74–2.15)	22.8	2.36 (1.30–4.26)	1.88 (1.02–3.49)

^a Were members in a sports club and participated in training sessions.

^b Adjusted for all variables in the table as well as for change in family type, place of residence, and parents' level of physical activity. OR, odds ratio; 95% CI, 95% confidence interval.

Table 7. Adolescents watching television for more than 3½ hours a day by background characteristics. Multivariable regression of high amount of television watching at age 15–16 years.

	Boys (N = 2505)			Girls (N = 2580)		
	TV time ≥3½ h/day (%)		Adjusted ^a OR (95% CI)	TV time ≥3½ h/day (%)		Adjusted ^a OR (95% CI)
	Unadjusted OR (95% CI)	Adjusted ^a OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^a OR (95% CI)		
Annual family income/consumption unit (€)						
I ≥18 600	21.9	0.82 (0.60–1.12)	1.03 (0.73–1.45)	18.7	0.91 (0.66–1.26)	1.18 (0.83–1.68)
II 13 600–18 599	26.7	1.18 (0.87–1.59)	1.26 (0.92–1.72)	21.5	1.08 (0.79–1.49)	1.24 (0.89–1.74)
III 9200–13 599	24.8	0.93 (0.68–1.27)	0.95 (0.69–1.31)	20.7	0.89 (0.63–1.24)	0.94 (0.67–1.33)
IV <9200	25.7	1.00	1.00	22.7	1.00	1.00
Mother's education						
I Tertiary/higher	16.1	0.63 (0.35–1.14)	0.79 (0.42–1.49)	13.9	0.44 (0.26–0.77)	0.55 (0.31–0.98)
II Upper secondary	25.6	1.16 (0.70–1.93)	1.20 (0.71–2.03)	21.2	0.58 (0.37–0.92)	0.63 (0.39–1.01)
III Basic (≤9 years)	24.1	1.00	1.00	34.1	1.00	1.00
IV Other or unfinished degree	29.1	1.42 (0.79–2.52)	1.48 (0.82–2.68)	22.6	0.66 (0.38–1.14)	0.76 (0.43–1.34)
Father's education						
I Tertiary/higher	14.1	0.47 (0.28–0.76)	0.56 (0.33–0.95)	10.8	0.33 (0.19–0.57)	0.35 (0.20–0.61)
II Upper secondary	26.3	1.04 (0.74–1.48)	1.08 (0.76–1.55)	20.9	0.73 (0.51–1.04)	0.76 (0.52–1.10)
III Basic (≤9 years)	25.9	1.00	1.00	30.6	1.00	1.00
IV Other or unfinished degree	19.6	0.70 (0.41–1.21)	0.72 (0.41–1.25)	15.0	0.44 (0.25–0.79)	0.43 (0.23–0.78)

^a Adjusted for all variables in the table as well as for change in family type, place of residence, and parents' level of physical activity. OR, odds ratio; 95% CI, 95% confidence interval.

Table 8. Participation^a in different types of physical activity by annual family income at age 15–16 years.

	Prevalence (%) by annual family income/consumption unit (€)										p-test for trend ^c
	Boys (N = 2422) ^b					Girls (N = 2497) ^b					
	I <9200	II 9200– 13 599	III 13 600– 18 599	IV ≥18 600	p-test for trend ^c	I <9200	II 9200– 13 599	III 13 600– 18 599	IV ≥18 600	p-test for trend ^c	
Aerobics	0.2	0.9	0.5	0.7	0.101	7.7	11.4	12.4	15.3	<0.001	
Athletics	13.9	11.0	7.9	8.2	<0.001	10.4	6.5	6.5	4.5	<0.001	
Badminton	8.4	6.6	10.5	11.1	0.002	10.4	11.3	9.3	8.7	0.606	
Bandy	17.0	15.3	13.3	11.6	0.003	2.5	1.9	1.9	1.7	<0.001	
Basketball	11.3	14.3	17.0	16.7	0.020	4.3	5.4	6.3	5.4	0.771	
Cross-country skiing	17.8	17.9	12.4	13.0	0.007	16.6	13.2	9.3	7.9	<0.001	
Cycling	69.3	67.9	68.6	68.4	0.516	76.7	81.3	83.0	81.6	0.072	
Dancing	1.3	1.9	1.3	2.5	0.153	12.1	17.8	17.7	27.2	<0.001	
Downhill skiing or snowboarding	11.2	11.4	14.0	20.0	<0.001	5.4	6.5	9.6	8.9	<0.001	
Figure skating	0.8	0.7	0.5	0.5	0.392	1.4	0.5	0.5	1.4	0.600	
Finnish baseball	16.8	14.2	12.5	12.9	0.023	11.8	9.5	9.6	6.9	0.001	
Floorball	32.4	29.7	31.8	27.1	0.055	9.4	7.8	8.2	5.7	<0.001	
Golf	0.2	1.9	1.1	4.8	<0.001	0.2	0.0	0.2	0.3	0.066	
Gym training	19.7	24.6	21.0	24.3	0.190	8.1	9.1	10.7	11.4	0.001	
Gymnastics	7.1	5.7	4.6	6.7	0.038	16.3	11.9	14.1	12.6	0.017	
Ice hockey	38.4	34.1	30.3	27.2	<0.001	4.9	4.1	2.6	2.6	<0.001	
Judo or karate or wrestling	4.0	3.7	5.1	4.6	0.976	1.1	1.9	1.8	2.8	0.087	

	Prevalence (%) by annual family income/consumption unit (€)									
	Boys (N = 2422) ^b					Girls (N = 2497) ^b				
	I <9200	II 9200– 13 599	III 13 600– 18 599	IV ≥18 600	p-test for trend ^c	I <9200	II 9200– 13 599	III 13 600– 18 599	IV ≥18 600	p-test for trend ^c
Orienteering	1.6	1.6	1.4	1.8	0.100	0.8	1.4	0.7	0.8	0.057
Riding	0.8	0.2	0.0	0.5	0.457	6.8	8.4	8.3	10.0	0.741
Roller skating or skateboarding	19.9	24.5	25.6	28.7	<0.001	24.0	27.7	26.7	27.1	0.042
Running	15.4	20.5	19.6	22.6	0.198	27.0	26.1	24.3	23.2	0.003
Skating	28.1	28.9	26.6	26.0	0.033	13.7	8.1	9.1	8.0	<0.001
Soccer	35.8	31.8	34.3	30.3	0.017	9.7	6.3	6.0	7.9	0.001
Swimming	27.1	18.3	17.5	14.9	<0.001	26.6	25.6	17.8	15.9	<0.001
Tennis	4.9	7.1	6.9	9.2	<0.001	2.6	2.2	2.8	2.5	0.469
Volleyball	10.2	7.0	7.0	4.9	<0.001	7.2	5.6	5.2	4.9	<0.001
Walking	22.5	22.9	19.9	24.8	0.337	59.7	55.8	54.7	55.4	0.064

^a Once a week or more often during the season that is suitable for that certain sport.

^b Numbers of adolescents who answered questions about participation in different sports varied from 2422 to 2440 among boys and from 2497 to 2526 among girls.

^c Linear-by-linear association test.

5.3 Physical activity in relation to adolescents' emotional and behavioural problems (II)

Among both boys (Figure 5) and girls (Figure 6), the mean scores of anxious/depressed, withdrawn/depressed, social and attention problems, and rule-breaking behaviour, and among girls also the mean scores of aggressive behaviour, were significantly higher for the inactive group compared with the active group. This indicates that physically inactive adolescents report more emotional and social problems than physically active adolescents. Among boys also in the moderately active group the mean scores of anxious/depressed, withdrawn/depressed and social problems were significantly higher than in the active group (Figure 5).

When adjusted for family type, family income, parents' education and BMI, physically inactive (OR 2.93, 95% CI 1.50–5.72) and moderately active (OR 3.21, 95% CI 1.61–6.40) boys were more likely to report anxious/depressed symptoms compared with physically active boys (Table 9). Similarly, inactive boys (OR 2.77, 95% CI 1.81–4.24) and girls (OR 2.31, 95% CI 1.48–3.58) were more likely to report withdrawn/depressed problems than physically active adolescents. Among girls, physical inactivity was also associated with somatic complaints (OR 1.40, 95% CI 1.04–1.88).

With regard to behavioural problems, physically inactive girls were more likely to report rule-breaking behaviour (OR 1.82, 95% CI 1.34–2.47) compared with physically active girls (Table 10). Additionally, moderate level physical activity was related to lowest prevalence of aggressive behaviour (OR 0.53, 95% CI 0.34–0.83) among girls. Among boys, lower levels of physical activity were not related to behavioural problems (Table 10).

Among boys, being moderately active (OR 2.43, 95% CI 1.15–5.13) or inactive (OR 3.59, 95% CI 1.84–5.13) was associated with social problems, when compared with being physically active (Table 11). Also among girls, physical inactivity was related to social problems (OR 3.18, 95% CI 1.67–6.05). Both among boys (OR 1.87, 95% CI 1.01–3.44) and girls (OR 2.06, 95% CI 1.34–3.16) being physically inactive was associated with attention problems (Table 8). Additionally physical inactivity was related to thought problems among boys (OR 2.34, 95% CI 1.05–5.21).

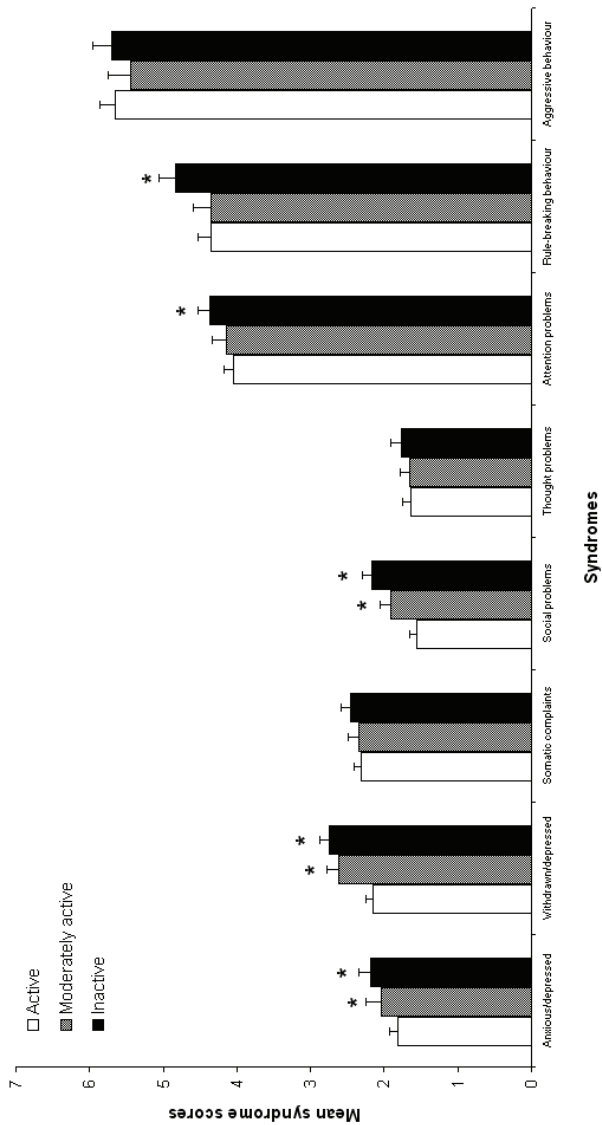


Fig. 5. Mean syndrome scores with 95% confidence intervals among boys (N = 3307) by the level of physical activity at age 15–16 years. ANOVA/LSD post-hoc significance compared with the active group: * $p < 0.05$.

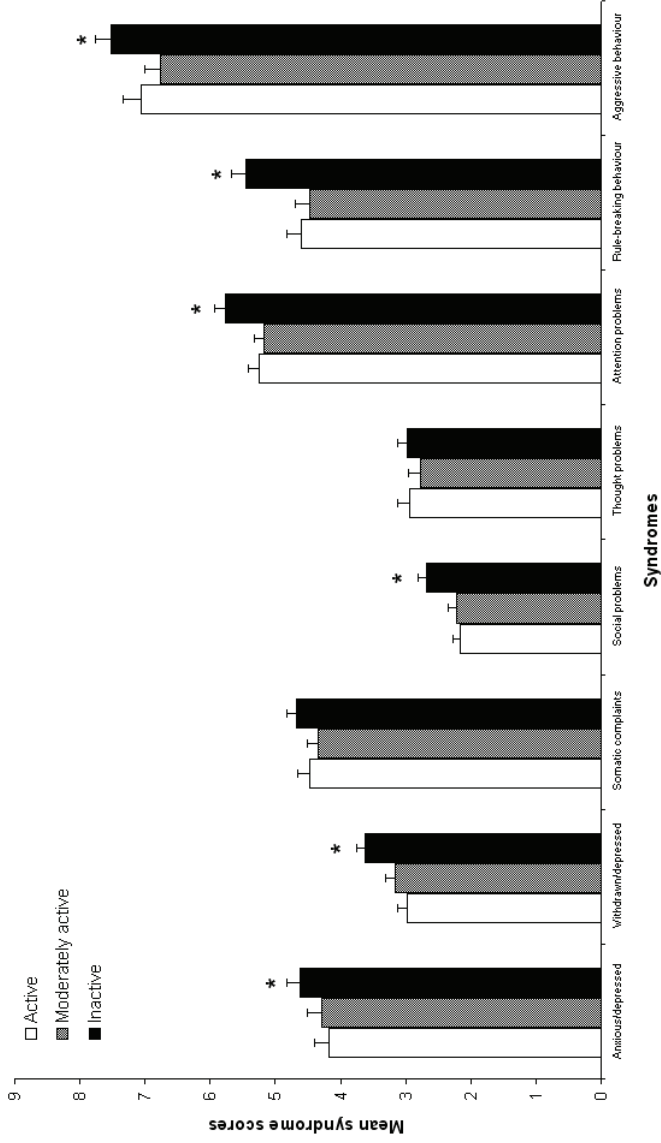


Fig. 6. Mean syndrome scores with 95% confidence intervals among girls (N = 3601) by the level of physical activity at age 15–16 years. ANOVA/LSD post-hoc significance compared with the active group: * $p < 0.05$.

Table 9. Logistic regression of emotional problems^a by the level of physical activity among boys (N = 2078) and girls (N = 2134).

Physical activity level ^b	Emotional problems							
	Anxious/depressed problems ^a		Withdrawn/depressed problems ^a		Somatic complaints ^a		Somatic complaints ^a	
	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)
Boys								
Active	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	3.37 (1.71–6.65)	3.21 (1.61–6.40)	1.92 (1.19–3.10)	1.99 (1.23–3.22)	0.79 (0.45–1.37)	0.74 (0.42–1.30)	0.79 (0.45–1.37)	0.74 (0.42–1.30)
Inactive	3.22 (1.68–6.16)	2.93 (1.50–5.72)	2.72 (1.79–4.12)	2.77 (1.81–4.24)	1.24 (0.80–1.94)	1.13 (0.72–1.79)	1.24 (0.80–1.94)	1.13 (0.72–1.79)
Girls								
Active	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	1.21 (0.71–2.06)	1.26 (0.74–2.14)	1.24 (0.75–2.06)	1.24 (0.74–2.06)	0.85 (0.60–1.20)	0.82 (0.58–1.16)	0.85 (0.60–1.20)	0.82 (0.58–1.16)
Inactive	1.35 (0.83–2.19)	1.42 (0.87–2.31)	2.30 (1.49–3.55)	2.31 (1.48–3.58)	1.46 (1.09–1.95)	1.40 (1.04–1.88)	1.46 (1.09–1.95)	1.40 (1.04–1.88)

^a Includes individuals scored on borderline clinical range and clinical range in the syndrome scales.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

^c Adjusted for family type, income, parents' education, and body mass index. OR, odds ratio; 95% CI, 95% confidence interval.

Table 10. Logistic regression of the behavioural problems^a by the level of physical activity among boys (N = 2078) and girls (N = 2134).

Physical activity level ^b	Behavioural problems					
	Rule-breaking behaviour ^a			Aggressive behaviour ^a		
	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)
Boys						
Active	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	1.30 (0.86–1.94)	1.25 (0.83–1.89)	0.99 (0.65–1.53)	0.97 (0.63–1.50)		
Inactive	1.38 (0.96–2.00)	1.33 (0.92–1.93)	0.99 (0.67–1.47)	0.95 (0.64–1.42)		
Girls						
Active	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	1.05 (0.74–1.50)	0.98 (0.68–1.40)	0.54 (0.34–0.84)	0.53 (0.34–0.83)		
Inactive	2.01 (1.49–2.72)	1.82 (1.34–2.47)	0.99 (0.70–1.42)	0.98 (0.68–1.40)		

^a Includes individuals scored on borderline clinical range and clinical range in the syndrome scales.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

^c Adjusted for family type, income, parents' education, and body mass index. OR, odds ratio; 95% CI, 95% confidence interval.

Table 11. Logistic regression of the other problems^a by the level of physical activity among boys (N = 2078) and girls (N = 2134).

Physical activity level ^b	Other problems											
	Social problems ^a				Thought problems ^a				Attention problems ^a			
	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)
Boys												
Active	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	2.61 (1.24–5.47)	2.43 (1.15–5.13)	0.75 (0.24–2.37)	0.80 (0.25–2.53)	1.58 (0.80–3.11)	1.44 (0.72–2.86)						
Inactive	3.99 (2.08–7.66)	3.59 (1.84–5.13)	2.15 (0.98–4.71)	2.34 (1.05–5.21)	2.15 (1.20–3.87)	1.87 (1.01–3.44)						
Girls												
Active	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Moderately active	1.86 (0.91–3.82)	1.83 (0.89–3.76)	1.32 (0.73–2.40)	1.29 (0.71–2.36)	0.59 (0.33–1.05)	0.60 (0.33–1.07)						
Inactive	3.32 (1.76–6.28)	3.18 (1.67–6.05)	1.28 (0.73–2.25)	1.21 (0.68–2.14)	2.01 (1.32–3.04)	2.06 (1.34–3.16)						

^a Includes individuals scored on borderline clinical range and clinical range in the syndrome scales.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

^c Adjusted for family type, income, parents' education, and body mass index. OR, odds ratio; 95% CI, 95% confidence interval.

5.4 Physical activity, emotional and behavioural problems and socio-economic position in relation to adolescents' self-rated health (III)

Physical inactivity was associated with poor self-rated health among boys (Table 12) and girls (Table 13). When adjusted for emotional and behavioural problems and socio-economic position the analyses showed an independent association between physical activity and self-rated health: moderately active boys (OR 1.91, 95% CI 1.41–2.58) and girls (OR 2.13, 95% CI 1.56–2.91) and physically inactive boys (OR 3.62, 95% CI 2.80–4.69) and girls (OR 3.44, 95% CI 2.59–4.57) were more likely to report poor self-rated health than physically active boys and girls.

In the unadjusted analyses emotional, behavioural and social problems were all related to poor self-rated health among boys (Table 12) and girls (Table 13). In the adjusted analyses emotional problems (OR 2.40, 95% CI 1.77–3.27) and behavioural problems (OR 2.09, 95% CI 1.60–2.74) remained independently related to poor self-rated health among boys. The association between social problems and self-rated health did not remain statistically significant (Table 12). Among girls all the three types of mental health problems, emotional problems (OR 2.08, 95% CI 1.64–2.64), behavioural problems (OR 2.20, 95% CI 1.77–2.73) and social problems (OR 3.23, 95% CI 2.16–4.84) were independently associated with poor self-rated health (Table 13).

Socio-economic position measured as mother's highest level of education was not related to self-rated health among boys (Table 12). Among girls socio-economic position was an independent predictor of poor self-rated health, girls with mother having upper secondary (OR 1.55, 95% CI 1.09–2.19) or basic level (OR 1.71, 95% CI 1.08–2.71) education being more likely to report poor self-rated health compared to girls with higher educated mother (Table 13).

Based on the previous results we wanted to get more detailed information about the association between physical activity and self-rated health in different 'risk groups' for poor self-rated health. In the subsample of adolescents with one or several types of mental health problems, moderately active and inactive adolescents were more likely to report poor self-rated health compared with physically active adolescents (Table 14). Similarly, physically inactive boys with either emotional (OR 1.94, 95% CI 1.10–3.42) or behavioural problems (OR 2.83, 95% CI 1.72–4.67) were more likely to report poor self-rated health than physically active boys with the same problems. The results were similar among

girls (Table 14). Additionally, in the subsample of adolescents with low socio-economic position, physically inactive boys (OR 4.08, 95% CI 1.82–9.16) and girls (OR 3.54, 95% CI 1.27–9.81) were more likely to report poor self-rated health compared with physically active adolescents having similar socio-economic backgrounds.

Table 12. Poor self-rated health by the level of physical activity, emotional and behavioural problems and mother's education among boys (N = 3355).

	Poor self-rated health ^a		
	(%)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
Physical activity level^c			
Active	7.9	1.00	1.00
Moderately active	15.0	2.07 (1.57–2.72)	1.91 (1.41–2.58)
Inactive	23.9	3.66 (2.89–4.64)	3.62 (2.80–4.69)
Emotional problems^d			
Normal range	12.5	1.00	1.00
Problem range	31.6	3.24 (2.54–4.15)	2.40 (1.77–3.27)
Behavioural problems^e			
Normal range	12.3	1.00	1.00
Problem range	26.7	2.59 (2.07–3.24)	2.09 (1.60–2.74)
Social problems			
Normal range	14.1	1.00	1.00
Problem range	29.5	2.54 (1.61–3.99)	1.11 (0.65–1.89)
Mother's education			
I Tertiary/higher	11.3	1.00	1.00
II Upper secondary	14.5	1.33 (0.95–1.86)	1.18 (0.83–1.67)
III Basic (≤9 years)	15.4	1.43 (0.91–2.23)	1.29 (0.81–2.06)
IV Other or unfinished degree	15.2	1.40 (0.91–2.16)	1.20 (0.76–1.89)

^a Includes adolescents, who rated their health as fair, poor or very poor.

^b Adjusted for all variables in the model. OR, odds ratio; 95% CI, 95% confidence interval.

^c Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤1 h of MVPA).

^d Includes anxious/depressed and withdrawn/depressed problems and somatic complaints.

^e Includes rule-breaking and aggressive behaviour.

Table 13. Poor self-rated health by the level of physical activity, emotional and behavioural problems and mother's education among girls (N = 3647).

	Poor self-rated health ^a		
	(%)	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
Physical activity level ^c			
Active	8.8	1.00	1.00
Moderately active	14.8	1.80 (1.37–2.36)	2.13 (1.56–2.91)
Inactive	25.3	3.51 (2.75–4.49)	3.44 (2.59–4.57)
Emotional problems ^d			
Normal range	13.5	1.00	1.00
Problem range	33.3	3.22 (2.66–3.89)	2.08 (1.64–2.64)
Behavioural problems ^e			
Normal range	12.8	1.00	1.00
Problem range	30.5	3.01 (2.51–3.60)	2.20 (1.77–2.73)
Social problems			
Normal range	15.8	1.00	1.00
Problem range	53.9	6.25 (4.49–8.69)	3.23 (2.16–4.84)
Mother's education			
I Tertiary/higher	11.6	1.00	1.00
II Upper secondary	17.3	1.59 (1.15–2.21)	1.55 (1.09–2.19)
III Basic (≤ 9 years)	20.4	1.94 (1.27–2.96)	1.71 (1.08–2.71)
IV Other or unfinished degree	16.8	1.53 (1.01–2.32)	1.56 (1.01–2.43)

^a Includes adolescents, who rated their health as fair, poor or very poor.

^b Adjusted for all variables in the model. OR, odds ratio; 95% CI, 95% confidence interval.

^c Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

^d Includes anxious/depressed and withdrawn/depressed problems and somatic complaints.

^e Includes rule-breaking and aggressive behaviour.

Table 14. Poor self-rated health among boys and girls with mental health problems and low socio-economic position by the level of physical activity^a.

	Poor self-rated health ^b					
	Boys			Girls		
	(%)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	(%)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)
Subsample 1: adolescents with emotional ^d , behavioural ^e and/or social problems (boys N = 755, girls N = 1271)						
Physically active	18.0	1.00	1.00	17.0	1.00	1.00
Physically moderately active	29.5	1.90 (1.22–2.96)	1.63 (1.01–2.64)	26.2	1.73 (1.19–2.51)	1.85 (1.23–2.78)
Physically inactive	36.1	2.57 (1.77–3.74)	2.41 (1.61–3.60)	38.8	3.10 (2.22–4.32)	3.15 (2.19–4.54)
Subsample 2: adolescents with emotional problems ^d (boys N = 363, girls N = 690)						
Physically active	21.7	1.00	1.00	19.3	1.00	1.00
Physically moderately active	41.0	2.50 (1.37–4.59)	2.36 (1.22–4.60)	29.1	1.72 (1.05–2.81)	1.80 (1.04–3.13)
Physically inactive	36.7	2.09 (1.24–3.54)	1.94 (1.10–3.42)	43.0	3.16 (2.04–4.89)	2.86 (1.75–4.68)
Subsample 3: adolescents with behavioural problems ^e (boys N = 518, girls N = 987)						
Physically active	17.8	1.00	1.00	17.2	1.00	1.00
Physically moderately active	24.8	1.52 (0.87–2.65)	1.29 (0.68–2.43)	29.3	1.99 (1.29–3.06)	2.30 (1.41–3.75)
Physically inactive	40.0	3.08 (1.97–4.81)	2.83 (1.72–4.67)	38.2	2.98 (2.03–4.37)	2.91 (1.87–4.51)

	Poor self-rated health ^b					
	Boys			Girls		
	(%)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)	(%)	Unadjusted OR (95% CI)	Adjusted ^c OR (95% CI)
Subsample 4: adolescents with social problems (boys N = 94, girls N = 152)						
Physically active	30.4	1.00	1.00	42.9	1.00	1.00
Physically moderately active	38.5	1.43 (0.44–4.69)	1.40 (0.36–5.43)	48.5	1.26 (0.46–3.46)	1.37 (0.42–4.50)
Physically inactive	24.4	0.74 (0.24–2.26)	0.78 (0.21–2.85)	59.3	1.95 (0.83–4.59)	2.07 (0.74–5.79)
Subsample 5: adolescents from low socio-economic position ^f (boys N = 279, girls N = 272)						
Physically active	9.2	1.00	1.00	7.7	1.00	1.00
Physically moderately active	10.9	1.21 (0.44–3.28)	1.30 (0.47–3.59)	23.4	3.66 (1.28–10.50)	2.93 (0.98–8.72)
Physically inactive	26.0	3.46 (1.60–7.47)	4.08 (1.82–9.16)	25.4	4.08 (1.51–11.03)	3.54 (1.27–9.81)

^a Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥ 4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤ 1 h of MVPA).

^b Includes adolescents, who rated their health as fair, poor or very poor.

^c Subsample 1 adjusted for mother's education; Subsample 2 for mother's education, behavioural and social problems; Subsample 3 for mother's education, emotional and social problems; Subsample 4 for mother's education, emotional and behavioural problems and Subsample 5 for emotional, behavioural and social problems. OR, odds ratio; 95% CI, 95% confidence interval.

^d Includes anxious/depressed and withdrawn/depressed problems and somatic complaints.

^e Includes rule-breaking and aggressive behaviour.

^f Includes adolescents with mothers having only basic education (lasting ≤ 9 years).

5.5 Physical activity, emotional and behavioural problems and socio-economic position in relation to adolescents' educational attainment (IV)

Physical activity was associated with high overall academic performance and plans for higher education among both boys (Table 15) and girls (Table 16). When adjusted for emotional, behavioural and social problems, and mother's education, physical activity was associated with high overall academic performance (OR 2.19, 95% CI 1.77–2.70) and plans for higher education (OR 1.97, 95% CI 1.60–2.42) among boys (Table 15). In the similarly adjusted models, physically active girls were 1.75 (95% CI 1.44–2.14) times more likely to report high overall academic performance and 1.84 (95% CI 1.53–2.22) times more likely to report plans of continuing into higher education when compared with physically inactive girls (Table 16).

In the adjusted models, boys with behavioural problems were 57% (OR 0.43, 95% CI 0.33–0.56) less likely to report high overall academic performance and 46% (OR 0.54, 95% CI 0.42–0.70) less likely to report plans of continuing into higher education compared with boys without these problems (Table 15). Girls with behavioural problems were 36% (OR 0.64, 95% CI 0.52–0.79) less likely to report high overall academic performance and 42% (OR 0.58, 95% CI 0.48–0.71) less likely to report plans for higher education than girls without these problems (Table 16). Emotional and social problems were not associated with overall academic performance or plans for higher education among boys (Table 15) or girls (Table 16).

Among both boys (Table 15) and girls (Table 16), a mother's high level of education was related to high overall academic performance and plans for higher education. Boys with highly educated mothers were 3.51 (95% CI 2.43–5.09) times more likely to report high overall academic performance and 4.86 (95% CI 3.32–7.11) times more likely to report plans for higher education than boys whose mothers only had basic education (Table 15). Also among girls, a mother's high level of education was related to high overall academic performance (OR 3.23, 95% CI 2.23–4.68) and plans of continuing into higher education (OR 4.33, 95% CI 3.03–6.20), when adjusted for physical activity and mental health problems (Table 16).

Table 15. Academic performance by physical activity, emotional and behavioural problems and mother's education among boys.

	High overall academic performance			Higher education plans				
	(%)	Unadjusted OR (95% CI)	Adjusted I ^a OR (95% CI)	Adjusted II ^a OR (95% CI)	(%)	Unadjusted OR (95% CI)	Adjusted I ^a OR (95% CI)	Adjusted II ^a OR (95% CI)
Physical activity level ^b								
Inactive	21.8	1.00	1.00	1.00	23.9	1.00	1.00	1.00
Moderately active	29.9	1.53 (1.23–1.90)	1.67 (1.31–2.12)	1.61 (1.26–2.06)	32.3	1.52 (1.23–1.88)	1.62 (1.28–2.06)	1.57 (1.24–2.00)
Active	36.1	2.02 (1.68–2.44)	2.31 (1.88–2.85)	2.19 (1.77–2.70)	38.0	1.95 (1.63–2.33)	2.09 (1.71–2.55)	1.97 (1.60–2.42)
Emotional problems ^c								
Normal range	30.2	1.00	1.00	1.00	32.0	1.00	1.00	1.00
Problem range	30.4	1.01 (0.80–1.28)	1.22 (0.90–1.65)	1.16 (0.86–1.58)	33.6	1.07 (0.85–1.36)	1.37 (1.02–1.83)	1.30 (0.97–1.75)
Behavioural problems ^d								
Normal range	32.6	1.00	1.00	1.00	34.2	1.00	1.00	1.00
Problem range	17.7	0.44 (0.35–0.56)	0.44 (0.33–0.57)	0.43 (0.33–0.56)	22.0	0.54 (0.44–0.68)	0.54 (0.41–0.69)	0.54 (0.42–0.70)
Social problems								
Normal range	30.2	1.00	1.00	1.00	32.3	1.00	1.00	1.00
Problem range	31.5	1.06 (0.68–1.67)	1.33 (0.75–2.33)	1.36 (0.77–2.41)	29.7	0.88 (0.56–1.40)	1.10 (0.64–1.89)	1.10 (0.63–1.90)
Mother's education								
III Basic (59 years)	22.9	1.00	1.00	1.00	21.6	1.00	1.00	1.00
II Upper secondary	28.4	1.34 (1.00–1.80)	1.34 (0.97–1.85)	1.34 (0.97–1.85)	29.6	1.53 (1.13–2.07)	1.68 (1.21–2.35)	1.68 (1.21–2.35)
I Tertiary/higher	53.1	3.82 (2.71–5.38)	3.51 (2.43–5.09)	3.51 (2.43–5.09)	56.6	4.75 (3.35–6.72)	4.86 (3.32–7.11)	4.86 (3.32–7.11)
IV Other or unfinished degree	29.0	1.38 (0.96–1.99)	1.41 (0.95–2.11)	1.41 (0.95–2.11)	34.9	1.95 (1.35–2.81)	2.23 (1.49–3.32)	2.23 (1.49–3.32)

^a Adjusted for family type and all variables in the model. OR, odds ratio; 95% CI, 95% confidence interval.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤1 h of MVPA).

^c Includes anxious/depressed and withdrawn/depressed problems and somatic complaints.

^d Includes rule-breaking and aggressive behaviour.

Table 16. Academic performance by physical activity, emotional and behavioural problems and mother's education among girls.

	High overall academic performance				Higher education plans			
	(%)	Unadjusted OR (95% CI)	Adjusted I ^a OR (95% CI)	Adjusted II ^a OR (95% CI)	(%)	Unadjusted OR (95% CI)	Adjusted I ^a OR (95% CI)	Adjusted II ^a OR (95% CI)
Physical activity level ^b								
Inactive	22.9	1.00	1.00	1.00	35.7	1.00	1.00	1.00
Moderately active	30.0	1.45 (1.21–1.73)	1.38 (1.13–1.69)	1.40 (1.14–2.14)	44.9	1.47 (1.25–1.73)	1.36 (1.13–1.63)	1.37 (1.13–1.66)
Active	36.5	1.94 (1.63–2.32)	1.80 (1.48–2.20)	1.75 (1.44–2.14)	51.7	1.93 (1.64–2.27)	1.90 (1.58–2.29)	1.84 (1.53–2.22)
Emotional problems ^c								
Normal range	29.8	1.00	1.00	1.00	44.3	1.00	1.00	1.00
Problem range	25.5	0.81 (0.67–0.98)	0.91 (0.72–1.15)	0.88 (0.69–1.11)	38.0	0.77 (0.65–0.92)	0.97 (0.79–1.21)	0.95 (0.76–1.18)
Behavioural problems ^d								
Normal range	31.6	1.00	1.00	1.00	46.6	1.00	1.00	1.00
Problem range	21.5	0.60 (0.50–0.71)	0.64 (0.52–0.79)	0.64 (0.52–0.79)	32.6	0.55 (0.47–0.65)	0.59 (0.49–0.71)	0.58 (0.48–0.71)
Social problems								
Normal range	29.0	1.00	1.00	1.00	43.4	1.00	1.00	1.00
Problem range	28.5	0.98 (0.68–1.40)	1.48 (0.96–2.28)	1.53 (0.99–2.38)	33.6	0.66 (0.46–0.94)	0.99 (0.65–1.50)	1.03 (0.67–1.58)
Mother's education								
III Basic (59 years)	22.5	1.00	1.00	1.00	29.2	1.00	1.00	1.00
II Upper secondary	29.0	1.41 (1.05–1.89)	1.41 (1.02–1.94)	1.41 (1.02–1.94)	42.7	1.80 (1.37–2.37)	1.84 (1.36–2.48)	1.84 (1.36–2.48)
I Tertiary/higher	48.6	3.25 (2.31–4.59)	3.23 (2.23–4.68)	3.23 (2.23–4.68)	64.8	4.45 (3.19–6.20)	4.33 (3.03–6.20)	4.33 (3.03–6.20)
IV Other or unfinished degree	26.5	1.24 (0.86–1.79)	1.26 (0.84–1.87)	1.26 (0.84–1.87)	42.8	1.81 (1.30–2.53)	1.89 (1.31–2.72)	1.89 (1.31–2.72)

^a Adjusted for family type and all variables in the model. OR, odds ratio; 95% CI, 95% confidence interval.

^b Physical activity level was defined according to weekly participation in moderate-to-vigorous intensity physical activity (MVPA): 1) active (≥4 h of MVPA), 2) moderately active (2–3 h of MVPA) and 3) inactive (≤1 h of MVPA).

^c Includes anxious/depressed and withdrawn/depressed problems and somatic complaints.

^d Includes rule-breaking and aggressive behaviour.

6 Discussion

6.1 Main Findings

In the present study, high parental education was associated with being physically active and with spending least time watching TV among adolescents. High family income was associated with being an active sports club member. In contrast, physical inactivity in adolescence was related to emotional, social, thought and attention problems, and rule-breaking behaviour. Physical inactivity, emotional, behavioural and social problems, and low parental socio-economic position were related to poor self-rated health. In addition, a higher level of physical activity, fewer behavioural problems and higher parental socio-economic position were independently associated with high academic performance and future plans for higher education among adolescents.

6.2 Discussion of results

6.2.1 Socio-economic position and physical activity among adolescents (I)

The results of the present study showed that a high level of parental education was related to being physically active among adolescents. These results confirm earlier findings from studies conducted in other countries of parental education being positively associated with the level of adolescents' physical activity (Chen *et al.* 2007, Lasheras *et al.* 2001, La Torre *et al.* 2006, Piko & Keresztes 2008, Singh *et al.* 2008), although Saxena *et al.* (2002) have also reported that a mother's level of education is not related to the level of physical activity among girls. However, some of the above mentioned studies have measured parental education on household level (Chen *et al.* 2007, Lasheras *et al.* 2001, Singh *et al.* 2008), and most of them have not focused on adolescents specifically, but have also included children or young adults in their study groups (Lasheras *et al.* 2001, La Torre *et al.* 2006, Piko & Keresztes 2008, Saxena *et al.* 2002, Singh *et al.* 2008).

Parents' level of education was inversely associated with the time spent watching TV. This finding is consistent with previous research reporting that parental education (Gordon-Larsen *et al.* 2000, Gorely *et al.* 2004, Schmitz *et al.*

2002) and parental occupational status (Schmitz *et al.* 2002, Vereecken *et al.* 2004) are inversely related to TV viewing among adolescents. Although Gordon-Larsen *et al.* (2000) used a measure combining TV viewing and computer/video game playing, and Schmitz *et al.* (2002) reported significant differences in the associations according to sex. However, Lindquist *et al.* (1999) have reported results indicating no association between parental socio-economic position and adolescents' TV watching, although they used the Hollingshead index of social class, a measure of socio-economic position, which combines parental educational attainment and occupational prestige.

According to previous studies, parental income is positively related to physical activity (Gordon-Larsen *et al.* 2000, Lasheras *et al.* 2001, Wagner *et al.* 2004) and physical activity guideline compliance (Butcher *et al.* 2008), and inversely related to sedentary lifestyle (Lowry *et al.* 1996) among adolescents. In the analyses of the present study, however, the association between family income and adolescents' physical activity disappeared once adjusted for parents' education, indicating that perhaps parental education is a more powerful factor affecting adolescents' physical activity than family income as such.

High family income was associated with sports club membership among both boys and girls being a stronger determinant of sports club activity than parental education. Parental education remained significantly related to sports club membership only with respect to father's level of education once adjustments were made for mother's education, family income, family type, place of residence and parents' level of physical activity. This finding is in line with that of Wagner *et al.* (2004), who concluded that family income is positively associated with participation in structured physical activity outside school hours. Similarly, Sallis *et al.* (1996) reported that high socio-economic status and frequent participation in organised sports after school hours are correlated, although they determined socio-economic status according to school district, rather than asking parents or adolescents themselves.

Regarding different types of physical activity, the likelihood of participating in downhill skiing, roller skating, badminton, and tennis among boys, and aerobics, gymnastics, and dancing among girls increased somewhat consistently with the increase of family income, while the trend was the opposite for most other sports. The few studies published on the association between parental socio-economic position and participation in different types of physical activities among adolescents have yielded inconsistent results (Sallis *et al.* 1996, Tammelin *et al.* 2003). This could be partly explained by the small number of studies and

lack of large study populations with information on these factors, which make it possible to compare different types of physical activities in association with socio-economic position. Our results, however, are more or less in line with a previous study from Finland stating that downhill skiing and dancing, for example, are typical of adolescents who come from high social positions, whereas strength sports (weight lifting, body building, strength training) are more characteristic of the adolescents from lower social positions (Tammelin *et al.* 2003). Sallis *et al.* (1996), in contrast, contended that socio-economic status was not a major factor in the selection of after-school activities by adolescents.

The present finding of an association between a family's socio-economic position and participation in certain types of physical activity is partly contrary to our hypothesis of types of physical activity requiring expensive equipment or participation fees being more typical of high-income families. Our finding could, however, be interpreted in terms of the theory of diffusion of innovations (Ferrencia 1996), which postulates that new lifestyles spread through populations in waves, first being adopted by higher social classes and subsequently by others. The higher prevalence of most types of sports in the lower income groups and other sports in the higher income groups may merely indicate differences in timing of behaviours.

The cross-sectional study design does not allow us to draw strong conclusions about direct causality between parental socio-economic position and physical activity in youth. There may also be some other factors (e.g. physical environment factors) not measured here, which could confound the association between parental socio-economic position and physical activity in the adolescents. In interpreting the results of the present study and extrapolating them to other populations, it is important to recognise that income inequality is relatively small in Finland, the Gini Coefficient being 0.27 and ranked 7th lowest in OECD countries in the mid-2000s (OECD 2009). The median income according to disposable income per consumption unit in 2001, at the time of the data collection, was EUR 18 629 (in 2007 currency), the poverty line being EUR 10 889 in 2000 (Statistics Finland 2009). It is possible that the differences in physical activity by income are even larger in countries with high income inequality. It is also worth noting that the Finnish government already supports child and youth sports financially through sports organizations and national federations, and physical activity in sports clubs differs substantially from physical education in schools. The question of social equality in adolescents' physical activity is critical in terms of the Sports Act in Finland (Finlex 2009), which aims at promoting the

population's welfare and health, supporting the growth and development of children and young people, and promoting equality and tolerance through sports.

6.2.2 Physical activity and emotional and behavioural problems among adolescents (II)

In the present study, physical inactivity was associated with an increased likelihood of having several emotional and behavioural problems among adolescents: anxious/depressed symptoms among boys, withdrawn/depressed symptoms among boys and girls, somatic complaints among girls, rule-breaking behaviour among girls, social and attention problems among boys and girls, and thought problems among boys.

These results are consistent with earlier findings suggesting that physical activity is inversely associated with emotional problems in general (Sagatun *et al.* 2007, Wiles *et al.* 2008), depression (Abu-Omar *et al.* 2004, Kirkcaldy *et al.* 2002, Motl *et al.* 2004, Tao *et al.* 2007), anxiety (Kirkcaldy *et al.* 2002), somatic complaints (Steptoe & Butler 1996), and social problems (Kirkcaldy *et al.* 2002, Sagatun *et al.* 2007) among adolescents. There is also some evidence for a dose-response relationship between physical activity and depression in some nations (Abu-Omar *et al.* 2004). Tao *et al.* (2007), however, reported that low-to-moderate intensity physical activity was a protective factor in depression and psychotic symptoms, while high-intensity physical activity was a risk factor of general psychological disorders among Chinese adolescents.

Although theoretical and applied considerations have emphasised the need for searching the mechanism(s) that explain changes in mental health through physical activity, to date, no single mechanism has been found to consistently explain these changes (Faulkner & Carless 2006). Research in adults has suggested both psychological and physiological mechanisms to explain the beneficial effects of exercise on mental health (Dunn *et al.* 2001, Goodwin 2003, Paluska & Schwenk 2000, Richardson *et al.* 2005). The psychological mechanisms include theories like the distraction hypothesis, the self-efficacy theory, the mastery hypothesis, and the social interaction hypothesis. The distraction hypothesis suggests that diversion from unpleasant stimuli leads to improved mood during and after exercise (Morgan 1985). The self-efficacy theory proposes that confidence in ability to exercise is related to actual ability to exercise which, by offering a challenging task in a regular manner, may improve mood and enhance ability to handle events that challenge mental health, when

successfully adopted (North *et al.* 1990). According to the mastery hypothesis, a feeling of control and success following a challenging pursuit such as exercise can utilise individual resources to improve mental health (Greist *et al.* 1979). The social interaction hypothesis, in turn, suggests that social relationships and mutual support, which are commonly inherent in physical activities, enhance psychological states and mental health (Ransford 1982).

The results of the present study suggest that similar associations and background mechanisms might exist in adolescents. Participation in physical activities provides opportunities for adult supervision, exposure to role models, and social interaction, which may protect adolescents from social isolation and emotional problems (Desha *et al.* 2007). The inverse relation between physical activity and rule-breaking behaviour could, to some extent be explained by the emotional and educational influence of physical activities; playing sports both in organised and informal settings can be an excellent way of discharging feelings and it also teaches cooperation and rule compliance. Improvement in teamwork, tolerance, and self-directedness through many types of physical activities might explain why active adolescents have fewer social problems than their inactive counterparts. Reduced attention problems in physically active adolescents compared with inactive adolescents might be due to better concentration and perception, abilities that are exercised through various types of physical activity. However, in this cross-sectional study setting, it is not productive to refer to any specific mechanism described above. It might be that an integrative psychobiological model that combines components of each hypothesis offers the most likely explanation for the beneficial associations between physical activity and mental health. More well-designed studies are needed to achieve a clear consensus regarding the previously proposed mechanisms (Paluska & Schwenk 2000).

The present study is the first one to give an extensive picture of the association between physical activity and mental health problems among Finnish adolescents. However, the cross-sectional setting in the present study does not allow us to draw strong conclusions about causality. It might be that some of the adolescents who reported less physical activity did so because of mental health problems. For example, adolescents with anxious/depressed or withdrawn/depressed problems may be less likely to engage in physically strenuous activities because of low energy or apathy (Richardson *et al.* 2005). On the other hand, adolescents with higher levels of problem behaviour may not receive as much support and encouragement for their participation, for example,

in team games as well-behaved adolescents, and may therefore be more inclined to drop out or choose not to be involved in the first place.

Around 20% of the world's children and adolescents are estimated to have mental health problems, about half of which begin before the age of 14 years (Kessler *et al.* 2005a, Vollebergh *et al.* 2006, WHO 2001). There are several problems in mental health care, including lack of resources, difficulties in guaranteeing continuity of services, and stigma about mental disorders, which prevent people from seeking mental health care (Liimatainen 2000, Mojtabai *et al.* 2002). Because of the widespread presence of mental health problems, the problems with seeking and receiving mental health care, and concerns about the clinical effectiveness and side effects of psychological, psychosocial, and biological treatments, low-risk and low-cost interventions are needed alongside prevailing therapeutic practices and medical treatment among adolescents. A few studies have so far evaluated exercise in the prevention and treatment of anxiety and depression among children and young people, but the effect of exercise is unknown because the evidence base is scarce (Larun *et al.* 2006). It is notable that major biological and psychosocial changes in adolescence make it challenging to measure and define mental health problems in this age group (U.S. Department of Health and Human Services 1999), setting additional challenges for studies of this kind. However, age appropriate and enjoyable physical activity may play an important role as a relatively simple, low-risk, and cost-effective therapy for adolescents' mental health problems.

6.2.3 Physical activity, emotional and behavioural problems and socio-economic position in relation to self-rated health among adolescents (III)

In the present study, physical inactivity and emotional and behavioural problems were, independently of each other, associated with poor self-rated overall health among boys and girls. Additionally, social problems and low socio-economic position were associated with poor self-rated health among girls.

Our finding, that physically inactive adolescents report poor self-rated health more often than physically active adolescents, is in line with previous studies (Breiblik *et al.* 2008, Heard *et al.* 2008, Mikolajczyk *et al.* 2008, Piko & Keresztes 2007, Tremblay *et al.* 2003). Recently, Breiblik *et al.* (2009) reported that self-rated health worsened with a decrease in sports and exercise over a 4-year observation period among adolescents. According to this longitudinal study,

self-rated health is a relatively stable construct during adolescence, which deteriorates consistently with various health-compromising lifestyle factors, including physical inactivity. Page and Suwanteerangkul (2009), in turn, concluded that Thai adolescents rating themselves as 'very healthy' were more likely to engage in vigorous physical activity, muscle strengthening activity, and play on sports teams as well as score higher on the physical activity index compared with adolescents who rated themselves as 'healthy' or 'not healthy'. Previous studies have reported both direct and indirect (e.g. through smoking, alcohol consumption and mental health problems) effects of sport and physical activity on perceived health (Pastor *et al.* 2003, Thorlindsson *et al.* 1990). Adolescents, who engage more frequently in sports, tend to experience fewer feelings of anxiety and depression, describe fewer psycho physiological symptoms and indicate higher perceived fitness (Pastor *et al.* 2003, Thorlindsson *et al.* 1990). These results are consistent with studies that have analysed the benefits of physical activity on healthy life styles and on psychological well-being (Pastor *et al.* 2003). Pastor *et al.* (2003) even suggested that perceived fitness was a more important mediator for perceived health than psychological state. However, the direct effect of sport on perceived health seems to be greater than the indirect effect.

Emotional and behavioural problems were related to increased likelihood of reporting poor self-rated health among both boys and girls. Among girls, social problems were also associated with poor self-rated health. Our results support the previous findings that emotional problems, especially depression and psychosomatic symptoms are related to poor self-rated health among adolescents (Piko 2007, Piko & Keresztes 2007, Tremblay *et al.* 2003). In addition, high levels of anger and bullying behaviour, which can be seen as types or symptoms of behavioural problems, have been found to associate with increased reporting of various psychosomatic symptoms and poor self-rated health among younger age groups (Fekkes *et al.* 2004, Kumpulainen *et al.* 1998, Piko & Keresztes 2007). The sex difference in the association between social problems and self-rated health could be related to higher levels of emotional distress, and greater preoccupation with other health matters, appearance, bodyweight, and social relationships among girls compared with boys (Tremblay *et al.* 2003). Despite the previous studies, little is known about emotional, behavioural and social problems in association with physical activity, when considering these problems from a wider perspective, including various syndromes, as in the present study. Studies with large, unselected population samples are especially rare. Although some

studies have reported associations of anger and bullying behaviour with self-rated health, to our knowledge the present study is the first one to assess more comprehensive measures of these problems, including syndromes of rule-breaking and aggressive behaviour, in association with self-rated health.

The present results are not strictly consistent with our hypothesis to the extent that socio-economic position was associated with self-rated health only among girls. Previous studies have reported associations between socio-economic position and self-rated health among both boys and girls, especially for older adolescents (Currie *et al.* 2008, Starfield *et al.* 2002, Tremblay *et al.* 2003). Three main pathways have been proposed between socio-economic position and health, which could also be interpreted in terms of adolescents' self-rated overall health: 1) cultural explanation, 2) material explanation and 3) psychosocial explanation (Bartley 2004). According to the first explanation, differences in beliefs, norms and values explain the differences in health behaviours and, consequently in health, between social groups. Among adolescents, there is some evidence of the Family Affluence Scale (FAS) being strongly associated with health outcomes that are related to family culture and behaviour (Currie *et al.* 2008). The material explanation, in turn, suggests that absolute individual income levels determine individual choices and lifestyles, and relative income between countries determine provision of schools, health care etc., which are all related to health. According to this explanation, it has been suggested that factors that do not change with age (e.g. health care quality) may best explain overall health status among young people (Chen *et al.* 2006). Finally, the psychosocial explanation emphasizes the differences in stressors, social support and status-related factors, which might explain the differences in health between social groups. It is possible that differences in these mechanisms/pathways partly explain the sex differences between socio-economic position and self-rated health in the present study.

Our results indicate, to some extent, the existence of a social class gradient between parental socio-economic status and self-rated health among girls. This is in line with Starfield *et al.* (2002), who concluded that in all aspects of self-rated health, there was a clear gradient in that adolescents with higher social class were healthier. However, in general, previous studies have reported inconsistent results according to the gradient between social class and self-reported health among adolescents (Starfield 2008, Starfield *et al.* 2002, West 1997). This might be due to traditional measures of socio-economic position, such as occupation, education and income, which may reflect adolescents' identity of their social position, but may not be entirely concordant with it (Goodman *et al.* 2007). Furthermore, the

few studies of older adolescents' achieved social position have indicated that the association is stronger between their own social position and health than their parents' social position and adolescents' health (Glendinning *et al.* 1992, Karvonen *et al.* 1999). All this underscores the need for clarification of concepts, measurement and choice of health outcomes, and social context, when examining their associations (Starfield 2008, Starfield *et al.* 2002).

The present study adds a new, relatively novel perspective to testing the role of physical activity on adolescents' self-rated health. Since the crude analyses showed that emotional and behavioural problems and low parental socio-economic position were associated with poor self-rated health among adolescents, we wanted to get more detailed information about the association between physical activity and self-rated health in these 'risk groups' for poor self-rated health. According to these results, the negative association between physical activity and self-rated health did not occur only when tested among the whole population sample, but also in smaller subsamples restricted to adolescents with (one or several types of) mental health problems and low socio-economic position. Even among adolescents with emotional and behavioural problems and among adolescents from lower socio-economic positions, those who were physically inactive were more likely to rate their current health as poor compared to those who were physically active. These results strengthen the role of physical activity on adolescents' self-rated health and encourage the development of longitudinal cohort studies and randomized controlled trials to test the causality of these associations.

6.2.4 Physical activity, emotional and behavioural problems and socio-economic position in relation to educational attainment among adolescents (IV)

In this study, physical activity, behavioural problems, and parental socio-economic position were associated with educational performance of adolescents. The results provide support for the hypothesis that a higher level of physical activity, fewer behavioural problems, and a mother's higher level of education are associated with high overall academic performance and plans for higher education among adolescents.

Our results are in line with previous studies reporting that physical activity (Fisher *et al.* 1996, Pate *et al.* 1996, Sigfusdottir *et al.* 2007) and a higher level of exercise (Field *et al.* 2001) are related to higher scores of grade point average

among adolescents. Similarly, Nelson and Gordon-Larsen (2006) have reported that adolescents partaking in five or more weekly bouts of MVPA were more likely to achieve A grades in mathematics and science than adolescents achieving less than five bouts of MVPA per week. However, the present results are somewhat inconsistent with those of Coe *et al.* (2006), who reported that only a vigorous level of physical activity was positively associated with overall grade score. According to them, moderate level physical activity had no association. An interesting conclusion was also drawn by Huang *et al.* (2006), suggesting that for physical activity to have an effect on academic or cognitive outcomes, it must first impact on one's fitness levels.

Despite the growing evidence of physical activity being related to academic performance in youth, it is still not clear what mechanisms lie behind this association. It may be that physical activity induces arousal and reduces boredom, which can lead to increased attention span and concentration (Coe *et al.* 2006, Shephard 1997). On the other hand, increase in self-esteem provides a potential explanation for the improved academic performance observed after a significant increase in physical activity (Coe *et al.* 2006, Shephard 1997, Tremblay *et al.* 2000). In addition, physiological mechanisms, such as an increase in neurotransmitters (Field *et al.* 2001), cerebral blood flow and changes in hormone levels (Shephard 1997), have been proposed as an explanation. The inconsistencies in previous studies and the uncertainty about the background mechanisms call for a further investigation of the association between adolescents' physical activity and academic performance.

Our finding that only behavioural problems are related to adverse academic outcomes is consistent with previous studies. The effect of mental health problems on educational attainment varies according to mental illness: several studies indicate that emotional problems have no effect on educational attainment, while behavioural problems have a fairly strong negative influence (Breslau *et al.* 2008, McLeod & Kaiser 2004, Miech *et al.* 1999). In their study, Breslau *et al.* (2008) found that behavioural disorders, more than emotional disorders, were consistently associated with termination of schooling across four educational milestones: primary school graduation, high school graduation, college entry and college graduation. Other studies examining behavioural disorders in association with school termination and low academic achievement have reported associations with conduct disorder (Miech *et al.* 1999), attention deficit hyperactivity disorder (Barkley *et al.* 1990, Miech *et al.* 1999) and overall behavioural problems (McLeod & Kaiser 2004). However, a recent study

concluded that when attention, internalizing and externalizing problems were examined simultaneously, only attention problems predicted performance in mathematics and reading (Breslau *et al.* 2009).

Although some previous studies have shown evidence suggesting that depression in adolescence is associated with a range of later adverse educational outcomes, Fergusson and Woodward (2002) propose that these outcomes are not a consequence of early depression, but rather a result of common social, familial, and personal factors related to both adolescent depression and later outcomes. Similarly, Johnson *et al.* (1999) have proposed that if emotional problems are associated with poor educational attainment, this may be due to the effects of parental psychopathology, parents' socio-economic position, or other factors. It is also possible that factors like parental pressure to perform well at school explain both adolescent emotional problems and poor educational attainment (Philip 1988). These and some earlier results emphasize the importance of placing young people's emotional and behavioural problems within the context of their life history, and social and personal circumstances (Fergusson & Woodward 2002, Johnson *et al.* 1999).

Our finding that socio-economic position is positively related to academic performance and educational plans among adolescents is also consistent with previous literature. Adolescents from families of low socio-economic position are more likely to have lower levels of literacy, numeracy and comprehension, lower higher education participation rates and less successful school to labour market transitions (Considine *et al.* 2002, OECD 2001). A high level of parental education can contribute to a highly supportive learning environment at home, more encouragement, foster a higher level of achievement, and provide higher levels of psychological support, day-to-day interaction and social and cultural communication between parents and adolescents, which are likely to enhance educational performance among children and adolescents (Considine & Zappala 2002, OECD 2001).

The finding of the positive association between parental socio-economic position and adolescents' future educational plans supports earlier findings suggesting that parental occupational status is strongly associated with adolescents' educational attainment (OECD 2001). Having parents in more prestigious jobs can influence students' own job expectations (e.g. as a result of role modelling), and raise their commitment to learning as the means of satisfying high occupational aspirations. High parental occupational status can also widen the range of options for further education of which children and youth are aware

(OECD 2001). These same explanations may apply to the relation between parental education and adolescents' future educational interests and plans. Although the role of adolescent's socio-economic position on academic performance and future educational attainment is important, it is only a part of the considerable issue of socio-economic inequalities in education. For example, the combined influence of the school's socio-economic intake and student background factors can have a significant effect on students' performance (OECD 2001). It is likely that students from adverse socio-economic backgrounds attend schools with features associated with lower performance, although in Finland the differences between schools in this respect are relatively small (OECD 2004).

The present results of the interrelations between parental social position and adolescents' physical activity, emotional and behavioural problems and educational performance indicate that various subjective pathways may exist between parental social position and adolescent educational attainment. Since educational attainment represents an important and potentially modifiable component of stratification hierarchies (McLeod & Kaiser 2004), understanding what can influence differences in educational performance can help practitioners and policy makers address quality and equity concerns. Schools and teachers need to consider their expectations of students from different backgrounds and adopt strategies to raise the level of self-confidence, motivation and learning skills on an individual level. This might require higher teacher to pupil ratios and the involvement of the family and the society more widely, including the media and the main actors in youth culture. On the other hand, the present results emphasize the role of life course perspective in health education and prevention. Increased physical activity could lead to improvements in adolescents' mental health, and moreover to improvements in educational performance, either directly or through improved mental health. A key to understanding these relations in future will be the examination of how these variables change with respect to each other over time or as the result of an intervention.

6.2.5 Physical activity reducing social inequalities in health and education

The results of the present study indicate interrelationships between parental socio-economic position and adolescents' physical activity, emotional and behavioural problems, self-rated health and educational attainment. Parental education, as a proximal measure of parental socio-economic position, is a strong determinant of

adolescents' physical activity, self-rated health and educational attainment. On the other hand, a higher level of physical activity in adolescence is related to higher academic attainment. In addition, both physical activity and educational attainment are associated with emotional and behavioural problems, and self-rated health among adolescents.

Models of life course epidemiology suggest that sources of risk for physical and mental health occur across the life course, sometimes reaching back to previous generations (Kuh & Ben-Shlomo 2004). Together, parental social position and adolescents' physical activity, emotional and behavioural problems, self-rated health and educational attainment may be critical and often interrelated factors affecting each other in adolescence as well as during later life phases. Figure 7 presents a hypothesized schematic representation for the interrelationships between these factors that are partly supported by the present study. These interrelationships may form subjective pathways from socio-economic position to health and education through physical activity, resulting in various health and educational outcomes. For example, according to the concept of 'accumulation of risk' (Kuh *et al.* 2003), adolescents from low socio-economic position may be more likely to be physically inactive, have emotional and behavioural problems, and low levels of academic performance, all of which increase the risk of having poor self-rated health. On the other hand, in the light of 'chains of risk' (Kuh *et al.* 2003), low parental socio-economic position may lead to physical inactivity, which in turn increases the risk of having emotional and behavioural problems, leading to academic failure and/or poor self-rated health.

These life course models are not mutually exclusive, may operate simultaneously and can be difficult to distinguish empirically (Kuh & Ben-Shlomo 2004). However, from a preventive point of view they offer a more extensive approach on adolescents' health and health behaviours than conventional adult lifestyle models, which are unable to fully explain temporal and social variations in health and health behaviours among young people (Kuh & Ben-Shlomo 2004). Chains of events may also help to identify appropriate timing and successful approaches for interventions to stop the accumulation of risk and to establish a new life course trajectory (Ben-Shlomo & Kuh 2002). For example, based on Figure 7, it could be hypothesized that equal opportunities to participate in age appropriate and enjoyable physical activity may increase physical activity levels, leading to improvements in adolescents' educational attainment and health status.

The methods used in the present study do not allow us to draw strong conclusions about actual pathways from parental social position to adolescents' physical activity, health and education. However, these results and the hypothesized model describing the interrelationships between these factors (Figure 7) highlight the potential role of physical activity as a modifiable factor influencing social inequalities in adolescents' health and education, and thus may serve as a valuable basis for future research. A key to understanding these relations in future will be the examination of how these variables change with respect to each other over time or as the result of an intervention, for example, by using causal modelling techniques like structural equation modelling.

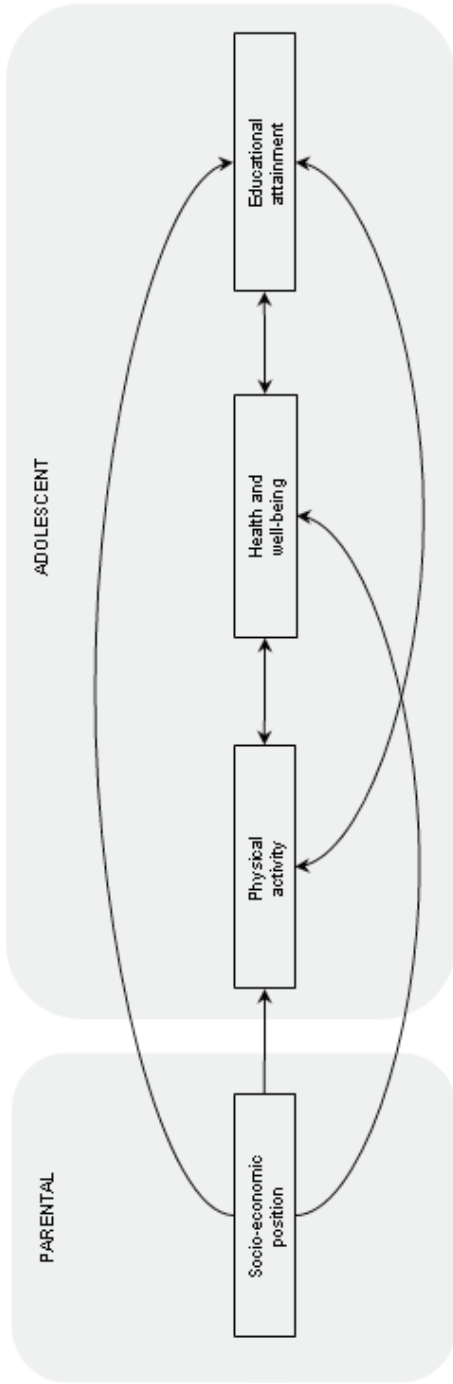


Fig. 7. Hypothesized model describing interrelationships between parental socio-economic position, and adolescents' physical activity, health and educational attainment.

6.3 Methodological considerations

The major strength of the present study is the large, unselected population sample, which provided a good opportunity to study the role of physical activity in adolescents' emotional and behavioural problems, self-rated health and educational attainment. Data on family and social circumstances and the possibility to control for potential confounding factors are particular values of large population samples such as the Northern Finland Birth Cohort 1986. The participation rate was high, at 80% in adolescents and 76% in their parents. The present study is one of the first to evaluate mental health problems in a broad sense including both emotional and behavioural syndromes among a large number of adolescents in Northern Finland. Furthermore, no study to date has viewed the role of physical activity on adolescents' emotional and behavioural problems, self-rated health and educational attainment in the light of life-course approach and social conditions.

The present study relied on self-reporting of physical activity, mental health problems, self-rated health and educational attainment, which might result in measurement errors and social desirability bias. Such an obviously non-differential bias is, however, unlikely to affect the associations between these factors. However, social desirability bias may partly explain our finding of girls reporting significantly more mental health problems than boys, although gender and sex differences are most likely due to different interactions between biological and environmental risk factors (e.g. genetics, hormones and life stress) in the sexes (Vigod & Stewart 2009). To overcome the problem of social desirability bias in reporting mental health problems, additional information from multiple informants, such as parents and teachers, would be needed. The YSR questionnaire is still undergoing validation, although it is frequently used both in clinical and research work in Finland, which is why the cut-off points proposed by Achenbach were used in this study. The reliabilities of the YSR scales ranged between 0.69 and 0.83, with aggressive behaviour highest and social problems lowest when measured with Cronbach's alpha coefficient (Cronbach 1951), which is used to test the internal consistency of the scale. The YSR questionnaire on the whole may be quite long (105 items) to read and complete for adolescents with problems in concentration.

The test-retest reliability of the question measuring MVPA outside school hours has been reported to be very good, with an intraclass correlation coefficient of 0.83 among Finnish adolescents aged 15–16 years (Tammelin *et al.* 2007). The

convergent validity of this question has been tested against physical fitness among Australian adolescents, showing that adolescents classified as active (1 hour a week or more of MVPA) had significantly higher aerobic fitness than adolescents classified as inadequately active (half an hour a week or less of MVPA) (Booth *et al.* 2001). However, self-reporting of physical activity may lead to overestimating the time or intensity of physical activity (Sallis & Saelens 2000), and the number of physically active adolescents may, therefore, be lower than that reported. On the other hand, the question did not assess physical activity at school, which may have led to underestimation of the number of sufficiently active adolescents. For young people, errors in recall of physical activity are also likely to be greater than for adults (Sallis & Saelens 2000, Shephard 2003). It is also probable that a questionnaire would be unlikely to capture all the different types of physical activity undertaken. However, objective measures of physical activity were not available in our representative samples of more than 9000 adolescents. The definition of *active* is not strictly consistent with current physical activity recommendations, which suggest that school-aged children should participate in MVPA for at least one hour per day (U.S. Department of Health and Human Services 2008). This recommended level of physical activity was met by only 23% of boys and 10% of girls in our population (Tammelin *et al.* 2007), partly due to unmeasured school based physical activity. Therefore we defined as *active* those members of the cohort (46% of boys and 29% of girls) who participated in MVPA for four hours or more per week.

Parental education and family income were used as proximal measures of parental socio-economic position. The information on parental education and income was acquired at first hand from parents, which is a strength in surveys of this kind. Much of the earlier research on parental socio-economic position and adolescents' characteristics has obtained the relevant information from adolescents themselves, which may be fallacious since few young people know their parents' income or can adequately describe their occupation (Currie *et al.* 1997). Although education and income have proved very useful indicators of socio-economic position in health research, they provide only a partial view of socio-economic inequalities in health, especially if considered in isolation (Galobardes *et al.* 2007). Furthermore, a considerable question remains regarding whether parental income and education are valid measures of adolescents' socio-economic position. It has been suggested that these traditional indicators of social position reflect the social-structural basis of living conditions, while measures of adolescents' own educational performance could be used as more efficient

indicators of actual social inequality between young people themselves (Koivusilta *et al.* 2006).

Self-rated health, measured by a single Likert-type scale item querying respondents' overall health has been shown to have high reliability, validity and predictive power for a variety of illnesses and conditions in various societies (Ivanova *et al.* 2007, Lundberg & Manderbacka 1996). Unweighted agreement of the collapsed three category measure of perceived health has been reported to be approximately 70% and unweighted k-values around 0.5 among Finnish adults (Martikainen *et al.* 1999), indicating fair to good reliability (Fleiss 2003). Although adolescence is a time of great changes in a young person's life, this measure of self-rated health has remained a stable construct over time (Breibdablik *et al.* 2009).

Self-reported academic performance of older students has been deemed sufficiently adequate for research use, with the Pearson product moment correlation between self-reported and actual cumulative grade point average being 0.97 (Cassady 2001). However, actual academic performance and cognitive skills may mediate self-reported grade validity (validity being higher for students with good academic performance) indicating that some caution is needed in interpreting the results (Kuncel *et al.* 2005). Furthermore, we did not measure actual self-reported academic performance, but adolescents were asked to rate their academic performance versus their peers. This kind of comparison might be associated with self-esteem and mental health issues, and represents a limitation in this study. The dichotomization of educational outcomes is also a limitation in the present study, and tones down the power of the findings. However, for statistical reasons, especially that of appropriate group sizes, this was seen as the best possible solution.

The representativeness of the study sample may be an important source of bias in epidemiological studies like the present one. Compliance with the study may be higher in the healthiest and the most advantaged portion of the population. In the present study, the response rate was very high for the adolescents (80%), enabling the comparison and characterization of different study samples. No difference was observed with regard to physical activity between adolescents in the original 15–16 years postal questionnaire sample and adolescents in the samples used in the present study. However, mothers' level of education was somewhat lower in the baseline sample than in the 15–16 years survey samples. The population samples used in the present study seem to be representative of the whole NFBC 1986 by their level of physical activity, the key variable in the

present study. However, a cross-sectional study design does not permit full examination of the causality between independent and dependent variables. Therefore, the results should be interpreted with a certain amount of caution, with the possibility of reverse causality and natural selection in mind. It is also possible that some chronic medical conditions or their treatments not reported in this study had a confounding effect on physical activity and self-rated health in association with emotional and behavioural problems.

The results can most likely be generalized to represent Finnish adolescents aged about 15–16 years, and probably also to some other developed Western countries with similar geographical and socio-political circumstances, including other Scandinavian countries. Some results, for instance the prevalence of different types of physical activities, and to some extent, the income distribution, are typical for (Northern) Finland. However, the changes in the society, as well as in the patterns of adolescents' physical activity and mental health might change considerably in a relatively short period of time. This emphasizes the need for further information regarding the role of physical activity on adolescents' emotional and behavioural problems, self-rated health and educational attainment today and in future.

7 Conclusions

7.1 Main conclusions and implications

The main study findings corresponding to the presented aims are:

1. High parental education was associated with being physically active and with spending least time watching TV among adolescents. High family income was associated with being an active sports club member. Additionally, adolescents' participation in different types of physical activity varied according to family income.
2. Physical inactivity in adolescence was related to emotional, social, thought and attention problems, and rule-breaking behaviour.
3. Physical inactivity, emotional, behavioural and social problems, and low parental socio-economic position were, independently of each other, related to poor self-rated health among adolescents.
4. A higher level of physical activity, fewer behavioural problems, and higher parental socio-economic position were, independently of each other, associated with high self-perceived academic performance and future plans for higher education.

Physical activity provides important health benefits for children and adolescents. However, social inequalities in young people's physical activity are evident. The present results confirm earlier findings that parental income and education are positively associated with the levels and types of physical activity among adolescents. Today, child and youth sport may cause considerable financial costs to families. Opportunities to participate in physical activities for free or at low cost should be guaranteed for young people. This may require changes in the rules for sports and games, sizing up competition systems and collaboration between sports federations and clubs. It may even call for some kind of consensus on social agreement between the government, the municipalities and the sports organizations to enable the equal participation of young people in physical activities.

According to the present results, physical inactivity was associated with an increased likelihood of having several emotional and behavioural problems among adolescents: anxious/depressed symptoms among boys, withdrawn/depressed symptoms among boys and girls, somatic complaints among girls, rule-breaking behaviour among girls, social and attention problems

among boys and girls, and thought problems among boys. Age appropriate and enjoyable physical activity may provide a practical and cost-effective tool for prevention and rehabilitation of mental health problems in adolescence. Furthermore, the potential holistic health gains of physical activity on adolescents should not be underestimated. Because a physically inactive lifestyle seems to be more common among adolescents with mental health problems, encouraging them to engage in physical activities is important for preventing other detrimental health effects of a sedentary lifestyle on cardiometabolic health, for instance.

Self-rating of health is a significant predictor of various illnesses and conditions. Although it has been suggested that adolescents differ from older people in their perception of health, the information on factors affecting adolescents' self-rated health is scarce. The results of the present study indicate that physical inactivity, emotional, behavioural and social problems, and low parental socio-economic position are independently related to poor self-rated health among adolescents. Public health promotion activities aimed at young people should focus on positive aspects of life and health, paying special attention to adolescents from low socio-economic backgrounds, with emotional and behavioural problems and low levels of physical activity.

Education is a key predictor of adolescents' life opportunities, including the economic and social sphere, as well as various health outcomes. In this study, a higher level of physical activity, fewer behavioural problems, and higher socio-economic position were, independently of each other, associated with high self-perceived academic performance and future plans for higher education. Understanding the factors that can influence differences in educational performance can help policy makers address quality and equity concerns. Schools and teachers need to consider their expectations of students from different backgrounds and adopt strategies to raise the level of interest, self-confidence and motivation in those areas where each are weak. This requires the involvement of the family and the society more widely, including the media and the main actors in youth culture.

The present results indicate interrelationships between socio-economic position, physical activity, educational attainment and health. The possible role of physical activity in reducing social inequalities in adolescents' health and education must be taken seriously not only at policy level, but also in sports, health and education organizations, municipalities, schools, sports clubs and other actors closely related to adolescents' everyday life. Adolescents should be encouraged to obtain physical activity in ways that allow them to attain health and

other benefits over the short term as well as maintain a physically active lifestyle over the long term. Developmentally appropriate physical activities that enable equal participation, minimize the potential risks of overtraining and injuries, and provide opportunities for enjoyable participation in a wide range of specific forms of physical activity may present the best chances of leading adolescents towards these goals.

7.2 Future research

The relationships between socio-economic position, physical activity, health and educational outcomes are complex and impossible to determine comprehensively in a cross-sectional study setting like the present one. The results of this study, however, form a basis for large, well-designed longitudinal cohort studies and intervention trials, which are needed to specify the causal relationships between these factors. The widespread presence of mental health problems in adolescence, major psychosocial and biological changes of puberty, critical educational transitions, and the relatively stable nature of physical activity pattern from youth to adulthood make this age group particularly important to address with future studies on the role of physical activity on emotional and behavioural problems, self-rated health and educational attainment.

Questions related to physical activity measurement methodology may be the major challenge for future studies of physical activity among adolescents. Technology that provides an objective assessment of physical activity in relatively large groups of adolescents is increasing, making it possible to draw more definitive estimates of adolescents' physical activity patterns. More information is needed about the optimal types and amounts of physical activity for enhancing adolescents' life opportunities and for reducing social inequalities in adolescents' health and education. The mechanisms behind, and the pathways between these associations also remain largely undiscovered. Additionally, more in-depth analyses of the patterning and co-occurrence of physical activity and other health behaviours, such as sedentary behaviours, in relation to health, education and socio-economic position are warranted.

Few studies so far have evaluated physical activity in the prevention and treatment of adverse health and educational outcomes. Some studies have examined exercise in the prevention and treatment of emotional problems among young people, but the effect of exercise is unknown because the evidence base is scarce (Larun *et al.* 2006). A wider perspective is needed on determinants and

outcomes of physical activity in future research. Instead of focusing on depression and anxiety, other syndromes like behavioural, social and attention problems should be examined too. Factors like psychosocial health, positive well-being and positive affect, health behaviours and bodily experiences could be combined as interrelated dimensions of adolescents' overall health and analysed in relation to physical activity. Educational attainment, on the other hand, could be seen as a function of future educational plans or self-efficacy for academics and examined in relation to physical activity.

Adolescents' personal social position is a new indicator that could be included in research on social inequalities in adolescents' health behaviours, education and health. Whether educational attainment is a sufficient measure of personal social position, is the question to be answered in future studies (Koivusilta *et al.* 2006). Research should also be conducted to determine the extent to which factors like age, developmental status and race/ethnicity influence the associations between physical activity, health, education and socio-economic position.

Although a lot is already known on the role of physical activity on adolescents' health and educational outcomes, many important questions remain unanswered. The more in-depth we go in our questions, the more likely it becomes that the perspective of any one discipline is not broad enough. Instead of searching for a specific explanation for health and educational changes through physical activity, it might be more appropriate to allow for individual variation through the adoption of an appropriately broad theoretical view and various suitable research methods. Such an approach will advance the case for physical activity within enhancement in adolescent health and other life chances by shedding light on how, why, for whom, and under what conditions physical activity is beneficial. Interdisciplinary study designs in collaboration between various fields of research open up the best possibilities for the brightest research and the brightest discoveries in future.

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Appendix 1

Table 1. Summary of studies on physical activity (PA) and parental socio-economic position (SEP)^a among adolescents. MVPA = moderate-to-vigorous intensity physical activity.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and socio-economic position	Main results
Butcher <i>et al.</i> 2008	6125, cross-sectional, 2005, US, 14–17 years	PA: frequency of MVPA by telephone interview SEP: education of the consenting parent, annual household income by telephone interview	High household income was related to PA guideline compliance.
Chen <i>et al.</i> 2007	546, cross-sectional, 2002–2003, Taiwan, 12–15 years	PA: AHP (frequency of exercise) by questionnaire SEP: parents' total years of education by questionnaire	Parental education level was positively associated with exercise behaviour.
Gomez <i>et al.</i> 2004	177, cross-sectional, US, 7 th graders	PA: frequency of outdoor physical activities away from school by questionnaire SEP: per capita income from the Censtats Information Service	Per capita income was not associated with PA.
Gordon-Larsen <i>et al.</i> 2000	17766, cross-sectional, 1995, US, 11–21, years	PA: frequency of MVPA and inactivity by questionnaire SEP: maternal education and income by questionnaire	Maternal education was inversely associated with high inactivity patterns. High family income was associated with increased MVPA.
Higgins <i>et al.</i> 2003	12120, cross-sectional, 1996–1997, Canada, 12–24 years	PA: Physical Activity Index (energy expenditure based on caloric output) SEP: derived total household income in 12 categories by questionnaire	Household income was not related to PA.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and socio-economic position	Main results
La Torre <i>et al.</i> 2006	2411, cross-sectional, 2002–2003, Italy, 11–17 years	PA: hours of scholastic and extra-curricular PA by questionnaire SEP: parental education by questionnaire	High parental education was important predictor of higher levels of PA.
Lasheras <i>et al.</i> 2001	1358, cross-sectional, 1991, Spain, 6–15 years	PA: frequency of PA by questionnaire (parents) SEP: education and income of the head of the household by questionnaire	Higher parental education and income were related to higher levels of PA.
Lee & Cubbin 2002	8165, cross-sectional, 1990/1992, US, 12–21 years	PA: frequency of MVPA by telephone interview SEP: median income for household from census tract data	Youth from low-income households were less likely to be physically active.
Lowry <i>et al.</i> 1996	6321, cross-sectional, 1992–1993, US, 12–17 years	PA: frequency of MVPA by interview SEP: combined annual family income of all family members by interview	Family income was inversely related to sedentary lifestyle.
Murphey <i>et al.</i> 2004	30916, cross-sectional, 2001, US, 8–12 th graders	PA: frequency of exercise or aerobic PA by questionnaire SEP: mother's education level by questionnaire from adolescents	Mother's high level of education was associated with higher level of engagement in aerobic exercise.
Piko & Fitzpatrick 2007	1114, cross-sectional, 2004, Hungary, 14–21 years	PA: frequency of PA (at least a half hour) by questionnaire SEP: parental education by questionnaire	Low level of parental education was associated with low levels of sports activity.
Piko & Keresztes 2008	1662, cross-sectional, 2003–2004, Hungary, 10–15 years	PA: frequency of PA (at least a half hour) by questionnaire SEP: parental education by questionnaire	High parental education was associated with youth's being physically active.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and socio-economic position	Main results
Saxena <i>et al.</i> 2002	305 (females), cross-sectional, 2000–2001, US, 12–21 years	PA: frequency of vigorous PA by questionnaire SEP: mother's education level by questionnaire from adolescents	Mother's level of education was not related to PA.
Singh <i>et al.</i> 2008	68288, cross-sectional, 2003, US, 6–17 years	PA: frequency of vigorous PA by telephone interview SEP: household or parental education by telephone interview	High level of parental education was related to low levels of physical inactivity and higher levels of regular PA.
Tuinstra <i>et al.</i> 1998	1984, cross-sectional, 1994–1995, Netherlands, 16 years (mean)	PA: participation in sports by questionnaire SEP: mother's and father's education by questionnaire from adolescents	Mother's and father's high level of education was related to active participation in sports.
Wagner <i>et al.</i> 2004	3437, cross-sectional, 2001, France, 12 years (mean)	PA: frequency of participation in structured PA outside school by questionnaire SEP: annual family income tax by questionnaire from parents	Family income was positively associated with participation in structured PA outside school.

^a Measured by parental income and/or education.

Appendix 2

Table 1. Summary of studies on physical activity (PA) and emotional and behavioural problems (EBP) among adolescents. MVPA = moderate-to-vigorous intensity physical activity.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of emotional and behavioural problems (EBP) and physical activity (PA)	Main results
Abu-Omar <i>et al.</i> 2004	16 230, cross-sectional, 2002, European Union, 15–24 years	EBP: Mental Health Inventory (MHI-5), The Energy and Vitality Scale (EVI-scale) PA: frequency, duration, and level of intensity of PA by interview	Those being more physically active had in general better mental health. Evidence for a dose-response relationship was found in some nations.
Desha <i>et al.</i> 2007	727, cross-sectional, 2002/2003, US, 13–18 years	EBP: Kovacs's Children's Depression Inventory (CDI-S) PA: duration of MVPA by open-ended time diaries	MVPA was not associated with severity of depressive symptoms. Involvement in sporting clubs of lessons was inversely related to depressive symptoms among boys.
Donaldson & Ronan 2006	203, cross-sectional, New Zealand, 11–14 years	EBP: The Youth Self-Report PA: type and frequency of sports participation by questionnaire	Participation in formal sports was negatively associated with anxious/depressed, social, and behavioural problems.
Haarasilta <i>et al.</i> 2004	509, cross-sectional, 1996, Finland, 15–19 years	EBP: UM-CIDISF (DSM-III-R major depressive episode) PA: physical exercise lasting at least 30 minutes by questionnaire	Physical exercise was not associated with major depressive episode.
Kirkcaldy <i>et al.</i> 2002	988, cross-sectional, 2000, Germany, 14–18 years	EBP: The Youth Self-Report PA: frequency of involvement in endurance sport by questionnaire	Participation in endurance sports was related to lower anxiety-depression scores and less social behavioural inhibition.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of emotional and behavioural problems (EBP) and physical activity (PA)	Main results
Motl <i>et al.</i> 2004	4594, longitudinal, 1998 → 2000, US, 12.7 years (mean at baseline)	EBP: Center for Epidemiological Studies Depression Scale (CES-D) PA: frequency of regular PA outside school by questionnaire	One SD unit change in the frequency of PA was inversely related to a 0.25 SD unit change in depressive symptoms.
Pastor <i>et al.</i> 2003	1038, cross-sectional, Spain, 15–18 years (mean)	EBP: subjective feelings of anxiety, depression and psycho physiological symptoms on a five-point scale by questionnaire PA: frequency of participation in sports by questionnaire	Sports participation was negatively related to anxiety, depression and psycho physiological symptoms.
Sagatun <i>et al.</i> 2007	3811, longitudinal, 2000–2001 → 2003–2004, Norway, 15–16 years	EBP: Strengths and Difficulties Questionnaire (SDQ) PA: weekly hours of PA in leisure time by questionnaire	PA at age 15–16 was negatively associated with emotional symptoms and peer problems at age 18–19 among boys.
Stephoe & Butler 1996	5061, cross-sectional, 1986, UK, 16 years	EBP: Malaise Inventory, General Health Questionnaire (GHQ) PA: frequency of vigorous PA by questionnaire	Sport and vigorous PA was positively associated with emotional well-being.
Tao <i>et al.</i> 2007	5453, cross-sectional, China, 15 years (mean)	EBP: The Symptoms Checklist 90 (general mental health problems) PA: frequency of MVPA by questionnaire	Low-to-moderate intensity PA was a protective factor of depression and psychotic symptoms, while high-intensity PA was a risk factor of general psychological disorders

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of emotional and behavioural problems (EBP) and physical activity (PA)	Main results
Wiles <i>et al.</i> 2008	1446, longitudinal, 1999–2000 → 2000–2001, UK, 11–14 years	EBP: Strengths and Difficulties Questionnaire SDQ PA: frequency of sporting activities (at least 20 minutes) by questionnaire	Physically active children had fewer emotional problems one year later.

Appendix 3

Table 1. Summary of studies on physical activity (PA) and self-rated health (SRH) among adolescents. MVPA = moderate-to-vigorous intensity physical activity.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and self-rated health	Main results
Breidablik <i>et al.</i> 2008	2741, cross-sectional, 2000–2001, Norway, 16–20 years	SRH: single item 4-point scale question by questionnaire PA: frequency of sports activity outside school by questionnaire	Absence of exercise was associated with poor SRH.
Breidablik <i>et al.</i> 2009	2399, longitudinal, 1995–1997 → 2000–2001, Norway, 13–19 years	SRH: single item 4-point scale question by questionnaire PA: frequency of sports activity outside school by questionnaire	Level of sport and exercise was a significant contributor to change in SRH over 4 years.
Heard <i>et al.</i> 2008	12737, longitudinal, 1994–1995 → 2001–2002, US, 16 years (mean)	SRH: single item 5-point scale question by questionnaire PA: frequency of PA during the last week by questionnaire	Frequent PA was associated with better SRH.
Mikolajczyk <i>et al.</i> 2008	2103, cross-sectional, 2005, Germany, Poland, Bulgaria, 21 years (mean)	SRH: single item 5-point scale question by questionnaire PA: frequency of MVPA on 3-category response scale by questionnaire	Higher PA was associated with better SRH.
Page & Suwanteerangkul 2009	2519, cross-sectional, Thailand, 16 years (mean)	SRH: single item 3-point scale question by questionnaire PA: Physical Activity Index (sum of the PA items: vigorous PA, muscle strengthening activity, play on sports teams).	'Not healthy' adolescents were less physically active compared to adolescents who rated their health as 'healthy' or 'very healthy'.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and self-rated health	Main results
Pan <i>et al.</i> 2009	5167, cross-sectional, 2002, Canada, 15–79 years	SRH: single item 4-point scale question by questionnaire PA: duration (h/day) and frequency (times/week) of MVPA by questionnaire	PA was not correlated with SRH in the age group of 15–24 years (N = 645).
Pastor <i>et al.</i> 2003	1038, cross-sectional, Spain, 15–18 years	SRH: single item 4-point scale question by questionnaire PA: participation (times/wk) in sports on 6-category response scale by questionnaire	Sports participation was associated with SRH directly and indirectly by decreasing smoking and alcohol consumption, feelings of depression and psycho physiological symptoms, and by increasing perceived physical fitness.
Piko & Keresztes 2007	548, cross-sectional, 2003, Hungary, 10–15 years	SRH: single item 4-point scale question by questionnaire PA: sports activity on 5-category response scale by questionnaire	Extra sport besides school physical education predicted poor SRH just occasionally, or not at all.
Piko 2000	980, cross-sectional, 1998, Hungary, 18–31 years	SRH: single item question by questionnaire PA: type, frequency and duration of PA by questionnaire	PA was a significant predictor of SRH.
Piko & Fitzpatrick 2007	1114, cross-sectional, 2004, Hungary, 14–21 years	SRH: single item 4-point scale question by questionnaire PA: exercise outside school for at least 30 min on 5-category response scale by questionnaire	Lack of PA was a significant predictor of poor SRH.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of physical activity and self-rated health	Main results
Tremblay <i>et al.</i> 2003	12715, cross-sectional, 2000/2001, Canada, 12–17 years	SRH: single item 5-point scale question by questionnaire PA: frequency and duration of leisure time PA by questionnaire	The odds for reporting good SRH were lower for physically inactive teens compared to their physically active peers.
Vindfeld <i>et al.</i> 2009	891–1648, cross-sectional, 1994–2006 (trend), Greenland, 11–15 years	SRH: single item 4-point scale question by questionnaire PA: duration (h/day) and frequency (times/week) of MVPA by questionnaire	Physically active children reported good SRH more often than physically inactive children.

Appendix 4

Table 1. Summary of studies on physical activity (PA) and educational performance (EP) among adolescents. MVPA = moderate-to-vigorous intensity physical activity, GPA = grade point average.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of educational performance and physical activity	Main results
Aaron & Gallagher 2003	1038, longitudinal, US, 13.6 years (mean at baseline)	EP: number of classes failed from academic records PA: duration (h/wk) of PA and participation in organized sports by questionnaire	Participation in organized physical activities was inversely associated with failing a class.
Coe <i>et al.</i> 2006	214, cross-sectional, 2002, US, 10–13 years	EP: grades from mathematics, English and world studies (grade score), and standardized test scores (Terra Nova percentiles) PA: MVPA outside school by questionnaire	Vigorous PA was positively related to school achievement. Moderate PA was not associated with school achievement.
Daley & Ryan 2000	232, cross-sectional, UK, 13–16 years	EP: performance grades for English, mathematics, and science from examination scores PA: types of PA (times/wk) by questionnaire	Weak negative correlation between sport and exercise and English (13, 14 and 16 years) and science scores (16 years).
Field <i>et al.</i> 2001	89, cross-sectional, US, high school seniors	EP: GPA scored on a 4-point scale (A-D) PA: exercise on a 5-point Likert scale (rarely-daily) measured by questionnaire	The high-exercise group had higher GPA compared to the low-exercise group.
Fisher <i>et al.</i> 1996	838, cross-sectional, 1992, US, 16 years (mean)	EP: GPA (A-F) by questionnaire PA: types and level of sports involvement, hrs/wk spent on sport activities by questionnaire	Sports involvement was not associated with academic performance.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of educational performance and physical activity	Main results
Huang <i>et al.</i> 2006	666, cross-sectional, US, 11–14 years	EP: self-reported grades in the last year on 4-point scale (average), PA: type and intensity of activities by self-reported previous day PA by questionnaire	Level of MVPA time was negatively related to measured and self-reported grades.
Lindner 2002	1447, cross-sectional, 1998–1999, China, 13–17 years	EP: self-reported academic potential on a 6-point scale (from 'far below average' to 'good') PA: type, frequency and duration of sport and PA by questionnaire	Boys with greater activity participation time had better academic measures. No association between PA and academic measures among girls.
Nelson & Gordon-Larsen 2006	11957, cross-sectional, 1994–1996 US, 16 years (mean)	EP: self-reported grades for mathematics, science and English PA: daily PA by 7-day recall questionnaire, participation in school physical education (days/wk) and sports clubs (number/year)	Five or more weekly bouts of MVPA and engagement in sports with parents were associated with higher grades in mathematics and science.
Sanders <i>et al.</i> 2000	89, cross-sectional, US, 17 years (mean)	EP: self-rated GPA on a 4-point scale by questionnaire PA: duration (h/wk) of sports involvement by questionnaire	Sports involvement was not associated with self-rated GPA.

Authors and publication year	Number of participants, design, year, country and age of the respondents	Measurement of educational performance and physical activity	Main results
Sigfusdottir <i>et al.</i> 2007	5810, cross-sectional, 2000, Iceland, 14–15 years	EP: self-rated GPA (Icelandic, mathematics, English, Danish) on a 7-point scale by questionnaire PA: self-reported participation in different levels of PA outside school hours by questionnaire	PA was a weak but significant predictor of academic achievement.
Tremblay <i>et al.</i> 2000	6923, cross-sectional, 1996, Canada, 12 years	EP: standardized mathematics and reading scores PA: frequency of regular participation in PA at school and outside school by questionnaire	PA had a weak negative association with mathematics and reading scores.
Pate <i>et al.</i> 1996	4293, cross-sectional, 1990, US, 12–18 years	EP: self-perception of academic performance on a 4-point scale (from 'bottom' to 'best') by questionnaire PA: frequency of light and vigorous level PA by questionnaire	Low level of PA was associated with low perception of academic performance.
Vindfeldt <i>et al.</i> 2009	891–1648, cross-sectional, 1994–2006 (trend), Greenland, 11–15 years	EP: self-perception of academic achievement on a 4-point scale (from 'very good' to 'below average') by questionnaire PA: duration (h/day) and frequency (times/week) of MVPA by questionnaire	PA was positively associated with academic achievement.

Appendix 5

Table 1. Distribution (%) of selected variables in different population samples of the Northern Finland Birth Cohort 1986.

	Original population samples		Study samples	
	Baseline sample N = 9432	15–16 years postal questionnaire sample N = 7344	The YSR ^a completed N = 7002 (original publications II–IV)	Family income reported at 15–16 years N = 5457 (original publication I)
Mother's education ^b				
I Tertiary/higher	7.0	12.8	12.9	13.8
II Upper secondary	67.8	66.4	66.4	66.9
III Basic (≤9 years)	23.5	9.6	9.4	8.4
IV Other or unfinished degree	1.7	11.2	11.3	10.9
MVPA ^c				
Active		37.5	36.9	37.8
Moderately active		26.8	26.9	26.2
Inactive		35.7	36.2	36.0

^a YSR = The Youth Self-Report.

^b In the baseline sample the class IV included only mothers who had a matriculation examination, but had not finished their university studies at the time of the survey.

^c Moderate-to-vigorous intensity physical activity.

Original publications

- I Kantomaa MT, Tammelin TH, Näyhä S & Taanila AM (2007) Adolescents' physical activity in relation to family income and parents' education. *Prev Med* 44(5): 410–415.
- II Kantomaa MT, Tammelin T, Ebeling H & Taanila A (2008) Emotional and behavioral problems in relation to physical activity in youth. *Med Sci Sports Exerc* 40(10): 1749–1756.
- III Kantomaa MT, Tammelin TH, Ebeling HE & Taanila AM (2009) Physical activity, emotional and behavioural problems, and self-rated health among adolescents. Manuscript.
- IV Kantomaa MT, Tammelin TH, Demakakos P, Ebeling HE & Taanila AM (2009) Physical activity, emotional and behavioural problems, maternal education and self-reported educational performance of adolescents. *Health Educ Res Sep* 17. In press.

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- I027. Matinolli, Maarit (2009) Balance, mobility and falls in Parkinson's disease
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