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Jaana Kari

Lifelong Physical Activity and Long-Term Labor Market Outcomes

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ABSTRACT

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This thesis examines the longitudinal associations between leisure-time physical activity, educational attainment, and labor market outcomes. Data are drawn from the ongoing longitudinal Cardiovascular Risk in Young Finns Study, which is combined with register-based data from Statistics Finland. The thesis consists of four empirical studies organized in separate chapters. The study chapters are preceded by an introductory chapter presenting the background literature and an overview of the thesis, including the research questions, data, and main results.

Chapter 2 analyzes the role of childhood physical activity in academic achievement and subsequent educational attainment. We find that physical activity level and an increase in physical activity level during childhood are positively related to grade point average at the end of compulsory basic education and years of post-compulsory education in adulthood.

Chapter 3 examines the association between childhood physical activity and adulthood earnings. The results show that, among men, childhood physical activity is positively related to long-term earnings calculated over a 10-year period. Among women, no such clear relation is found.

Chapter 4 further studies the relationship between childhood physical activity and long-term labor market outcomes by focusing on employment and unemployment. The results indicate that childhood physical activity is positively related to employment months and negatively related to unemployment months. As well, persistently active individuals have the highest employment levels and lowest unemployment levels compared with other activity groups.

Chapter 5 scrutinizes the role of annual earnings in self-reported and objectively measured physical activity. The results suggest that higher incomes are associated with higher self-reported physical activity in both genders, whereas the results from the objective measures of physical activity are gender-specific and depend on the measurement day (weekday vs. weekend).

Keywords: physical activity, academic achievement, educational attainment, earnings, employment, unemployment, register-based data

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CONTENTS

1 INTRODUCTION

The importance of physical activity and the detriments of physical inactivity for health and well-being are well documented. Among children and youth, strong evidence that physical activity improves cardiorespiratory and muscular fitness, cardiovascular and metabolic health biomarkers, bone health, and body mass has been demonstrated (Physical Activity Guidelines Advisory Committee, 2008; Lee et al., 2012; Murray and Lopez, 1997; Raitakari et al., 1997; World Health Organization, [WHO], 2010). Physical inactivity, in contrast, has been identified as the fourth-leading risk factor for global mortality, ahead of, for example, obesity (Lee et al., 2012; WHO, 2010). It is estimated that physical inactivity is a principal cause for approximately 21%–25% of breast and colon cancer burden, 27% of diabetes burden, and 30% of ischemic heart disease burden (WHO, 2009). Nevertheless, only around one-fifth of children and youth are estimated to be sufficiently active and meet the current physical activity recommendations for health (WHO, 2014; Ekelund et al., 2011; Hallal et al., 2012; Tremblay et al., 2016; Tammelin et al., 2016).

Research related to the economics of physical activity has increased in recent years. Coldiz (1999), Ding et al. (2016), Katzmarzyk et al. (2000), Katzmarzyk and Janssen (2004), Kohl et al. (2012), and Lee et al. (2012), among others, document increasing healthcare costs due to physical inactivity. Studies by, for example, Lechner (2009), Hyytinen and Lahtonen (2013), Rooth (2011), Kavetsos (2011), and Lechner and Downward (2017) examine the associations between adulthood physical activity and labor market outcomes, while Meltzer and Jena (2010) and Humphreys and Ruseski (2006, 2011) scrutinize the reverse relationship between individuals' economic resources and physical activity. These studies' findings consistently show that higher physical activity in adulthood is related to higher labor market returns and that higher individual economic resources are related to higher physical activity. Additionally, evidence indicates that physical activity contributes positively to learning outcomes (Stevens et al., 2008; Fox et al., 2010) and is related to higher levels of education (Long and Caudill, 1991; Barron et al., 2000; Pfeifer and Cornelißen, 2010). The economy-level perspective is adopted by, for example, Ruhm (2000), who suggests that participation in physical activity increases when the economy deteriorates.

In a recent study, Ding et al. (2016) estimate the direct healthcare costs, productivity losses, and disability-adjusted-life-years (DALYs) attributable to physical inactivity worldwide. In 2013, physical inactivity caused approximately INT$ 53.8 billion of direct healthcare costs, $13.7 billion in productivity losses, and 13.4 million DALYs (Ding et al., 2016). Moreover, Katzmarzyk and Janssen (2004) show that the total economic costs[1] of physical inactivity represented approximately 2.5% of the total Canadian healthcare costs in 2001. Lechner (2009) and Rooth (2011), in turn, find a positive association between physical activity and labor market returns, and Hyytinen and Lahtonen (2013) report similar findings for men based on Finnish twin data. Rooth (2011) also suggests that employers may interpret physical activity as a positive signal. In particular, Rooth (2011) finds that individuals who indicate in job applications that they are physically active have higher probability of receiving callbacks to job interviews. Using cross-sectional data from 25 European countries, Kavetsos (2011) shows that physically active individuals have a higher probability of being employed, while Lechner and Downward (2017) find a negative association between sports participation and unemployment. Considering the relationship in reverse, Meltzer and Jena (2010) and Humphreys and Ruseski (2006, 2011) find that individuals with higher incomes report higher physical activity levels. Regarding educational outcomes, prior studies suggest that physical activity is positively related to, among others, mathematics and reading achievement (Stevens et al., 2008), grade point average (GPA) (Fox et al., 2000), graduation rates (Long and Caudill, 1991), and post-secondary education (Barron et al., 2000; Pfeifer and Cornelißen, 2010).

Despite this research, very little is known about the longitudinal associations among physical activity, educational attainment, and labor market outcomes. In particular, many previous studies lack register-based information on post-compulsory education and labor market outcomes. Additionally, a growing number of recent population-based studies use objective measures of physical activity (e.g., pedometers and accelerometers), in addition to self-reported questionnaires. However, little is known about the association between income and physical activity using both self-reported and objective measures of physical activity. Thus, there exists a notable gap in economic research, which raises important questions: can childhood physical activity have longitudinal consequences for post-compulsory education, labor market returns, and labor market participation? In particular, can childhood physical activity explain differences in individuals' academic achievement, educational attainment, and labor market outcomes? Can individuals' economic resources explain adulthood physical activity behavior, and does this association depend on the measurement type of physical activity?

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1 The estimates include direct healthcare costs and indirect costs, which include the value of economic output lost because of illness, injury-related work disability, or premature death (Katzmarzyk and Janssen, 2004).

Answering these questions is important for several reasons. First, understanding whether and how economic resources are related to individuals' physical activity behavior might make it possible to improve individual health and well-being by paying attention to the development of these characteristics. For example, understanding the economic determinants of physical activity could aid health promoters and employers in implementing efficient tools for increasing physical activity among individuals from different socioeconomic backgrounds. Second, understanding whether and how childhood physical activity is related to later educational attainment and the development of working careers could encourage developing programs and interventions aiming to foster children's participation in physical activity. This could push the young toward more physically active lifestyles, and improve their educational attainment and labor market outcomes in later life, providing both personal and societal benefits. In a broader context, possibilities for improving labor force' productivity are important, given that higher productivity increases economic welfare and strengthens competitiveness.

The purpose of this thesis is to examine the longitudinal associations between physical activity, educational attainment, and labor market outcomes. This thesis consists of four studies organized into separate chapters. The first three studies (Chapters 2, 3, and 4) focus on childhood physical activity, academic achievement, educational attainment, and labor market outcomes. The fourth study (Chapter 5) explores the relationship between individuals' economic resources and adulthood physical activity behavior. More specifically, the purpose of the first study is to investigate the role of childhood physical activity in academic achievement at the end of compulsory basic education and in post-compulsory educational attainment in adulthood. The second study examines whether participation in physical activity outside school hours is related to long-term earnings in adulthood. The third study further investigates the relationship between childhood physical activity and labor market outcomes in adulthood. In particular, whether labor market outcomes, including employment status, employment months, and unemployment months, differ according to childhood physical activity behavior. The fourth study provides information about the correlates of adulthood physical activity and studies the role of annual earnings in self-reported and objectively measured physical activity.

The remainder of this introductory chapter is organized as follows. Section 1.1 defines the concept of physical activity, introduces the economic framework behind the decision to participate in physical activity, and reviews earlier literature related to physical activity, educational attainment, and labor market outcomes. This is followed by a section that provides an overview of the thesis, including the research questions, data, and methods. Section 1.2 also presents the main findings, limitations, suggestions for future research, and concluding remarks.

1.1 Background

Examining the role of physical activity in educational and labor market outcomes requires first understanding the decision to participate in physical activity. Especially, *why* are people physically active and *who* is more likely to participate in physical activity. This background section first defines the concept of physical activity and then introduces the economic framework behind the decision to participate in physical activity. In particular, the models of Becker (1965), Grossman (1972), and Cawley (2004) are presented. Thereafter, decisions regarding participation in physical activity are linked to economic outcomes. Covering the scope of this thesis, the following subsection presents a review of the literature related to educational and labor market outcomes.

1.1.1 Concept of physical activity

Physical activity is defined as any bodily movement caused by skeletal muscles that requires energy expenditure (Caspersen et al., 1985). In daily life, physical activity is typically divided into five categories: occupational, sports, conditioning, household, and other activities (Caspersen et al., 1985).

The Global Recommendations on Physical Activity for Health (Physical Activity Guidelines Advisory Committee, 2008; WHO, 2010) urge children (aged 5–11 years) and youth (aged 12–17 years) to engage in at least 60 minutes of moderate to vigorous-intensity physical activity daily. Additionally, vigorous-intensity activities, including activities that strengthen the muscles and bones, should be incorporated at least three times per week. For adults, the recommended level of weekly physical activity is at least 150 minutes of moderate-intensity aerobic physical activity, 75 minutes of vigorous-intensity aerobic physical activity, or an equivalent combination of these two. Muscle-strengthening activities, including major muscle groups, should also be included at least two times per week. (Physical Activity Guidelines Advisory Committee, 2008; WHO, 2010.)

The overall physical activity levels among children and youth are low in many countries (Ekelund et al., 2011; Hallal et al., 2012; Tremblay et al., 2016), and Finland is not an exception (Tammelin et al., 2016). Globally, according to the WHO's (2014) *Global status report*, 84% of girls and 78% of boys aged 11–17 years do not reach the recommended level of activity, while the percentage for adults is 23%. In Finland, 60%–80% of children and youth do not meet the recommendations (Tammelin et al., 2016). When focusing on the changes in physical activity levels during the years, according to 1993/1994 Health Behavior in School-aged Children (HBSC) study (WHO, 1996), 85% of Finnish boys aged 11 years and 70% of boys aged 15 years reported being physically active at least 2 to 3 times per week outside school hours. The percentages for girls were 75 and 62. The latest HBCS survey, conducted in 2013/2014 shows that 69% of boys and 66% of girls aged 11 years and 68% of boys and 69% of girls aged 15 years reported participating in vigorous physical activity for at least two or more hours per week (Inchley et al., 2016). According to Borodulin et al. (2016), approximately 20% of Finnish adults were physically inactive in 2012. During the past 30 years, however, leisure-time physical activity has slightly increased, while occupational and commuting physical activity trend downward (Borodulin et al., 2016).

Typically, economic studies use self-reported measures of physical activity (e.g., Hyytinen and Lahtonen, 2013; Lechner, 2009; Lechner and Sari, 2015) with few exceptions (see e.g., Rooth, 2011). Some studies focus only on the frequency of physical activity (e.g., Kavetsos, 2011; Kosteas, 2012; Lechner, 2009) or high school athletic participation (e.g., Barron et al., 2000; Ewing, 1998; Ewing, 2007; Long and Caudill, 1991; Stevenson, 2010). For example, Lechner (2009) bases sports participation on the frequency of adulthood physical activity (at least every week, at least every month but not every week, less often than every month, and none) and then formulates two activity levels: active at least monthly and being active less than monthly. Kavetsos (2011) measures the frequency of physical activity (3 times a week or more, 1–2 times a week, 1–3 times a month, less often, never) across data from 25 European countries. Most studies on high school athletic participation use binary variables to illustrate sports participation. For example, Long and Caudill (1991) formulate a binary variable for college athletes that equals 1 if a student earns a varsity letter in a college and 0 otherwise. Similarly, Ewing (1998) uses a binary variable that equals 1 if an individual participates in high school athletics and 0 otherwise. Pfeifer and Cornelißen (2010) use retrospective information on physical activity. The participants aged 17–99 years are asked whether they participated in sports and sports competitions other than school gym activities during childhood and adolescence.

Different measures of physical activity in the economic literature are used by, for example, Hyytinen and Lahtonen (2013), Rooth (2011), and Lechner and Sari (2015). Hyytinen and Lahtonen (2013) measure physical activity with several questions covering monthly frequency, duration, intensity of physical activity sessions, individuals' opinions of overall physical activity level, and active commuting to and from work. Based on responses to these questions, Hyytinen and Lahtonen (2013) develop a categorical classification of physical activity, in which the most active group includes individuals who report engaging in physical activity at least 6 times per month for a mean duration of at least 30 minutes and with a mean intensity corresponding to at least vigorous walking or running. Rooth (2011), in contrast, uses two measures of physical activity: signaling leisure sports activities during the hiring process and objectively measured cardiovascular fitness (physical fitness). Rooth (2011) conducts a field experiment in Sweden, sending more than 8,000 fictitious job applications to nearly 4,000 employers. In Rooth's (2011) study, objectively measured physical fitness corresponds to the maximum watts attained on a stationary bike divided by the individual's body weight. Finally, Lechner and Sari (2015) divide respondents into three groups according to the current physical activity recommendations for health. Individuals are classified as physically active if their daily energy expenditure from all leisure-time physical activities (LTPA) exceeds 3 kcal/kg, moderately active if their daily energy expenditure varies between 1.5 and 3 kcal/kg from all LTPA, and physically inactive, if their daily energy expenditure falls below 1.5 kcal/kg from all LTPA (Lechner and Sari, 2015).

1.1.2 Correlates of physical activity

From the economic perspective, Becker's (1965) allocation-of-time model for non-working time, Grossman's (1972, 1999) demand-for-health-model, and Cawley's (2004) sleep–leisure-occupation-transports-home (SLOTH) model are examples of models aimed at explaining *why* people choose to participate in physical activity.

Becker (1965) derives the allocation-of-time-model from the traditional income-leisure-tradeoff model of labor supply, in which individuals first decide whether to work or not and, once employed, how many hours to work. Becker's (1965) model assumes that individuals within a household derive their utility from consumption and production of basic commodities, such as going to the movie theater, eating at a restaurant, and spending time on physical activity, by combining time and market goods subject to budget constraint. In the income-leisure-tradeoff, the production and consumption of basic commodities requires time, which is called non-working time. As Becker (1965, pp. 493) states, *"the allocation and the efficiency of non-working time may be more important to economic welfare than that of working time; yet the attention paid by economists to the latter dwarfs any paid to the former."*

Drawing on Becker's (1965) model, Grossman (1972; 1999) constructs the demand-for-health-model, which threats health capital as one component of human capital. In sum, the model assumes that individuals have an innate stock of health that depreciates with age and can be increased or decreased by health inputs. Examples of inputs include housing, diet, smoking, alcohol consumption, and physical activity. Efficiency depends on the amount of health obtained from a given amount of health inputs. Compared with other forms of human capital in which individuals' stock of knowledge affects market and nonmarket activities, in this model, health determines the total amount available on market and nonmarket activities. Gerdtham et al. (1999) employs Grossman's (1972) model and empirically tests the demand for health in Swedish data. Three measures of overall health status are used and health inputs include, for example, smoking, alcohol consumption, body mass, and the degree of sporting activities. Gerdtham et al. (1991) find that the demand for health decreases with overweight and smoking and increases with higher level of sporting activities. In particular, sports participation is a strong predictor of health status.

Cawley (2004) utilizes Becker's (1965) framework to derive the SLOTH model. The underlying assumption of the model arises from the observation that individuals choose how to allocate their 24 hours of the day to competing activities such as sleeping, leisure, occupation, transportation, and home production in order to maximize their lifetime utility subject to time, budget, and biology constraints. In every domain, except sleeping, individuals may choose whether to be physically active, and these decisions depend on their differing preferences. Once an activity is chosen, the next decision involves how long, at what intensity, and how often to engage in it.

Humphreys and Ruseski (2006) extend the Cawley's (2004) SLOTH model and develop a consumer choice model of participation in physical activity. In this model, individuals face two distinct decisions: 1) whether to participate in physical activity, and 2) how much time to spend in physical activity. The utility maximization problem has three components: individuals' decisions to participate in physical activity (A), duration of physical activity sessions (T), and individuals' decisions to engage in other activities (Z). Individuals choose A, T, and Z to maximize their utility subject to time and budget constraints. Using data from the Behavioral Risk Factor Surveillance System, Humphreys and Ruseski (2006) empirically test the model. The study includes more than 175,000 Americans with a mean age of 47 years. Physical activity questions cover the frequency, type, and duration of physical activity sessions. The empirical results suggest that higher income is positively associated with the probability of participating in physical activity, but the effect is relatively small: a US$10,000 increase in income increases the probability of participating in physical activity by 1%. The results also provide evidence that economic factors affect the choice to participate in physical activity, and the time spent in physical activity in opposite directions: higher income increases the probability of participating in physical activity but decreases the amount of time spent in physical activity. (Humphreys and Ruseski, 2006.)

Meltzer and Jena (2010) utilize Becker's (1965) and Grossman's (1972) models and introduce the costs of health investments to the literature of the allocation-of-time-model. Meltzer and Jena (2010) analyze the role of time constraints in physical activity and examine whether the intensity of physical activity sessions increases relative to the time spent on physical activity as wages rise. In Meltzer and Jena's (2010) model, individuals' utility depends on three components: health (H), intensity of physical activity sessions (I), and consumption of composite goods (X). The model assumes that utility increases with respect to H and X and decreases with respect to I. The model includes two constraints — budget constraints for time and for goods —which depend on hours worked, hourly wages, income endowments, and the price of X. The results suggest that people respond to higher time costs of physical activity by increasing the intensity of physical activity sessions: individuals in the highest income group record approximately 26% higher energy expenditures and 3% higher exercise intensity than individuals in the lowest income group. Thus, Meltzer and Jena (2010) suggest that, while higher income enables more opportunities to invest in health, it also makes investments more costly due to the use of time. Therefore, individuals with higher incomes may increase the intensity rather than the duration of physical activity sessions.

Finally, Brown and Roberts (2011) modify the time allocation framework based on Becker's (1965) and Cawley's (2004) models and empirically determine the factors related to participation in physical activity using 2001–2006 data drawn from the Household Income and Labour Dynamics of Australia survey. The study sample consists of women (n=6,379) and men (n=6,767) with an age range of 18–65 years (Brown and Roberts, 2011). In the model, individuals have a finite amount of time to devote to market work, nonmarket work, and leisure. The model assumes that the opportunity cost of physical activity increases due to work and home commitments; that is, they make individuals less likely to participate in physical activity. Brown and Roberts (2011) confirm this assumption empirically: the negative association between education level and frequency of physical activity suggests a possible trade-off between nonmarket work, market work, and physical activity. Moreover, Brown and Roberts (2011) find that the impact of non-labor income has a relatively small impact on the frequency of physical activity, less than 1%. Therefore, Brown and Roberts (2011) imply that subsidies to promote participation in physical activity among working individuals may lead to a less than 1% increase in the frequency of physical activity.

Regarding the question of *who* is more likely to be physically active, a systematic review by Bauman et al. (2012) summarizes the correlates and the determinants of physical activity presented in earlier empirical literature[2]. In sum, a small number of variables are identified as consistent correlates of physical activity: *family social support* among adolescents; *male sex*, *self-efficacy*, and *previous physical activity* among individuals of all ages; and *reported health* and *intention to exercise* among adults (Bauman et al., 2012). Examples of studies examining the economic correlates of physical activity include Farrell and Shields (2002) and McInnes and Shinogle (2009). In general, the evidence suggests a positive association between individuals' economic resources and physical activity. For example, Farrel and Shields (2002) provide clear evidence that income increases the probability of sports participation and that low income may act as a barrier to participate in physical activity. Similarly, McInnes and Shinogle (2009) find that individuals with higher incomes are more likely to participate in physical activity than individuals with lower incomes.

1.1.3 Physical activity in relation to educational and labor market outcomes

The first researchers to set out to estimate physical activity benefits for educational and labor market outcomes focus mostly on high-school athletic participation, while fewer examine childhood leisure-time physical activity. A growing amount of recent studies analyzes the labor market returns of adulthood physical activity. Table 1 summarizes the main findings presented in the literature.

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2 Studies by Trost et al. (2002) and Sterdt et al. (2014) are other examples of systematic reviews on the correlates of physical activity. Additionally, Cabane and Lechner (2015) view a wide range of literature in economics, epidemiology, sports sciences, and social sciences and summarize the reasons for adults' participation in physical activity.

TABLE 1 Main findings in the literature

Focus	Main findings
High school athletic participation	• Higher academic achievement (grade point average) (Lipscomb, 2007; Rees and Sabia, 2010) • Higher graduation rates (Long and Caudill, 1991) • Higher level of post-secondary education among men (Barron et al., 2000) • Higher college enrollment and labor force participation among women (Stevenson, 2010) • Positive relation to union membership, performance pay, and supervisory status among men (Ewing, 1998) • Higher educational attainment and earnings among black male athletes, higher educational attainment among white female athletes, and lower educational attainment among white male athletes (Eide and Ronan, 2001) • Higher earnings among men (Long and Caudill, 1991; Barron et al., 2000)
Childhood and adolescent physical activity	• Higher educational attainment (Pfeifer and Cornelißen, 2010) • Higher levels of autonomy at work and more managerial responsibilities (Cabane and Clark, 2015) • Improvements in educational outcomes: cognitive skills, school grades and future educational plan from joint engagements in music and sport activities (Cabane et al., 2016)
Adulthood physical activity	• Higher earnings among women and men (Lechner, 2009; Kosteas, 2011; Lechner and Sari, 2015) • Higher earnings among men (Cabane, 2010; Rooth, 2011; Hyytinen and Lahtonen, 2013) • Quicker transition from unemployment to employment among women (Cabane, 2014) • Higher probability of employment (Kavetsos, 2011) • Higher educational attainment and occupational outcomes among men (Åberg et al., 2009) • Higher probability of callbacks to job interviews (Rooth, 2011) • Higher initial access to employment and higher earnings (Lechner and Downward, 2017)

In a research stream starting in the early 1990s, Long and Caudill (1991) find that women and men who participate in varsity athletics at the college level have a higher probability of graduating, and among men, college athletic participation is also related to higher subsequent earnings. Long and Caudill's (1991) study involves nearly 10,000 freshmen from 487 American colleges who participated in baseline interviews in 1971 as a part of an ongoing study of higher education by the American Council of Education. The re-interviews with questions on college activities (athletic participation), educational attainment, and annual earnings were conducted in 1980 (Long and Caudill, 1991). Aligning with Long and Caudill (1991), Barron et al. (2000) find that high school athletic participation is related to higher subsequent educational attainment and wages. Barron et al. (2000) also analyze the relationship between high school sports and employment. However, the results do not support the view that male athletes are more likely to be employed than non-athletes. The study includes only men (n=4,061) and the data relies on two data sets: the National Longitudinal Survey of Youth (NLSY) and the National Longitudinal Study of the High School Class of 1972. When the measures of ability (comprehensive tests on mathematics, verbal skills, and reading) and high-school rank are taken into account, the estimates for education and wages decrease but remain significant (Barron et al., 2000). Ewing (1998) also utilizes the NSLY data and focuses only on men (n=1,301) to study the labor market returns of high school athletic participation. Labor market outcomes include three measures: performance pay, union membership, and number of workers supervised by the respondents. In sum, Ewing (1998) finds that high-school athletic participation is positively related to labor market outcomes regardless of outcome variable: athletes are more likely to be employed in jobs paid based on performance, to belong to unions, and to hold supervisory positions.

Eide and Ronan (2001), Lipscomb (2007), and Rees and Sabia (2010) further investigate the role of high school sports in educational and labor market outcomes. Using data from the National Education Longitudinal Study of 1998 (n=16,449), Lipscomb (2007) finds both immediate and long-term effects from sports participation. High school athletic participation is associated with an approximately 2% increase in math and science test scores, club participation with an approximately 1% increase in math test scores, and involvement in either activity with an approximately 5% increase in bachelor-degree attainment expectations (Lipscomb, 2007). Rees and Sabia (2010) also examine the role of high school sports participation in academic achievement. In particular, the data are drawn from the National Longitudinal Study of Adolescent to Adult Health (Add Health) and ordinary least squares (OLS), fixed effects (FE), and instrumental variable (IV) models are employed. Like Lipscomb (2007), Rees and Sabia (2010) find a positive association between sports participation and academic achievement as measured by GPA in math and English. However, the FE and IV (with height as an instrument) estimates are smaller (FE) than the corresponding OLS estimates or are insignificant and negative (IV). Eide and Ronan (2001) further examine the associations of high school sports by including both educational and labor market outcomes in the analysis. Educational attainment consists of three measures (dropping out of high school, college enrollment, and college graduation), while labor market outcomes are defined as earnings measured ten years after the respondents' senior year in high school. An IV approach is employed, and students' height at age 16 is used as an instrument. The results indicate that the associations differ by race and ethnicity: among white male students, sports participation is related to lower educational attainment, whereas among white female students, sports participation increases educational attainment. Among black male students, sports participation is related to both higher educational attainment and higher earnings, and among Hispanic men and Hispanic and black women, no association is found. (Eide and Ronan, 2001.)

Similarly to, for example, Barron et al. (2000), Eide and Ronan (2001), and Rees and Sabia (2010), Stevenson (2010) uses an IV approach to tease out the causal relationship between high school athletic participation, subsequent years of education, and labor market outcomes, particularly employment status, occupation, and wages. Stevenson (2010) uses Title IX as an instrument, a law, which was launched in 1972 and which banned gender discrimination in federally funded educational institutions in the United States. Regarding athletic participation, Title IX mandates that schools increase their female athletic participation rates equal to their male athletic participation rates. Stevenson (2010) finds that a 10 percentage-point increase in female sports participation is related to a 1 percentage-point higher female college attendance and a 1–2 percentage-point increase in female labor force participation (1.3 percentage points in the probability full-time employment). Regarding wages, Stevenson (2010) indicate that increased wages result solely from the rise in labor force participation.

Pfeifer and Cornelißen (2010), Cabane et al. (2016), and Cabane and Clark (2015) are examples of studies that estimate the role of childhood or adolescence physical activity, instead of high school athletic participation, in educational and labor market outcomes. Pfeifer and Cornelißen (2010) and Cabane et al. (2016) focus on educational outcomes, and Cabane and Clark (2015) on labor market outcomes. Using German Socio-Economic Panel (SOEP) data, Pfeifer and Cornelißen (2010) show that participation in outside school athletic activities during adolescence is positively related to educational attainment measured by attainment of secondary school diplomas and professional degrees. The study sample consists of individuals (n=6,050) who have completed their education (age range: 17–99 old) and the information on physical activity during adolescence is retrospective (Pfeifer and Cornelißen, 2010). Using the same SOEP data, Cabane et al. (2016) assess the role of playing music, practicing sports, or both at age 17 years in educational and health outcomes, including school grades (math, German, and foreign languages), school type, plans to attend university, and cognitive skills measured by standardized tests (word analogies, figures, and mathematics operators). The questions regarding physical activity and sports cover the frequency of physical activity, type of physical activity, and participation in sports competitions[3]. An IV approach is employed and parental artistic activities are used as an instrument (Cabane et al., 2016). Cabane et al. (2016) find that playing music and sports during adolescence have different implications for health and educational outcomes. In particular, musically active adolescents earn better grades in languages and attend more likely to upper secondary school and university than physically active adolescents. As well, physical activity is positively related to subjective health.

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[3] In the baseline models, an individual is considered to be musically active based on the following criteria: 1) plays a musical instrument at age 16 or 17 years; and 2) starts to play musical instrument at age 14 years or younger. Similarly, individuals are considered to be physically active if they are active in sports at age 16 and 17 years and start their main sport at age 14 years or younger.

Finally, Cabane and Clark (2015) use data from two waves of the Add Health survey to analyze the relationship between childhood sporting activities and adulthood labor market outcomes. The study sample consists of children in grades 7 and 12 at baseline (1994–1995 academic year). Their labor market outcomes are obtained 13 years later, when the participants' age ranges from 24 to 32 years. Childhood sporting activities are divided into three groups: active transportation (e.g., cycling, roller-skating), exercise (individual sports such as jogging, dancing, and gymnastics), and active sports (team sports such as basketball, baseball, and soccer). Labor market outcomes consist of five variables: probability of employment, wages, managerial responsibilities, autonomy at work, and job satisfaction. The results suggest that the associations vary by the outcome variable and type of physical activity. For example, individual sports (exercise) predict adulthood managerial responsibilities, whereas team sports (active sports) predict autonomy at work. No association involving employment probability, wages, and job satisfaction are found. The results also seem to differ by gender as team sports have a larger effect on boys' adulthood labor market outcomes and individual sports on girls' labor market outcomes.

Lechner (2009), Cabane (2010), Kavetsos (2011), Rooth (2011), Kosteas (2012), Hyytinen and Lahtonen (2013), Cabane (2014), Lechner and Sari (2015), and Lechner and Downward (2017) analyze the labor market returns of adulthood physical activity. Using SOEP data from 1984–2006, Lechner (2009) shows that physical activity is positively related to monthly earnings and hourly wages among women (n=3,253) and men (n=3,498). Hyytinen and Lahtonen (2013) report similar findings for men (n=5,042) based on Finnish twin data (Older Finnish Twin Cohort Study). According to Hyytinen and Lahtonen (2013), the long-term income premium over 1990–2004 is 14%–17% among physically active males, while Lechner (2009) reports an earnings gain of approximately 100 euros per month and 1 euro per hour. Lechner (2009) also analyzes the labor supply effects of physical activity. Among women, the results suggest that increased probability of full-time employment accompanies a declining share of women considered to be out-of-the-labor force; among men, no association is found (Lechner, 2009).

Cabane (2010) demonstrates how adulthood extracurricular activities (sports participation, artistic activities, or volunteer work) favor life success in terms of individuals' job quality measured by hourly wage and level of autonomy at work. Due to the specificity of woman's career paths, Cabane (2010) excludes women from the sample, and the study focuses only on men aged 16–55 years. As in Lechner (2009) and Pfeifer and Cornelißen (2010), among others, the data are drawn from SOEP and the study covers the years from 1991 to 2007. For sports practice, a dummy variable of practicing sports at least once a week is formulated. The results suggest a positive association between sports participation and wage levels. No clear association of wages is observed with levels of autonomy or other extracurricular activities, such as artistic activities or volunteer work. Cabane (2010), however, finds that artistic activities are positively related to autonomy levels. Using the same SOEP data Cabane (2014) further examines the role of sports participation in labor market outcomes, with a special focus on unemployment duration. A quicker transition from unemployment to employment is found among those who practice sports at least weekly. In particular, not previously physically active women who practice sports during unemployment spend less time unemployed. Among men, no such clear association is found. Using cross-sectional data from 25 European countries, Kavetsos (2011) also examines the role of physical activity in employment probability. In sum, Kavetsos (2011) finds a positive association between physical activity and employability as being physically active increases the probability of employment by 5% among men and 3.8% among women.

Åberg et al. (2009) and Rooth (2011) analyze the longitudinal associations of physical activity, educational attainment, and labor market outcomes among Swedish men. Åberg et al. (2009) extends the literature by using objectively measured cardiovascular fitness (physical fitness), that is, the maximum watts attained on a stationary bike divided by the individual's body weight, as a starting point for the analysis. Åberg et al., (2009) includes all Swedish men born between 1950 and 1976 who enlisted to the military service at age 18 years (n=1,221,727). According to results, higher physical fitness at age 18 years is associated with higher educational attainment (university vs. high school) and higher occupational outcomes (professions ranked by high and low socioeconomic status) later in life. Rooth (2011), in turn, uses two unique data sets from Sweden to examine the role of adulthood physical activity in labor market outcomes. The first data set consists of all Swedish men who enlisted in the military between 1984 and 1997 and were 28–38 years old in 2003 (n=446,930[4]). Instead of physical activity, in line with Åberg et al, (2009), the study focuses on physical fitness. The baseline results indicate a statistically significant fitness premium: one standard deviation increase in physical fitness is associated with 7% higher earnings. When including all the control variables (e.g., family factors, non-cognitive skills) the physical fitness premium decreases to 4%. Additionally, Rooth (2011) conducts a field-experiment in which fictitious job applications (n=8,466) are submitted to real job openings in the Swedish labor market. In the results, individuals who indicate sports skills (team sports or individual sports) in their job applications receive 2 percentage-point more callbacks to job interviews. In the case of physically demanding occupations, the effect doubles.

Lechner and Sari (2015) use the data from Canadian National Population Health Survey. The analysis is based on individuals aged 20–44 years in 1994 and who were followed until 2008 (n=4,796). In line with Lechner (2009) and Hyytinen and Lahtonen (2013), Lechner and Sari (2015) find a positive association between sports participation and earnings. In particular, the results suggest that the income premium rises to 10%–20% after 8–12 years. Regarding other labor market outcomes, such as employment status and work hours, no associa-

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4 The baseline sample consists of 468,312 individuals. Of these, 96% have positive earnings in 2003. To analyze variation between siblings, the sample size is reduced to 144,671 individuals.

tion is found. Kosteas (2012)[5] also reports a physical activity premium: physical activity is related to a 6%–10% increase in earnings. Additionally, the results suggest that, while moderate physical activity is related to higher earnings, the effect is even stronger among those who are more physically active (frequently active) (Kosteas, 2012). Similarly, Lechner and Sari (2015) argue that, to gain long-term labor market benefits, individuals must meet the recommended levels of physical activity.

Finally, in a recent study Lechner and Downward (2017) examine the associations between different types of adulthood sports participation and labor market outcomes in England (n=79,561)[6]. The study analyzes five distinct sports groups: team sports, keep fit activities, racquet sports, leisure activities, and outdoor activities. Labor market outcomes include two variables: employment and earnings. Overall, Lechner and Downward (2017) find that sports participation is associated with an approximately 10% increase in earnings among women and men of all ages and higher employability among younger women and men. Regarding different sports groups, Lechner and Downward (2017) find that team sports contribute more to employability and that fitness and outdoor sports contribute to higher income.

1.1.4 The mechanism between physical activity and labor market outcomes

Previous studies consistently find that physical activity is positively related to labor market outcomes, but the mechanism between the variables is unclear. The literature outlines four potential explanations for this correlation (Figure 1). The first explanation concerns health. The health benefits of physical activity are self-evident (Physical Activity Guidelines Advisory Committee, 2008; Lee et al., 2012; WHO, 2010), and health itself is a significant factor of human capital (Grossman, 1972). Thus, physical activity may improve health, thereby decreasing absences due to sickness (Amlani and Munir, 2014; Lahti, 2010), encouraging better employee performance (Lahti, 2013), and increasing labor productivity and earnings (Lechner, 2009; Lechner, 2015). Second, participation in physical activity, especially organized sports, creates networks (Lechner, 2009), which may promote career development, leading to a higher labor market outcomes.

Third, physical activity may help to develop cognitive (Åberg et al., 2009; Barron et al., 2000) and non-cognitive skills (Bailey, 2005; Bailey et al., 2009; Ewing, 1998), which are rewarded later in the labor market. For example, Åberg et al., (2009), finds that the changes in physical fitness predict changes in cognitive performance: 15–18-year-old adolescents whose physical fitness increases have higher global intelligence, logical, verbal, visuospatial, and technical scores than adolescents whose physical fitness decreases. As well, Åberg et al.

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5 In line with Barron et al. (2000), Kosteas (2012) utilizes NSLY79 data, including the 1998 and 2000 waves in the analysis. The participants ages range from 33 to 41.

6 Baseline data are drawn from the ongoing Active People Survey and combined with data on the number of sports facilities at the local-authority level. Other part of the data are drawn from the Annual Population Survey, which combines the results from the Labour Force Survey, including data on social and socioeconomic variables.

(2009) show that higher physical fitness at age 18 years is associated with higher educational and occupational attainment in later life. Fourth, Rooth (2011) shows that individuals who include sports activities in job applications have a higher probability of receiving callbacks to job interviews. Thus, physically active individuals might signal to employers their good health, motivations, ambitions, and productivity, and therefore can cause a positive discrimination, which explains the success in individuals' work lives.

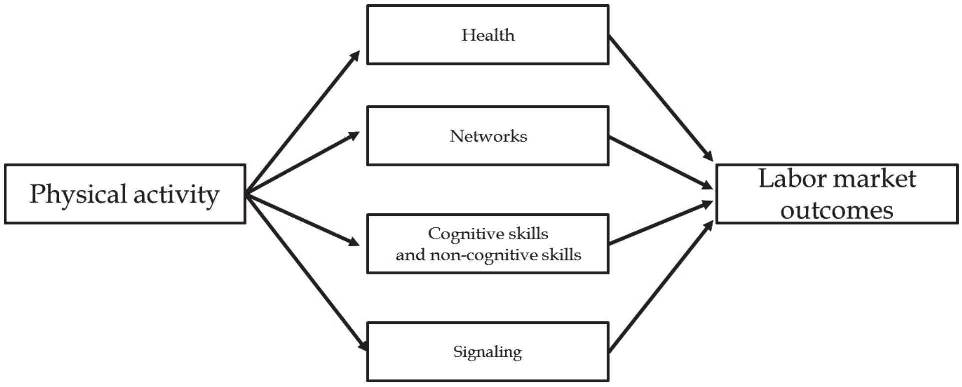

FIGURE 1 Potential explanations for the correlation between physical activity and labor market outcomes presented in prior literature

1.2 Overview of the thesis

1.2.1 Research questions

This thesis consists of four studies organized into separate chapters (Figure 2). Chapters 2, 3, and 4 examine the role of childhood physical activity in academic achievement, educational attainment, and long-term labor market outcomes. Chapter 5 studies the relationship between individuals' economic resources and physical activity behavior in adulthood. The research questions, by chapter, are:

- Chapter 2: How are physical activity level and the changes in physical activity level during childhood related to academic achievement at the end of compulsory basic education and subsequent educational attainment in adulthood?
- Chapter 3: How is childhood physical activity associated with long-term earnings in adulthood?
- Chapter 4: Do the level and the changes in physical activity during childhood explain adulthood labor market outcomes, particularly employment status, employment, and unemployment?
- Chapter 5: Are individuals' economics resources (i.e. annual income) related to adulthood physical activity? Does the association depend on the measurement type of physical activity (self-reported vs. objectively measured) or the measurement day of physical activity (weekday vs. weekend)?

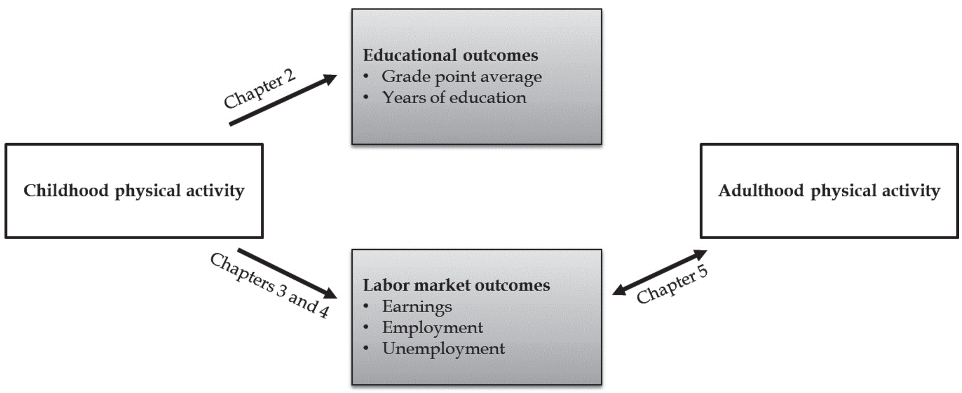

FIGURE 2 Framework of the thesis

Chapter 2 investigates whether physical activity level at age 15 years and changes in physical activity level between the ages of 12 and 15 are associated with GPA at age 15 and subsequent years of post-compulsory education in adulthood. The roles of participation in sports club training sessions and sports competitions in educational outcomes are also examined. Although earlier studies show that physical activity is positively related to academic achievement and educational attainment, some research findings are inconsistent and suggest the existence of unmeasured heterogeneity, selection issues, and the endogeneity of physical activity (see e.g., Barron et al., 2000; Eide and Ronan, 2001; Rees and Sabia, 2010; Stevenson, 2010). Additionally, earlier economic studies generally focus on high school athletic participation and use data obtained from the United States (Barron et al., 2000; Eide and Ronan, 2001; Long and Caudill, 1991; Rees and Sabia, 2010; Stevenson, 2010). Therefore, little is known about the longitudinal consequences of childhood leisure-time physical activity outside school hours for academic achievement and educational attainment within the same individual and data collected in Europe. As Becker (2009) states, education is one of the most important investments in human capital. To inform and develop physical activity interventions targeted at school-aged children, it is important to examine whether and how childhood physical activity is related to educational outcomes during the life course.

Chapter 3 examines the association between childhood physical activity and long-term earnings in adulthood. Concerning physical activity and labor market returns, the empirical literature mainly focuses on adulthood physical activity and high school athletic participation (see e.g., Long and Caudill, 1991; Barron et al., 2000; Lechner, 2009; Hyytinen and Lahtonen, 2013). Consequently, there is little information on the longitudinal associations of childhood physical activity, especially leisure-time physical activity measured outside school hours, and long-term labor market outcomes in adulthood.

Chapter 4 further examines the relationship between childhood physical activity and long-term labor market outcomes focusing on employment status, employment months, and unemployment months. The research presented in chapter 4 includes three aims. First, the association between childhood physical activity and the probability of employment is examined. Second, the associations of childhood physical activity with long-term employment months and long-term unemployment months are investigated. Third, whether changes in physical activity level during childhood are related to long-term employment and unemployment months is scrutinized.

Focusing on childhood physical activity in Chapters 3 and 4 is important for at least two reasons. First, the literature (e.g., Farrell and Shields, 2002; McInnes and Shinogle, 2009; Hyytinen and Lahtonen, 2013) suggests that adulthood physical activity can be partly explained by individuals' economic resources. This can make the direction of the association between physical activity and labor market outcomes unclear. Focusing on childhood physical activity measured before any labor market experience eliminates the potential problem of reverse causality. Second, the impact of physical activity on labor outcomes might take time to materialize. The longitudinal study design from childhood onwards enables studying whether the consequences of physical activity in labor market outcomes start to develop as early as childhood. As well, the policy-perspective presents at least two reasons for the importance of focusing on childhood physical activity: if childhood physical activity can boost individuals' labor market outcomes in later life, then increasing participation in physical activity during the life course may constitute an important policy goal. Second, encouraging children to be physically active, providing equal possibilities for children to participate in physical activity regardless of socioeconomic background, and targeting interventions at children and youth with the lowest physical activity levels should become important policy objectives.

Chapter 5 examines the associations between annual income and physical activity in adulthood. The study uses three measures to illustrate daily physical activity: self-reported leisure-time physical activity, pedometer-based daily total steps, and pedometer-based aerobic steps. In recent years, a growing number of studies use objective measures of physical activity (e.g., pedometers, accelerometers) (Hallal et al., 2012; Hendelman et al., 2000; Tudor-Locke et al., 2002; Tudor-Locke and Basset, 2004; Vanhees et al., 2005), apart from self-reported questionnaires. However, studies that investigate the relationship between income and physical activity by using self-reported and objectively measured physical activity have not been conducted. A better understanding of whether and how individuals' economic resources are related to different dimensions of physical activity can aid health promoters in implementing efficient tools to increase participation in physical activity by individuals with different socioeconomic backgrounds.

1.2.2 Data and variable definitions

The data in this thesis are drawn from three data sets and cover the period from 1980 to 2011 (Figure 3): 1) the ongoing longitudinal Cardiovascular Risk in Young Finns Study (YFS); 2) the Finnish Longitudinal Employer-Employee Data (FLEED) of Statistics Finland, and 3) the Longitudinal Population Census (LPC) of Statistics Finland. Chapters 2, 3, and 4 utilize all three data sets, and Chapter 5 YFS and FLEED.

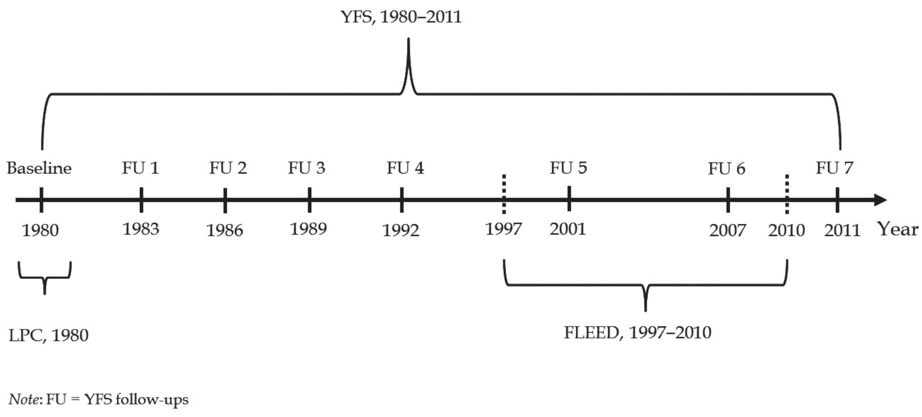

FIGURE 3 Overview of the data

YFS was launched in the late 1970s to study cardiovascular risk in youth (Raitakari et al., 2008). The first cross-sectional study was conducted in 1980. Altogether 3,596 children and adolescents aged 3, 6, 9, 12, 15, and 18 years participated in the baseline study. The participants were randomly chosen boys (51% boys) and girls (49%) from the population registers of the five Finnish university cities with medical schools (Helsinki, Turku, Tampere, Kuopio, and Oulu) and their rural surroundings to produce a representative sample of Finnish children and adolescents[7]. Since 1980, seven follow-ups (1986, 1989, 1992, 2001, 2007, and 2011/2012) have been conducted. Each follow-up has entailed comprehensive data collection using questionnaires, physical measurements, and blood tests measuring, for instance, general health status, blood pressure, lifestyle factors, physical activity, and socioeconomic status (see Raitakari et al., 2008 for additional details). The YFS research protocol has been approved by the ethics committees of the five universities (Helsinki, Turku, Tampere, Oulu, and Kuopio), and all participants provide prior written, informed consent. Moreover, data protection issues are taken into account as specified in current Finnish law. (Raitakari et al., 2008.)

Register-based FLEED is an annual panel that covers the entire working-age population of Finland. In this thesis, FLEED data from 1997 to 2010 are used. FLEED records detailed information on labor market outcomes, such as employment relationships, unemployment periods, income, and post-compulsory education. The data come directly from tax and other comprehensive administrative registers (e.g., employer's enterprise code, establishment code) and are maintained by Statistics Finland. Information on family background factors from 1980 (parental education and family income) are drawn from the register-based LPC.

Similarly to, for example, Böckerman et al. 2016 and Pehkonen et al. 2015 YFS data are linked to FLEED and LPC data using unique personal identifiers. This method provides exact matching without misreported identification codes and avoids problems created by errors in record linkages (Ridder and Moffitt, 2007). Moreover, post-compulsory educational information and labor market variables do not suffer under- or over-reporting or recall errors. Combining these three data sets enables tracking the individuals who participated in the YFS in the baseline year (1980) from childhood to adulthood (Table 2).

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7 In the baseline year 1980, altogether 4,320 children and adolescents from six age cohorts were randomly chosen from the population registers to produce a nationally representative sample of Finnish children. In practice, boys and girls of each age-cohort in each study community (Helsinki, Turku, Tampere, Kuopio, Oulu), were separately placed in a random order based on a unique personal identification number. Thereafter, every *k*th girl and every *k*th boy in each community was selected so as the sample consisted of the required number of boys and girls. The varying *k* factors were determined based on the sample size and the total number of boys and girls in the different age-cohorts in each community (see Raitakari, et al., 2008 for additional details of the cohort profile).

TABLE 2 Links between YFS, FLEED, and LPC and participants' age, 1980–2011

	YFS + FLEED + LPC									
	1980	1983	1986	1989	1992	1997	2001	2007	2010	2011
Cohort 1 (born in 1977)	3	6	9	12	15	20	24	30	33	34
Cohort 2 (born in 1974)	6	9	12	15	18	23	27	33	36	37
Cohort 3 (born in 1971)	9	12	15	18	21	26	30	36	39	40
Cohort 4 (born in 1968)	12	15	18	21	24	29	33	39	42	43
Cohort 5 (born in 1965)	15	18	21	24	27	32	36	42	45	46
Cohort 6 (born in 1962)	18	21	24	27	30	35	39	45	48	49

Notes: YFS — Cardiovascular Risk in Young Finns Study; FLEED — Finnish Longitudinal Employer-Employee Data; LPC — Longitudinal Population Census. YFS was launched in 1980, with follow-ups conducted in 1983, 1986, 1989, 1992, 2001, 2007, and 2011. FLEED covers 1997–2010, and LPC 1980.

Physical activity variables are based on YFS data. In each follow-up, physical activity is measured with a self-reported questionnaire (see Telama et al., 1996; Telama et al., 2014, Raitakari et al., 2008 for additional details). This thesis utilizes physical activity details from years 1980, 1983, 1986, 1989, 1992, and 2011. In 1980, 1983, 1986, and 1989, the questions concern the frequency and intensity of leisure-time physical activity, participation in sports club training sessions, participation in sports competitions, and most common ways of spending leisure-time (Telama et al., 1996; Telama et al., 2014). Following Telama et al. (1996), the response alternatives are coded 1, 2, or 3 — except participation in sports competitions, which is coded 1 or 2 — and are summed to form a physical activity index (PAI), with scores ranging from 5 to 14. In 1992 and 2011, the questions concern the intensity of leisure-time physical activity, frequency of intensive physical activity, weekly hours of intensive physical activity, average duration of physical activity sessions, and membership in a sports club. Following Telama et al. (2014), the response alternatives are coded 1, 2, or 3 —except the membership of a sports clubs in 1992, which is coded 1 or 2— and are summed to form a PAI (1992), with scores ranging from 5 to 14. In 2011, the PAI varies with a scores ranging from 5 to 15. In 2011, physical activity is also measured objectively with a pedometer for seven consecutive days (Hirvensalo et al., 2011). The results are expressed as total steps per day and aerobic steps per day. Total steps include every step taken throughout the day, while aerobic steps are calculated automatically for continuous, uninterrupted walking for more than 10 minutes at a pace of >60 steps/min.

In chapter 2, academic achievement and educational attainment are indicated by two measures: GPA at age 15 years and years of post-compulsory education in adulthood. YFS provides GPA information, which consists of a self-reported numerical assessment on a scale of 4–10, in which 4 denotes *failed* and 10 denotes *excellent*. Information on post-compulsory education is provided by FLEED. Years of education are calculated by transforming the highest obtained degree in 2010 into years of education using Statistics Finland's official estimates for completing a specific degree.

The labor market variables in Chapters 3 and 4 are based on FLEED data. In Chapter 3, earnings are measured as a logarithm of the average annual wages and salaries calculated over the sample period of 2000–2010. The values are deflated using the consumer price index with the base year of 2000. Chapter 4 has three labor market variables: employment status, average employment months, and average unemployment months. Employment status is formulated as a binary variable, which equals 1 if an individual was employed throughout the observational year and 0 otherwise (unemployed, retired, or out-of-the labor force). Employment months refer to the average number of months of employment per year from 1997 to 2010. Similarly, unemployment months refer to the average number of unemployment months per year over 1997–2010.

In Chapter 5, information on annual income is obtained from YFS and FLEED. In YFS, information is collected with a self-reported questionnaire in years 2007 and 2011. To avoid potential misclassification in self-reported income measures, register-based earnings from 2010 are drawn from FLEED.

1.2.3 Methods

The empirical analysis in Chapter 2 consists of four stages. First, in ordinary least squares (OLS) models, the association between childhood physical activity and educational outcomes is regressed using the GPA at age 15 years and years of completed education as the dependent variables and PAI at age 15 years as an explanatory variable. Second, the role of changes in physical activity level between ages 12–15 years in educational outcomes is examined. This is done by constructing two binary variables, which equals 1 if the physical activity level increases or decreases between the two time points, and 0 otherwise. Third, the roles of participation in sports club training sessions and participation in sports competitions in educational outcomes are scrutinized. The original PAI is divided into three parts: 1) a variable representing participation in sports club training sessions; 2) a variable representing participation in sports competitions; and 3) the original PAI subtracted from the sports competitions and sports club training sessions variables. Finally, to alleviate possible endogeneity of childhood physical activity, omitted variable bias, and measurement error, the analysis follows Eide and Ronan (2001), Rees and Sabia (2010), and Pfeifer and Cornelißen (2010): an IV approach is employed, and individuals' body height is used as an instrument. Following Cabane et al. (2016) who use parental artistic activities as an instrument for children playing music or sports, parents' physical activity details are also selected as an instrument in the IV model.

In Chapter 3, the empirical analysis is based on the OLS models. In the baseline analysis, the association between childhood physical activity and subsequent labor market returns is regressed using the logarithm of average annual earnings over 2000–2010 as the dependent variable and the PAI at ages of 9, 12, and 15 years as an explanatory variable. The consistency and the robustness of the OLS results are tested in four ways. First, to alleviate the possibility that childhood physical activity reflects omitted variables without having an independent effect on subsequent labor market outcomes, the models are extended with several additional covariates, including individual and family background factors. Following Angrist and Picshke (2009 p. 68), all controls are obtained before any labor market experience. Thus, future labor market outcomes cannot have effect on controls measured before labor market entry. Second, to examine whether the differences between the point estimates reflect the differences in the sample, the sample size is locked to the participants whose physical activity details can be tracked at each time points (at ages 9, 12, and 15 years). Third, to investigate the possibility that the results are driven by physically active individuals' more intense labor market attachment, the baseline models are augmented with average employment months over 2000–2010. Finally, to examine whether the quality of the leisure-time physical activity affects the results, the original PAI is divided into two parts: 1) a variable representing participation in sports competition; and 2) the original PAI subtracted from the sports competition variable. The former variable indicates more target-oriented physical activity, and the latter overall leisure-time physical activity outside school hours.

The analysis in Chapter 4 is based on the OLS model using average employment months and unemployment months as the dependent variables and the PAI at ages 9 and 15 years as the explanatory variable. Employment and unemployment months are calculated for single years in 2000, 2005, and 2010 and over the sample periods of 1997–2010 and 2005–2010. The former covers the entire working history of YFS participants, while the latter represents the so-called prime working age, since the YFS participants' age ranges from 28 to 48 years. The robustness of the results is evaluated with the addition of various controls, including individual and family background factors. To examine whether the labor market outcome (employment/unemployment) differs according to changes in physical activity level from childhood to youth, individuals are divided into five activity groups: persistently active, increasingly active, moderately active, decreasingly active, and persistently inactive[8]. Before the

[8] The participants are first divided into three groups according to their PAI values at age 9 years: physically active (PAI values ≥11), moderately active (PAI values = 9–10), and physically inactive (PAI values ≤8). At age 15, the participants are divided into five activity groups: persistently active, increasingly active, moderately active, decreasingly active, and persistently inactive. Persistently active individuals have PAI values of ≥ 11 ages of 9 and 15. The increasingly active participants raise their physical activity level from "physically inactive" to "moderately active" or "physically active" or from "moderately active" to "physically active". Moderately active individuals have PAI values of 9 or 10 at both ages. Decreasingly active individuals physical activity level falls from "physically active" to "moderately active" or "physically inactive", or from "moderately active" to "physically inactive". Persistently inactive individuals have PAI values of ≤ 8 at both ages.

OLS models, a probit model is employed to illustrate the association between childhood physical activity and the probability of employment.

In Chapter 5, the baseline OLS analysis examines the association between annual income and physical activity. Three measures of physical activity are used: self-reported PAI, pedometer-based total steps per day, and pedometer-based aerobic steps per day. The baseline models control for socioeconomic characteristics (age, neighborhood, marital status, number of children, years of education, work status, and workload); health endowments (summary of the self-reported number of diseases and body mass index); and family background factors (family income, parents' education, and parents' physical activity). The baseline models are extended in three ways. First, to deal with possible misclassification in self-reported income measures, YFS data are linked with register-based FLEED data. To ensure the comparison with the baseline results, the register-based income details are divided into 13 categories, similarly to the self-reported income information. Second, to alleviate possible measurement error and omitted variable bias, an IV approach is employed. The data consist of two possible instruments: income in 2007 and family income in the baseline year of 1980. Finally, to test the role of time constraint, that is, whether the results depend on the measurement day, the pedometer-based physical activity is divided by weekdays and weekends.

1.2.4 Main findings

The main findings of each chapter are summarized in Table 3. The results in Chapter 2 show that childhood physical activity is positively related to academic achievement at the end of compulsory basic education and to years of subsequent education. More specifically, physical activity level at age 15 years and an increase in physical activity level between ages 12 and 15 years are positively related to GPA at age 15 years and years of post-compulsory education in adulthood. The results are robust to controlling for individual and family background factors, including health endowments, family income, and parents' education. When controlling for prior academic achievement (i.e., GPA at age 12 years), the strength of the association decreases. This implies that the association between physical activity and education can be partly attributed to the higher GPA of physically active children. In line with OLS estimation results, the IV results indicate a positive association between physical activity and educational outcomes. In general, the results suggest that childhood physical activity may not only predict academic success during compulsory basic education but also boost educational outcomes later in life.

The results in Chapter 3 show a positive association between childhood physical activity and long-term earnings in men: leisure-time physical activity at ages 9, 12, and 15 years is related to higher earnings calculated over 2000–2010. The results are robust while controlling for individual and family background factors, including health endowments, family income, parents' education, and parents' physical activity. Among women, however, no such clear association is found.

Interestingly, when controlling for employment months, the physical activity point estimate decreases among men and becomes statistically significant among women. This implies that the connection between physical activity and earnings can be partly attributed to the more intense labor market attachment of physically active individuals; that is, they experience less unemployment, or their labor market participation is higher. One explanation for the positive association between physical activity and earnings is that some unobserved traits, such as ambition, competitiveness, and target orientation are related to physical activity and earnings. These traits may be more prevalent among competitive athletes. This explanation is tested by dividing the original PAI into leisure-time physical activity and participation in sports competitions. The results, however, do not support the assumption that children who participate in sports competitions receive higher earnings once the overall leisure-time physical activity level is controlled. Instead, what matters most seems to be the overall physical activity level, not the single measure of sports competition participation. In general, the association between physical activity and earnings seems to be more positive and more robust among men and more volatile for women. One possible explanation for this is the differences in the labor force participation of fertility-aged women and men. The results indirectly support this explanation because a positive association between physical activity and earnings is also found among women when controlling for employment months.

The findings in Chapter 4 are twofold. First, higher childhood physical activity level at ages 9 and 15 years increases the probability of employment, is positively related to employment months, and is negatively related to unemployment months. Second, individuals who are persistently active during childhood have the highest level of employment and the lowest level of unemployment. These results remain intact when controlling for pre-existing health endowments, family income, and parents' education. In a broader perspective, the results in Chapters 2, 3, and 4 suggest that the consequences of childhood physical activity on educational attainment and labor market outcomes may start to develop as early as childhood. Thus, childhood physical activity not only promotes health but may also contribute positively to educational and labor market outcomes in later life.

The results in Chapter 5 show that higher adulthood income is associated with higher self-reported physical activity among both genders. The results are robust with the inclusion of control variables, including socioeconomic characteristics, health endowments, and family background factors, as well as the use of register-based income information. The pedometer-based results, in contrast, are gender-specific: the association is positive among women and negative or non-existent among men. The pedometer-based results also indicate that the relationship between income and physical activity may be more complex than suggested in previous studies, which have used self-reported measures of physical activity. This complexity is particularly marked in the model that divides steps by measurement day (weekday/weekend). Among women, income is positively associated with total steps measured on the weekends and with aerobic steps across the measurement days. Among men, income is negatively associated with aerobic steps measured on weekdays. In line with Humphreys and Ruseski (2006), the negative sign of income suggests a possible trade-off between work and physical activity. During working days, higher income might increase the opportunity costs of leisure time and consequently reduce the time spent on physical activity.

TABLE 3 Summary of the studies by chapter (Chapters 2–5)

Chapter	Focus	Data and methods	Main findings
Chapter 2	How is childhood physical activity related to academic achievement and educational attainment?	• YFS, FLEED, LPC • PAI measured at age 15 years • Change in PAI between ages 12 and 15 years • Participation in sports competitions and sports club training sessions at age 15 years • Self-reported GPA at age 15 years and register-based years of post-compulsory education in adulthood • OLS and IV	• PAI at age 15 years and an increase in PAI between the ages of 12 and 15 years are positively related to GPA at age 15 and years of post-compulsory education in adulthood.
Chapter 3	How is childhood physical activity related to long-term earnings in adulthood?	• YFS, FLEED, LPC • PAI at ages 9, 12, and 15 years • Participation in sports competitions at ages 9, 12, and 15 years • Register-based earnings across 2000–2010 • OLS	• Childhood PAI is positively related to long-term earnings among men. • When controlling for employment months, a positive association between childhood PAI and earnings is found among women.
Chapter 4	How is childhood physical activity related to long-term labor market outcomes, particularly employment and unemployment?	• YFS, FLEED, LPC • PAI measured at ages 9 and 15 years • Changes in physical activity level during ages 9–15 years divided into five activity groups • Register-based employment status, employment months, and unemployment months across 1997–2010 • Probit and OLS	• Childhood PAI is positively related to the probability of employment and employment months and negatively related to unemployment months. • Persistently active children have higher level of employment and lower level of unemployment in adulthood than other activity groups
Chapter 5	Do earnings explain self-reported and objectively measured physical activity in adulthood	• YFS, FLEED • Self-reported and register-based earnings in 2010 • Self-reported and objectively measured physical activity in 2011 • OLS and IV	• Income is positively related to self-reported physical activity in both genders. • Objectively measured results are gender-specific and depend on the measurement day (weekday vs. weekend).

1.2.5 Limitations

The results provide evidence that childhood physical activity is related to educational and labor market outcomes, but the causality cannot be interpreted. As prior literature suggests (Figure 1, page 27), there are many potential pathways through which physical activity might affect educational and labor market success: health, networks, cognitive and non-cognitive skills, and signaling. However, the association might also be spurious and stem from unobserved factors that simultaneously affect physical activity and the outcome variable of interest. For example, children from families with more education and wealth might be encouraged to participate in physical activity and have more opportunities to invest in physical activity. Simultaneously, whether via nature or nurture, children from wealthier and more educated families may obtain higher educational and labor market returns once they become adults. Thus, better educational and labor market performances found in Chapters 2, 3, and 4 might have occurred regardless of the participation in physical activity as a child. Other possible explanations may include an individual's health, innate ability, or personality. Although each chapter accounted for an individual's health endowments and family background factors (including family size, family income, and parents' education), a wide range of unobserved factors may remain.

Existing studies examining the effects of physical activity on educational and labor market outcomes use instrumental variables (IV) (e.g., Barron et al., 2000; Cabane et al., 2016; Eide and Ronan, 2001; Pfeifer and Cornelißen, 2010; Rees and Sabia, 2010; Stevenson, 2010), selection on observables (e.g., Lechner, 2009, Cabane et al., 2016, Lechner and Downward, 2017), or panel data methods (e.g., Rees and Sabia, 2010; Rooth, 2011) to tackle this endogeneity problem. Following prior studies, an IV approach was employed in Chapter 2. In theory, the IV method replaces the physical activity variable with a variable that is highly correlated with physical activity but is uncorrelated with the outcome variable of interest (Angrist and Pischke, 2009). In practice, however, it is difficult to find valid instruments, and the same limitation exists in this thesis.

In the case of physical activity, prior studies have used distance to sports facilities (Felfe et al., 2016), school characteristics (Barron et al., 2000), body height (Eide and Ronan, 2001; Pfeifer and Cornelißen, 2010; Rees and Sabia, 2010), legislation (Stevenson, 2010), and family background factors (Cabane et al., 2016) as instruments. In Chapter 2, following Eide and Ronan (2001), Pfeifer and Cornelißen (2010), Rees and Sabia (2010), and Cabane et al. (2016), an individual's body height and family background factors were selected as instruments to explain the variation in childhood physical activity. Although the IV results align with the baseline OLS results, there are multiple reasons why an individual's body height might not be a good instrument. For example, according to Cinnirella et al. (2011) and Magnusson et al. (2006), height is positively related to educational outcomes. Furthermore, according to Case and Paxson (2008), an individual's body height correlates with cognitive ability and, hence, with educational attainment and labor market success in adulthood. Therefore, the results reported in Chapter 2, with an individual's body height as an instrument, should be interpreted with caution.

Another selected instrument in Chapter 2 is parents' physical activity behavior. Clearly, highly educated parents might be more physically active, and if these educated parents have children who achieve higher educational success as adults, then the parents' physical activity behavior might not only affect children's educational outcomes through their child's physical activity behavior. Therefore, the validity of the instrument might be violated. However, recent literature has identified genes as an important determinant of physical activity behavior (see e.g., Bauman et al., 2012; Joosen et al., 2005). This finding means that the heritable component affects not only fitness aptitude but also physical activity behavior (Bauman et al., 2012). For example, twin and family studies have shown that genetic factors contribute to the variation in daily physical activity levels (Aaltonen et al., 2010; Joosen et al., 2005). Therefore, using the information about parents' physical activity was an attempt to capture the heritable component of physical activity behavior.

One notable feature in each chapter is the difference between the results for men and women. More specifically, in Chapter 2, childhood physical activity is related to educational outcomes in men regardless of the model specifications. Among women, however, when controlling for prior academic achievement, the association becomes insignificant in the case of post-compulsory education. In Chapter 3, the positive association between physical activity and earnings can be seen in men, but not in women. However, when an individual's months of employment are controlled for, the association is also significant in women. In Chapter 4, the association between physical activity and employment months is significant only in men, while the association between physical activity and unemployment months is significant among men as well as women. In Chapter 5, especially the pedometer-based results differ according to gender.

These findings provide clear evidence that the associations between physical activity, educational attainment, and labor market outcomes are gender-specific. However, there are at least three issues that has to be discussed while interpreting these divergent results. First, in each chapter, the gender-specific results are based on relatively small sample sizes; therefore, the results might be sensitive to subsampling, which may produce biased estimates.

Second, in the latest YFS follow-up in 2011, the mean age of the participants was 42 years. Thus, women's choices regarding childbearing and how those decisions influence their educational and labor market outcomes are important to consider when interpreting the results found in Chapters 2, 3, and 4. Especially in Chapters 3 and 4, the specificity of women's career paths may lead to more complex labor supply and occupational choices among women compared to men of the same age. A currently available solution to address this issue is to adjust the models with, for example, the number of children or the amount of maternity allowances. Both variables are available in FLEED, but were nevertheless taken into account in the analysis. This was mainly due to avoid the potential problem of reverse causality; therefore, all controls were measured prior to post-compulsory education and any labor market experience.

Finally, in Chapter 5, the inconsistent pedometer-based results for women and men may be explained by noting the preferences for different types of physical activity. More specifically, Finnish women prefer walking, cycling, and aerobics/gymnastics, whereas men prefer running, ball games, and gym training (Tammelin et al., 2003). Additionally, the results in Chapter 5 suggest that men report more intensive and frequent participation in physical activity than women. In the analysis, however, information about the type of physical activity was not available. As pedometers are not designed to discern the intensity of physical activity and are not sensitive to non-ambulatory activities, such as swimming or gym workouts, inadequacies in the pedometer method may therefore partially explain the inconsistent results between women and men.

1.2.6 Suggestions for future research

This dissertation's findings open important new paths for future research. First, a good starting point for scholars could be to explore the potential mechanisms behind the findings of this dissertation. Although the results provide evidence that childhood physical activity is positively related to educational and labor market outcomes, the explanation for this correlation is unclear. As presented in Figure 1 in page 27, prior literature suggests many potential pathways: health, networks, cognitive and non-cognitive skills, and signaling. To uncover these mechanisms, future studies need larger sample sizes and informative data sets covering, for example, health endowments, personality, and cognitive ability.

Second, Cabane (2014) shows that physical activity is related to quicker transitions from unemployment to employment, especially among women. However, less is known about whether and how physical activity is related to other educational and labor market transitions, such as shifts from education to working careers and changes in occupational status during different phases of life. Moreover, the decision to participate in physical activity needs to be linked to an individual's entire working history. Specifically, what role does physical activity play in retirement decisions? In 2017, the age range of the YFS participants varies from 40 to 55 years; thus, discussions related to retirement are not yet pertinent. However, in 10 to 20 years, describing the entire working history of YFS participants and examining the roles of health behaviors, including physical activity, as potential determinants of working career will emerge as an interesting avenue for research.

Third, Chapter 5 provides evidence that annual income is positively related to self-reported physical activity. However, earlier studies suggest that labor market shocks and economic fluctuations are also related to health behaviors (e.g. Ruhm, 2000). To better understand this relationship, it would be valuable to examine whether negative and positive labor market shocks, such as transitions from employment to unemployment, are related to adulthood physical activity behavior. Studying this question could help policy makers, health promoters, and employers develop efficient tools to increase participation in physical activity among working-age individuals.

Fourth, prior studies suggest that playing music and practicing sports as a child may be related for health and educational outcomes (Cabane et al., 2016). Also, Cabane (2010) shows that adulthood extracurricular activities (sports participation, artistic activities, or volunteer work) favor labor market outcomes in terms of hourly wages and autonomy levels at work. However, information about how these recreational activities (e.g., having one activity or having many activities) are related to educational attainment as well as long-term labor market outcomes is limited. Therefore, suggestion for future research is to explore whether practicing sports, playing music, or practicing in other extracurricular activities as a child can explain the differences in individuals' education levels and labor market outcomes later in life.

Fifth, numerous societal and technological changes in recent decades have made lifestyles increasingly sedentary among children (Pate et al., 2011) and adults (Matthews et al., 2012). Unsurprisingly, interest in understanding the benefits and the detriments of sedentary behavior has also increased. So far, little is known about the longitudinal consequences of sedentary behavior on educational attainment and labor market outcomes. Therefore, an interesting avenue for future research is to focus on the role of sedentary behavior and the joint effects of physical activity and sedentary behavior in educational and labor market outcomes.

Finally, future research should pay attention to the endogeneity of physical activity. Previous studies use, for example, school characteristics (Barron et al., 2000), body height (Eide and Ronan, 2001; Pfeifer and Cornelißen, 2010; Rees and Sabia, 2010), legislation (Stevenson, 2010), and family background factors (Cabane et al., 2016) as instruments to explain participation in physical activity. However, recent research also identifies genetics as an important determinant of physical activity (see e.g., Bauman et al., 2012). Capturing genetics as an instrument to explain variations in physical activity behavior could aid researchers in teasing out the causal relationship between physical activity and economic outcomes.

1.2.7 Concluding remarks

Only one-fifth of children and youth are estimated to be sufficiently active and meet the current physical activity recommendations for health (WHO, 2014; Tremblay et al., 2016; Tammelin et al., 2016). The importance of physical activity and the detriments of physical inactivity on health and well-being are well documented (Lee et al., 2012; WHO, 2009; WHO, 2010). In recent years, research on the economic consequences of physical activity has emerged, with several valuable studies conducted (e.g., Ding et al., 2016; Katzmarzyk and Janssen, 2004; Lechner, 2009; Cabane and Clark, 2015; Lechner and Downward, 2017). However, little is known about the longitudinal associations among an individual's physical activity, educational attainment, and labor market outcomes. The findings of this thesis provide evidence that the consequences of physical activity may be far-reaching: childhood physical activity may positively contribute to academic achievement, educational attainment, earnings, and employment.

From a policy-perspective, the findings are twofold. First, the conclusions in Chapters 2, 3, and 4 encourage maintaining and developing programs and interventions aimed at promoting children's participation in physical activity regardless of their socioeconomic background. This emphasis could encourage young people to pursue more physically active lifestyles in childhood and beyond, thereby potentially improving their educational and labor market outcomes later in life, providing both personal and societal benefits. Although the focus in Chapters 2, 3, and 4 is on leisure-time physical activity outside school hours, the school setting in Finland could be an essential arena to reach all children and thereby has the possibility to impact the development of children's physical activity behavior. A prime example of such a program is the ongoing Finnish Schools on the Move program that aims to increase physical activity and decrease sedentary time among children and adolescents (Blom et al., 2012; Haapala et al., 2014). The Finnish Schools on the Move program is one of the key projects in the field of knowledge and education in the Government Program of Finland. The government's goal is to expand the Schools on the Move project across the country and ensure that every child has one hour of physical activity each day (Prime Minister's office, Finland, 2015.) The program was launched in 2010 with a pilot study, and by September 2017, 90% of Finnish municipalities and 80% of comprehensive schools were involved in the program. Second, the findings in Chapter 5 provide evidence that an individual's economic factors relate to their physical activity behavior. This finding may help policy makers, health promoters, and employers in developing efficient tools for maintaining and increasing physical activity levels and decreasing sedentary time among working-age individuals from different socioeconomic backgrounds.

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2 LONGITUDINAL ASSOCIATIONS BETWEEN PHYSICAL ACTIVITY AND EDUCATIONAL OUTCOMES *

Abstract**

This study examined the role of leisure-time physical activity during adolescence in academic achievement at the end of compulsory basic education and subsequent educational attainment. The data were drawn from the ongoing longitudinal Cardiovascular Risk in Young Finns Study, which was combined with register-based data from Statistics Finland. The ordinary least squares model and the instrumental variable approach were employed, and several physical activity measurements were included: leisure-time physical activity outside school hours, participation in sports club training sessions, and participation in sports competitions. We found that physical activity level at age 15 and an increase in physical activity level between the ages of 12 and 15 years were positively related to grade point average at age 15 and years of post-compulsory education in adulthood. The results were robust to control for several individual and family background factors, including health endowments, family income, and parents' education. The results provide evidence that physical activity during adolescence may not only predict academic success during compulsory basic education but also boost educational outcomes later in life.

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2.1 Introduction

Previous studies have linked physical activity with positive returns in terms of academic achievement (Fox et al., 2010; Kantomaa et al., 2013; Kristjnsson et al., 2009; McCormick and Tinsley, 1987; Singh et al., 2012; Stevens et al., 2008) and educational attainment (Åberg et al., 2009; Barron et al., 2000; Long and Caudill, 1991; Pfeifer and Cornelißen, 2010). However, some of the research findings are mixed and suggest the existence of unmeasured heterogeneity (Rees and Sabia, 2010), selection issues (Barron et al., 2000; Stevenson, 2010), and the endogeneity of physical activity decisions (Eide and Ronan, 2001). Additionally, prior studies largely focus on high school athletic participation and data obtained from the United States (e.g., Barron et al., 2000; Eide and Ronan, 2001; Long and Caudill, 1991; Rees and Sabia, 2010; Stevenson, 2010). Therefore, less is known about the longitudinal implications of leisure-time physical activity during adolescence for academic achievement and educational attainment among the same individuals and data collected in Europe.

This study used data drawn from the ongoing longitudinal Cardiovascular Risk in Young Finns Study (YFS) combined with registries from Statistics Finland. The purpose was to examine whether physical activity during adolescence is associated with academic achievement at the end of compulsory basic education and with post-compulsory education later in life. The study augmented the previous literature in the following ways: First, we investigated whether the physical activity level at age 15 or a change in physical activity level between the ages of 12 and 15 years are associated with grade point average (GPA) at age 15 and subsequent years of post-compulsory education. Second, we investigated how participation in sports club training sessions and participation in sports competitions are associated with academic achievement and educational attainment. Finally, following the studies by Eide and Ronan (2001), Pfeifer and Cornelißen (2010), Rees and Sabia (2010), and Cabane et al. (2016), we employed an instrumental variable (IV) approach to deal with the potential endogeneity, omitted variable bias, and measurement error.

The rest of the paper proceeds as follows: In Section 2.2, the background literature related to physical activity and educational outcomes are discussed, and the Finnish education system and physical activity among Finnish adolescents are briefly introduced. This is followed by a section that describes the data and the identification strategy. In Section 2.4, the estimation results are presented, and in Section 2.5, conclusions are provided.

2.2 Background

2.2.1 Physical activity: A positive academic spillover?

Educational attainment has been used as a measure of the skills available in the population and the labor force (Becker, 2009; Organization for Economic Cooperation and Development [OECD], 2015). In addition to the strong correlation between academic achievement and later educational attainment, previous studies have shown that a higher level of education is positively associated with health outcomes (Cutler and Lleras-Muney, 2006; Grossman, 1972; Ross and Wu, 1995), employability (OECD, 2015), earnings (Becker, 2009; Card, 1999), and economic growth (Hanushek and Woessmann, 2012). At the same time, physical inactivity has been identified as the fourth-leading risk factor for global mortality (Lee et al., 2012; Murray and Lopez, 1997; World Health Organization [WHO], 2010), and several studies have reported increasing healthcare costs due to physical inactivity (Colditz, 1999; Ding et al., 2016; Katzmarzyk et al., 2000; Katzmarzyk and Janssen, 2004; Kohl et al., 2012).

The overall physical activity levels are low in many countries (Ekelund et al., 2011; Hallal et al., 2012; WHO, 2010; Tremblay et al., 2016), and Finland is not an exception (Tammelin et al., 2016). Similarly, cardiorespiratory fitness has decreased among adolescents during the last few decades (Tomkinson and Olds, 2007), and the same trend can be seen in Finland (Huotari et al., 2010; Santtila et al., 2006). According to the WHO's (2010) Global Recommendations on Physical Activity for Health, the recommended levels of physical activity for children age 5–17 years is to accumulate at least a total of 60 minutes of moderate to vigorous intensity physical activity (MVPA) daily. Moreover, vigorous-intensity activities should be incorporated at least three times per week, including activities that strengthen the muscles and bones.

The results from the latest Health Behavior in School-aged Children (HBSC) survey (Inchley et al., 2016) conducted in 2013–2014 confirmed that only a minority of young people meet the current recommendations for daily physical activity. Globally, 30% of boys and 21% of girls aged 11 years and 21% of boys and 11% of girls aged 15 years reported at least 60 minutes of MVPA daily.[10] In Finland, 47% of boys aged 11 years and 22% of boys aged 15 years reported at least 60 minutes of MVPA daily. The percentages for girls were 34% and 13%, respectively. Cross-country comparisons show that, on average, the difference in the level of physical activity between the ages of 11 and 15 years is relatively high in Finland. This means that, on average, younger children are physically more active compared to older children, and based on cross-sectional data at the ages of 11 and 15 years, the physical activity levels of Finnish children seems to decline more than those of children in other countries. However, participation in organized sports is common, as half of the children, aged 7 to 18

10 Because the questions are not administered in every country at the same time of the year, the cross-country comparisons must be cautiously interpreted (King et al., 1996).

years, report participation in sports club activities at least once a week in surveys and interviews (Tammelin et al., 2016).

Previous studies have provided evidence that physical activity may lead to positive academic spillovers. Stevens et al. (2008), for example, showed a positive association between physical activity, mathematics and reading achievement among boys and girls, while in the study by Fox et al. (2010), physical activity and sports team participation were positively associated with grade point average. According to Long and Caudill (1991), athletes who attended colleges and universities had higher graduation rates than non-athletes. Moreover, McCormick and Tinsley (1987) showed a positive association between athletic success and academic success.[11] Barron et al. (2000), in turn, explained the high school athletic participation choice and its implications for subsequent educational attainment. The results indicated that athletic participation is associated with a higher post-secondary level of education. Similarly, Pfeifer and Cornelißen (2010) showed that non-professional physical activity during childhood and youth increased the probability of attaining a higher school degree. A broader perspective was adopted by Åberg et al. (2009), who demonstrated that cardiovascular fitness change between 15 and 18 years predicted cognitive performance at 18 years, and cardiovascular fitness at 18 years predicted higher subsequent educational attainment in adulthood.

Although a positive association between physical activity, academic achievement, and educational attainment has been shown, some research findings are mixed. Eide and Ronan (2001) argued that many of the previous studies have failed to control for the endogeneity of sports participation. In their analysis, as in the study by Rees and Sabia (2010), endogeneity was taken into account by using an individual's body height as an instrument to explain sports participation. The results were mixed; athletic participation was shown to be positively associated with educational attainment (Eide and Ronan, 2001), whereas Rees and Sabia (2010) showed only limited evidence that participation in sports is related to academic achievement. In contrast to academic spillovers, Rees and Sabia (2010) suggested that the positive association between physical activity and academic achievement was a result of an individual-level unmeasured heterogeneity. Thus, it is not clear whether the associations demonstrated in previous studies reflect a causal relationship or are entirely or partly driven by unmeasured heterogeneity. Stevenson (2010), in turn, argued that sports participation is not randomly determined, and therefore, selection issues may explain the positive findings in previous studies. Barron et al. (2000) also speculated that the associations found between physical activity and educational outcomes appears to reflect differences across individuals in ability or value of leisure.

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11 In addition, studies have reported a negative association between athletic success and academic success (Hernández-Julián and Rotthoff, 2014; Lindo et al., 2012). These studies focused on football teams' winning percentages and students' academic performance as measured by grades.

2.2.2 Finnish education system in brief

The main aim of education system in Finland is to guarantee equal opportunity to learn irrespective of sex, social status, or ethnic group. Each child enters compulsory nine-year basic education at age 7.[12] Then, approximately 90% of the age cohort attends non-compulsory upper secondary education, which is divided into two tracks: general upper secondary school and vocational upper secondary education and training. This education is followed by post-compulsory higher education, which is provided by universities and polytechnical institutes (Hanhijoki et al., 2012; National Board of Education, 2004). Education in Finland is mostly a public service. Compulsory basic education and both tracks of non-compulsory upper secondary education are free. Unlike in many other countries, universities are not allowed to charge tuition, and the Finnish government offers subsidies for students who enroll in universities: Only books and transportation are purchased by the students whereas, for example, students' meals are subsidized by the state (National Board of Education, 2004).

In Finland, every school has the same goals outlined by the Finnish National Board of Education. Similarly, the distribution of lesson hours for basic education and the minimum number of lessons for each subject during basic education are determined by the government (National Board of Education, 2004). The focus is on learning rather than testing. During compulsory basic education, there are no national tests for pupils. Instead, assessment is based on teacher-rated academic achievement scores (GPAs), which describe the level of performance in relation to the objectives outlined by the National Core Curriculum for Basic Education (National Board of Education, 2004). These objectives consist of skills, knowledge, behavior, and students' work skills (Quakrim-Soivio, 2013).

In general, the level of education among the Finnish population has increased in the last decades. Since 1970, for example, the number of individuals who have a post-compulsory education has increased by approximately 40% (Official Statistics of Finland, 2016). Cross-country comparisons revealed that, in terms of educational level, Finns aged 25 to 64 years are ranked seventh among OECD countries (Valle et al., 2015). In addition to post-compulsory education, the Finnish compulsory basic education system has received interest worldwide due to the country's success on the Program for International Student Assessment (PISA) surveys (OECD, 2010a, 2010b, 2014).

12 Before compulsory basic education, children participate in pre-primary education at the age of 6.

2.3 Data and method

2.3.1 Study population

The data were drawn from the ongoing longitudinal Cardiovascular Risk in Young Finns Study (YFS), which was launched in 1980, when 3,596 individuals aged 3, 6, 9, 12, 15, and 18 years participated in the baseline study. The participants were randomly chosen boys (51%) and girls (49%) from five Finnish university cities with medical schools (Helsinki, Turku, Tampere, Oulu, and Kuopio). Since 1980, seven follow-up phases (1983, 1986, 1989, 1992, 2001, 2007, and 2011) have been conducted. The examinations include comprehensive data collection using blood tests, physical measurements, and questionnaires (Raitakari et al., 2008).

To obtain register-based information on educational attainment, the YFS data were linked with register-based Finnish Longitudinal Employer-Employee Data (FLEED) from Statistics Finland. FLEED is an annual panel that includes information on individuals' educational attainment obtained directly from the comprehensive administrative registers maintained by Statistics Finland. Register-based information on family background factors since 1980 were obtained from the Longitudinal Population Census (LPC) of Statistics Finland. To avoid problems created by errors in record linkages (Ridder and Moffitt, 2007), FLEED and LPC were combined with the YFS data based on the unique personal identifiers.

The present study consisted of adolescents who were 12 and 15 years old when the information about physical activity was collected; that is, the study sample consisted of 2,445 individuals (48% boys) who were born between 1965 and 1977.[13] Thereafter, the individuals were followed until 2010 when the participants' mean age was 40 years. Depending on the model specification, the sample size varied from 1,126 to 1,628.[14]

Data protection issues have been taken into account as specified in current Finnish legislation. Moreover, the research protocol of the YFS has been approved by the ethics committees of the five universities (Helsinki, Turku, Tampere, Oulu, and Kuopio), and each participant has signed written informed consent before participating in the study.

2.3.2 Variable definition

Leisure-time physical activity at the ages of 12 and 15 was measured with a self-reported questionnaire. The participants were asked: "How often do you en-

13 The study included the five youngest cohorts (born between 1965 and 1977), as in the baseline year (1980), the participants in the oldest cohort were 18 years old.

14 The physical activity details at the age of 15 were obtained from 2,445 individuals. The GPA details were obtained from 1,729 individuals at the age of 12 years and 1,941 individuals at the age of 15 years (see Appendix B, Table B.1 for additional details).

gage in leisure-time physical activity for at least half an hour per session?", "How much are you breath-taking and sweating when you engage in physical activity and sports?", "How many times a week do you usually engage in training sessions for a sports club?", "What do you usually do in your leisure time?", and "Do you participate in regional- or national-level competitions?" (see Appendix A, Table A.1 for additional details). The response alternatives were coded from 1 to 3—except participation in sports competitions, which was coded as 1 or 2—and thereafter summed to form a physical activity index (PAI) with scores ranging from 5 to 14 (Appendix A, Table A.1; Telama et al., 1996; Telama et al., 2014).

Two measures were used to illustrate individuals' educational outcomes, self-reported grade point average (GPA) at age 15 and register-based information on the years of completed post-compulsory education. The information on GPA at age 15 was provided by the YFS; the variable referred to a numerical assessment on a scale of 4–10, where 4 denotes *failed* and 10 denotes *excellent*. Information on post-compulsory education was provided by the register-based FLEED. Using official estimates from Statistics Finland for completing a specific degree, the years of education were formulated by transforming the highest obtained degree in 2010 into years of education.

2.3.3 Identification strategy

The analysis was based on ordinary least squares (OLS) models stratified by sex. The models used the GPA at age 15 and the years of completed education as the dependent variables and the PAI at age 15 as an explanatory variable. All models were adjusted by birth cohort and birth month, which are predetermined variables (Angrist and Picshke, 2009, p. 68). Before running the OLS models, the correlation coefficients were calculated to illustrate the unconditional connections between adolescent physical activity and educational outcomes (Appendix C, Table C.1).

The baseline models were extended in the following ways. First, to reduce the possibility that physical activity reflects omitted variables without having an independent effect on educational outcomes, the models were augmented with several covariates: 1) individuals' chronic conditions and body fat in 1980 (Slaughter et al., 1988); 2) family background factors in 1980, including register-based family income, register-based parents' education, and family size; and 3) individual's prior academic achievement measured with the self-reported GPA at the age of 12 (see Appendix B, Table B.1 for additional details). Information on family background factors provided controls for unobserved heterogeneity, such as innate ability and preferences, thus alleviating possible biases in the estimated correlation with physical activity and educational outcomes. Moreover, as Becker (2009, p. 21) suggested, the influence of families on their children's knowledge, skills, values, and habits (e.g., physical activity behavior) cannot be omitted.

Typically, during childhood and youth, participation in sports decreases with age (Inchley et al., 2016; Nader et al., 2008). An open question is whether this change is related to academic achievement and educational attainment. To find an answer, the association between educational outcomes and the change in the physical activity level between ages 12 and 15 was examined. Additionally, two binary variables were formulated, which equals 1, if the physical activity level increased or decreased between the two time points, and 0 otherwise.

Almost half of the Finnish children aged 7 to 18 years report participation in sports club activities at least once a week (Tammelin et al., 2016). To examine whether participation in sports club training sessions or participation in sports competitions have an independent role in educational outcomes, the original PAI was divided into three parts: 1) a variable that indicated participation in sports club training sessions (1 = participates in sports club training sessions, 0 = does not participate in sports club training sessions), 2) a variable that indicated participation in sports competitions (1 = participates in national- or regional-level sports competitions, 0 = does not participate in sports competitions), and 3) the original PAI subtracted from the participation in sports club training sessions and participation in sports competitions variables. The original PAI was replaced with these three new variables in the equation, and the same covariates were used as in the baseline OLS models.

Finally, we employed an IV approach to alleviate the possible endogeneity of physical activity, omitted variable bias, and measurement error (Angrist and Picshke, 2009, pp. 114–115). Following the studies by Eide and Ronan (2001), Rees and Sabia (2010), and Pfeifer and Cornelißen (2010), we used an individual's body height as an instrument for sports participation. Furthermore, we included parents' physical activity details as an instrument to explain physical activity of their children.

2.4 Results

2.4.1 The association between academic achievement, educational attainment, and adolescent physical activity

Regardless of the utilized measures of physical activity and participation in sports, at the ages of 12 and 15, boys had higher values than girls ($P < 0.001$; Table 1). The average PAI was approximately one unit higher among boys compared to girls. Relative to girls, boys more commonly participated in sports club training sessions and sports competitions at the age of 15 (P < 0.001; Table 1). Between the ages of 12 and 15 years, however, boys' physical activity levels decreased more than those of girls ($P < 0.001$; Table 1). In terms of educational outcomes, the GPA at age 15 was approximately 0.6 units higher among girls compared with boys (P < 0.001; Table 1). Similarly, the level of post-compulsory education was higher among women than men; that is, women had approximately 0.7 more years of education than men during the follow-up period (P < 0.001; Table 1).

TABLE 1 Descriptive statistics

		All		Women		Men		
	Data Source	*N*	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)	*p* value[a]
Physical activity in adolescence								
PAI at 12 y[b]	YFS	1723	9.57 (1.80)	886	9.06 (1.63)	837	10.11 (1.82)	$p <$ 0.001
PAI at 15 y	YFS	2445	8.97 (1.97)	1271	8.61 (1.77)	1174	9.37 (2.10)	$p <$ 0.001
ΔPAI 12–15 y[c]	YFS	1723	–0.52 (1.84)	886	–0.37 (1.80)	837	–0.70 (1.88)	$p <$ 0.001
+ΔPAI 12–15 y[e]	YFS	1723	0.27 (0.45)	886	0.31 (0.46)	837	0.23 (0.42)	$p <$ 0.001
-ΔPAI 12–15 y[f]	YFS	1723	0.50 (0.50)	886	0.46 (0.50)	837	0.53 (0.50)	$p <$ 0.004
Participation in sports club training at 15 y[f]	YFS	2445	0.28 (0.45)	1271	0.24 (0.43)	1174	0.32 (0.47)	$p <$ 0.001
Participation in sports competitions at 15 y[g]	YFS	1854	0.24 (0.43)	981	0.19 (0.39)	873	0.30 (0.46)	$p <$ 0.001
Academic achievement at the age of 15								
GPA at 15 y[h]	YFS	1941	7.82 (0.93)	1022	8.08 (0.88)	919	7.53 (0.90)	$p <$ 0.001
Educational attainment at the age of 33–45								
Years of education[i]	FLEED	2445	13.53 (2.88)	1271	13.88 (2.82)	1174	13.23 (2.86)	$p <$ 0.001

Cardiovascular Risk in Young Finns Study (YFS) and Finnish Longitudinal Employer-Employee Data (FLEED) from Statistics Finland. [a] P values for gender differences (*t*-test). [b] Physical activity index (PAI) (min. 5 – max. 14) at the age of 12 and 15 years is a summary of five variables that illustrate the frequency and intensity of leisure-time physical activity, frequency of participation in sports clubs training sessions, participation in sports competitions, and the most common activity during leisure time. [c] ΔPAI illustrates the change in the PAI levels between the ages of 12 and 15 years. [d] +ΔPAI is a binary variable that gets value 1 if the individual has increased his or her physical activity level between the ages of 12 and 15 years, and 0 otherwise. [e] -ΔPAI is a binary variable that gets value 1 if the individual has decreased his or her physical activity level between the ages of 12 and 15 years, and 0 otherwise. [f] Participation in sports club training sessions at the age of 15 is a binary variable that gets value 1 if an individual participates in organized sports clubs training sessions, and 0 otherwise. [g] Participation in sports competitions at the age of 15 is a binary variable that gets value 1 if an individual participates in national- or regional-level competitions, and 0 otherwise. The sample size varies because in the 1992 follow-up participation in sports competitions was not asked. [h] GPA at the age of 15 refers to a self-reported numerical assessment on a scale of 4–10, where 4 is failed and 10 is excellent. [i] Register-based information on educational attainment in adulthood based on the years of completed education.

The baseline OLS estimates (Table 2, Columns 1) suggested that a higher PAI at age 15 was associated with a higher GPA at age 15 and a higher level of education in later life. Among women, a one-unit increase in the PAI was related to a 0.11 unit increase in GPA and 0.17 additional years of education (Table 2, Columns 1). Among men, the coefficients were 0.06 for GPA and 0.17 for years of education. As a rough estimate, at the end of compulsory basic education, children with the highest physical activity level (PAI = 14 at the age of 15) had a GPA that was approximately 1.0 unit higher among girls and 0.5 unit higher among boys compared with those with the lowest physical activity level (PAI = 5 at the age of 15). In terms of educational attainment, the most physically active girls and boys (PAI = 14 at the age of 15) had approximately 1.5 more years of education in adulthood compared with their least physically active counterparts (PAI = 5 at the age of 15).

Possible self-selection into physical activities cannot be ignored. As suggested by Stevenson (2010), substantial self-selection into physical activities can be found, and without adequate controls, the impact of physical activity on educational outcomes can be upwardly biased. Moreover, as demonstrated in studies by Hanushek and Woessman (2010) and Björklund and Salvanes (2010), an individual's academic achievement and educational attainment are highly correlated with his or her parents' education level or socioeconomic status. Thus, the baseline models were augmented with individual characteristics and family background factors, including health endowments, parents' education, family size, and family income. To ensure the comparison between the baseline and extended models (Table 2, Columns 1–4), subjects with missing observations were excluded from the analysis. Allowing the sample size to vary, however, did not change the main results.[15] Among men, the inclusion of a comprehensive set of control variables (Table 2, Columns 2–4) kept the physical activity estimate statistically significant, but decreased the point estimate. In the extended model (Table 2, Column 4), one-unit increase in PAI was related to a 0.03 increase in GPA and 0.09 additional years of education. Among women, when the models were adjusted by individuals' prior academic achievement (Table 2, Column 4), in the case of educational attainment, the association remained positive but became statistically insignificant. The coefficient for GPA, however, remained statistically significant indicating a positive association between physical activity and academic achievement. The R^2 of the extended models (Table 2, Columns 4) varied from 0.28 to 0.67. In the case of GPA, approximately 70% of the variance was accounted by the model, whereas the percentage for educational attainment was approximately 30%.

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15 The results from the extended models with varying sample size are available upon request.

TABLE 2 OLS estimates of the relationship between physical activity level at the age of 15 (PAI, academic achievement at the age of 15, and educational attainment in adulthood.

	Academic achievement at the age of 15 years, grade point average				Educational attainment at the age of 33–45 years, years of education			
	1	2	3	4	1	2	3	4
Panel I: Women								
PAI at 15 y	0.108***	0.107***	0.083***	0.048***	0.174***	0.174***	0.103**	0.028
	(0.019)	(0.019)	(0.018)	(0.011)	(0.050)	(0.050)	(0.048)	(0.043)
N	661	661	661	661	850	850	850	850
R^2	0.11	0.11	0.19	0.67	0.05	0.06	0.13	0.28
Panel II: Men								
PAI at 15 y	0.060***	0.062***	0.054***	0.032***	0.166***	0.162***	0.139**	0.092**
	(0.018)	(0.018)	(0.017)	(0.010)	(0.051)	(0.052)	(0.049)	(0.043)
N	586	586	586	586	778	778	778	778
R^2	0.05	0.05	0.19	0.66	0.05	0.05	0.16	0.32
Control variables								
Birth cohort and mon	x	x	x	x	x	x	x	x
Individual characteristics[a]		x	x	x		x	x	x
Family back-ground[b]			x	x			x	x
GPA at 12 years[c]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ***p < 0.01, **p < 0.05, *p < 0.10. All models include controls for cohort (1–5) and birth month. The cohort dummies illustrate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, and Cohort 5= born in 1965. PAI = physical activity index (min. 5 – max. 14) at the age of 15 years is a summary of five variables that illustrate the frequency and intensity of leisure-time physical activity, frequency of participation in sports clubs training sessions, participation in sports competitions, and the most common activity during leisure time. [a] Individual characteristics: summary of an individual's chronic conditions and body fat. [b] Family background factors: family income, parents' education, family size. [c] Academic achievement: predetermined academic achievement (GPA) at the age of 12 refers to a self-reported numerical assessment on a scale of 4–10 (4 is failing and 10 is excellent).

Taken together, the OLS results indicated a positive association between adolescent physical activity and educational outcomes. The results were robust to control for several individual and family background factors. In line with the findings of Barron et al. (2000), the results also support the view that differences across individuals' abilities, especially prior academic achievement, partially explains the correlation between physical activity and educational outcomes: When the models were adjusted by individual's prior academic achievement, in all model specifications, the strength of the association decreased. This finding implies that the connection between physical activity and education may be partly attributed to the higher GPA of physically active adolescents. Therefore, it remains unclear whether the educational benefits of adolescent physical activity are caused by participation in physical activity (treatment effect) or are merely related to the types of individuals who prefer to be physically active during their leisure-time (the selection effect).

2.4.2 The dynamics of changes in physical activity level between the ages of 12 and 15

Participation in sports during childhood and adolescence typically decreases with age (Inchley et al., 2016; Nader et al., 2008; Tomkinson and Olds, 2007). According to Nader et al. (2008), at the age of 9 years almost all children meet the recommended 60 minutes of moderate to vigorous intensity physical activity daily, whereas at the age of 15 only 30% achieve the benchmark. A similar decline can be seen in our data. As shown in Table 1, at the age of 15 the average physical activity level was approximately 0.5 units lower than at the age of 12. An open question is whether this change is related to academic achievement and educational attainment. As an answer, we examined the association between the change in physical activity level between the ages of 12 and 15 and educational outcomes. We also focused on individuals whose physical activity level increased or decreased between the ages of 12 and 15. The results are presented in Table 3. Because the results from the baseline OLS models were qualitatively and quantitatively similar for women and men, from Table 3 onward, the results are presented for women and men combined and the models were adjusted by sex.[16]

In line with the baseline OLS results, change in physical activity level (ΔPAI at 12–15 y) was positively associated with academic achievement and educational attainment. When the models were adjusted by individual characteristics, family background factors, and prior academic achievement (Table 3, Columns 3–4), the point estimate decreased by half while remaining positive and statistically significant. In the extended models, the corresponding coefficients were approximately 0.05 (academic achievement) and 0.09 (educational attainment). When focusing on those whose physical activity levels increased between the ages of 12 and 15 (+ΔPAI at 12–15 y), the results implied a positive association between the variables (Table 3, Panel II). For academic achievement, the point estimates of physical activity were approximately 0.3 (Table 3, Panel II, Column 1) and 0.16 in the extended model (Table 3, Panel II, Column 4). For educational attainment, the corresponding point estimates were approximately 0.7 (Table 3, Panel II, Column 1) and 0.3 (Table 3, Panel II, Column 4). For those, whose physical activity levels decreased between the ages of 12 and 15 (-ΔPAI at 12–15 y), the associations were negative in all model specifications (Table 3, Panel III, Columns 1–4).

One notable feature in the results was that in the case of academic achievement, the physical activity level at age 12 as well as the change in physical activity between the ages of 12 and 15 were associated with higher GPA at age 15. Regarding educational attainment, however, only the change, not the

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16 The separate results for women and men are available upon request.

level of physical activity level, seemed to matter. More specifically, an increase in the physical activity level was associated with higher educational returns in adulthood, whereas the association with respect to the decrease in physical activity level was negative. From a policy-perspective, this finding could encourage developing programs and interventions targeted to school-aged children aiming to foster children's participation in physical activity. This could push the young toward more physically active lifestyles, and improve their educational attainment in later life, providing both personal and societal benefits (Becler, 2009; Cutler and Lleras-Muney, 2006).

TABLE 3 Changes in physical activity levels between ages of 12 and 15 years in association with academic achievement at the age of 15 and educational attainment in adulthood.

	Academic achievement at the age of 15 years, grade point average				Educational attainment at the age of 33–45 years, years of education			
	1	2	3	4	1	2	3	4
Panel I: Change in physical activity level								
ΔPAI at 12–15 y[a]	0.099***	0.099***	0.080***	0.050***	0.209***	0.208***	0.148***	0.088**
	(0.015)	(0.015)	(0.014)	(0.009)	(0.042)	(0.042)	(0.040)	(0.036)
PAI at 12 y[b]	0.064***	0.064***	0.052***	0.032***	0.103**	0.101**	0.073	0.022
	(0.016)	(0.016)	(0.016)	(0.009)	(0.016)	(0.047)	(0.045)	(0.040)
N	1191	1191	1191	1191	1556	1556	1556	1556
R^2	0.17	0.17	0.26	0.70	0.06	0.06	0.16	0.31
Panel II: Increase in physical activity level								
+ΔPAI at 12–15 y[c]	0.297***	0.297***	0.229***	0.156***	0.678***	0.675***	0.474***	0.326**
	(0.059)	(0.059)	(0.055)	(0.034)	(0.167)	(0.167)	(0.156)	(0.141)
PAI at 12 y	0.037**	0.037**	0.030**	0.019**	0.055	0.054	0.039	0.005
	(0.016)	(0.016)	(0.015)	(0.009)	(0.044)	(0.044)	(0.042)	(0.038)
N	1191	1191	1191	1191	1556	1556	1556	1556
R^2	0.15	0.17	0.25	0.70	0.06	0.06	0.16	0.31
Panel III: Decrease in physical activity level								
-ΔPAI at 12–15 y	-0.263***	-0.264***	-0.201***	-0.123***	-0.696***	-0.696***	-0.537***	-0.36**
	(0.053)	(0.053)	(0.051)	(0.032)	(0.149)	(0.149)	(0.142)	(0.130)
PAI at 12 y[d]	0.044**	0.044**	0.035*	0.021*	0.073	0.072	0.055	0.015
	(0.016)	(0.016)	(0.015)	(0.009)	(0.044)	(0.045)	(0.042)	(0.038)
N	1191	1191	1191	1191	1556	1556	1556	1556
R^2	0.15	0.15	0.25	0.70	0.06	0.07	0.16	0.31
Control variables								
Birth cohort and month	x	x	x	x	x	x	x	x
Gender	x	x	x	x	x	x	x	x
Individual characteristics[e]		x	x	x		x	x	x
Family background[f]			x	x			x	x
Academic achievement 12y[g]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ****p* < 0.01, ***p* < 0.05, **p* < 0.10. All models include controls for cohort (1–5) and birth month. The cohort dummies illustrate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, and Cohort 5= born in 1965. [a] ΔPAI at 12–15 y illustrates the change in the PAI level between the ages of 12 and 15 years. [b] Physical activity index (PAI) (min. 5 – max. 14) at the age of 12 years is a summary of five variables that illustrate the frequency and intensity of leisure-time physical activity, frequency of participation in sports clubs training sessions, participation in sports competitions, and the most common activity during leisure time. [c, d] +ΔPAI and -ΔPAI are binary variables, which get value 1 if the physical activity level increases/decreases, and 0 otherwise. [e] Individual characteristics: summary of an individual's chronic conditions and body fat. [f] Family background factors: family income, parents' education, family size. [g] Academic achievement: predetermined academic achievement (GPA) at the age of 12 refers to a self-reported numerical assessment on a scale of 4–10 (4 is failing and 10 is excellent).

2.4.3 Participation in sports club training sessions and sports competitions in association with educational outcomes

The physical activity variable PAI used in the study was a summary of five variables. In addition to the frequency of weekly physical activity, the PAI included information about the individuals' participation in sports club training sessions and participation in sports competitions (Telama et al., 1996). As prior analyses have shown, high school athletic participation, participation in organized sports, and participation in sports competitions (e.g., Pfeifer and Cornelißen, 2010; Rees and Sabia, 2010) are related to educational outcomes. Moreover, almost half of Finnish children and adolescents participate in organized sports[17] (Tammelin et al., 2016). Therefore, we also examined the role of sports participation in educational outcomes. The results are reported in Table 4.

In the case of academic achievement (Table 4, left-hand side), the association were positive for all measures of physical activity: overall physical activity level, participation in sports club training sessions, and participation in sports competitions. The inclusion of a comprehensive set of potential confounding factors (Table 4, left-hand side, Columns 2–4) kept the estimates statistically significant. In the case of educational attainment (Table 4, right-hand side), however, no such clear association was observed. In the baseline model (Table 4, right-hand side, Column 1), the association depended on the measurement type of physical activity. More precisely, participation in sports club training sessions was positively related to educational attainment (Table 4, right-hand side, Panel I, Column 1), whereas the association between participation in sports competitions and educational attainment was statistically insignificant (Table 4, right-hand side, Panel II, Column 1). In the extended model (Table 4, right-hand side, Column 4), regardless of the measures of physical activity, the point estimates became statistically insignificant.

In general, the results were in line with the baseline OLS results, suggesting a positive association between physical activity and educational outcomes. However, some features required attention. First, irrespective of the different measures of physical activity, each physical activity variable was positively related to academic achievement. Second, in the case of educational attainment, no such clear association was observed. Instead, when the models were adjusted by individual and family background factors, the point estimate became statistically insignificant. Therefore, the results support the view that in the case of post-compulsory education, what matters is the overall physical activity level expressed as the PAI, not the single measures of organized sports.

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[17] In our data, approximately 30% of boys participated in sports club training sessions and sports competitions, whereas approximately 20% of girls participated.

TABLE 4 Participation in sports club training sessions and participation sports competitions in association with academic achievement at the age of 15 and educational attainment in adulthood

	Academic achievement at the age of 15 years, grade point average				Educational attainment at the age of 33–45 years, years of education			
	1	2	3	4	1	2	3	4
Panel I: Participation in sports club training sessions								
Overall PA at 15 y	0.078*** (0.024)	0.078*** (0.024)	0.067*** (0.023)	0.052*** (0.014)	0.128* (0.075)	0.124* (0.075)	0.095 (0.072)	0.078 (0.065)
Participation in Sports Club at 15 y[c]	0.210*** (0.061)	0.210** (0.061)	0.155*** (0.058)	0.088** (0.037)	0.445** (0.209)	0.452** (0.210)	0.265 (0.202)	0.116 (0.186)
N	1126	1126	1126	1126	1168	1168	1168	1168
R^2	0.15	0.15	0.25	0.69	0.06	0.06	0.14	0.30
Panel II: Participation in sports competitions								
Overall PA at 15 y[a]	0.086*** (0.023)	0.086*** (0.023)	0.066*** (0.022)	0.056*** (0.014)	0.161** (0.072)	0.158** (0.072)	0.101 (0.070)	0.089 (0.063)
Participation in Sport Competitions at 15 y[b]	0.186*** (0.060)	0.185*** (0.061)	0.186*** (0.057)	0.077*** (0.036)	0.274 (0.202)	0.276 (0.203)	0.256 (0.196)	0.049 (0.181)
N	1126	1126	1126	1126	1168	1168	1168	1168
R^2	0.15	0.15	0.25	0.69	0.06	0.06	0.14	0.30
Control variables								
Birth cohort and month	x	x	x	x	x	x	x	x
Gender	x	x	x	x	x	x	x	x
Individual characteristics[a]		x	x	x		x	x	x
Family background[b]			x	x			x	x
Academic achievement at 12y[c]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. All models include controls for cohort (1–5) and birth month. The cohort dummies illustrate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, and Cohort 5= born in 1965. [d] Individual characteristics: summary of an individual's chronic conditions and body fat. [e] Family background factors: family income, parents' education, family size. [f] Academic achievement: predetermined academic achievement (GPA) at the age of 12 refers to a self-reported numerical assessment on a scale of 4–10 (4 is failing and 10 is excellent).

2.4.4 Endogeneity of physical activity

As several previous studies have suggested (Cabane et al., 2016; Eide and Ronan, 2001), participation in sports might be endogenous. This means that the choice to participate in physical activity might be influenced by the same forces that affect the outcome variable of interest (Bound et al., 1995). In the case of physical activity, such forces might be an individual's personality and abilities. An alternative identification strategy for examining the relationship between physical activity and educational outcomes, and address the potential endogeneity of physical activity is to use an IV approach. This approach requires instruments that affects educational outcomes only through its effects on physical activity. Prior literature has used, for example, legislation (Stevenson, 2010), school characteristics (Barron et al., 2000), and body height (Eide and Ronan, 2001; Pfeifer and Cornelißen, 2010; Rees and Sabia, 2010) as instruments. Additionally, in a recent study by Cabane et al. (2016), parental artistic activities were used as an instrument to examine the role of playing music or doing sports in education and health outcomes. As suggested by Cabane et al. (2016) parental artistic activities are a strong predictor of an adolescent' participation in music and are unlikely to influence the outcome directly. In the present study, we captured parents' physical activity details as an instrument. Parents' physical activity is a strong predictor of adolescent physical activity and is unlikely to affect educational outcomes directly. Moreover, as in the studies by Pfeifer and Cornelißen (2010), Rees and Sabia (2010), and Eide and Ronan (2001), we used an individual's body height as an instrument.

In addition to the OLS estimates (Table 5, Column 1), Table 5 presents the IV estimates of the relationship between physical activity, academic achievement, and educational attainment (Table 5, Columns 2–4). Since the IV estimates can differ systematically from the target parameter if the sample size is small (Angrist and Pischke, 2009, p. 205), the IV analysis was conducted using a pooled sample of women and men, and the models were adjusted by sex, birth cohort, and birth month.

The IV results showed a similar picture of the association as the baseline OLS results. Regardless of the instrument, the IV estimates were positive and statistically significant, suggesting that adolescent physical activity is positively related to educational outcomes. When individual's body height was used as an instrument (Table 5, Column 2), the F statistic varied from 4.67 to 6.23 indicating that body height is only weakly correlated with adolescent physical activity.[18] Therefore, the IV estimator may be biased toward the OLS estimator, and the results should be interpreted with caution. In the case of parents' physical activity (Table 5, Columns 3 and 4), the F values varied from 26.85 to 70.19 indicating that parents' physical activity is highly correlated with their children's physical activity. In general, the IV estimates were greater than the corresponding OLS estimates suggesting an even stronger association between physical activity and educational outcomes.

Taken together, the IV results were in line with those in a study by Pfeifer and Cornelißen (2010), who demonstrated a positive association between participation in sports and educational attainment. However, in contrast to Rees and

18 To be valid, two requirements must hold. First, the instrument needs to be correlated with the included endogenous regressor, that is, participation in sports, and second, uncorrelated with the error term (Agrist and Pischke, 2009, p. 117; Stock and Yoko, 2005).

Sabia's (2010) findings, the present results also support the view that adolescent physical activity is positively associated with academic achievement. Therefore, our results provide evidence that leisure-time physical activity during adolescence may not only predict academic success during compulsory basic education but also boost educational outcomes later in life.

TABLE 5 2SLS Estimates of relationship between physical activity level at 15 years and educational outcomes.

	Academic achievement at the age of 15 years, grade point average				Educational attainment at the age of 33–45 years, years of education			
	1	2	3	4	1	2	3	4
PAI at 15 y	0.081*** (0.013)	0.966** (0.476)	0.285*** (0.063)	0.277*** (0.061)	0.69*** (0.036)	2.501** (1.086)	0.850*** (0.192)	0.833*** (0.186)
First-stage F	-	4.67	52.06	26.85	-	6.23	70.19	36.07
N	1247	1247	1247	1247	1628	1628	1628	1628

Robust standard errors are in parentheses. The level of statistical significance: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$. All models include controls for cohort (1–5) and birth month. The cohort dummies illustrate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, and Cohort 5= born in 1965. I Baseline OLS. Instruments used: II height; III Physical Activity, Father; IV Physical Activity, Father and Mother.

2.5 Conclusion

Using data from a population-based follow-up study from youth to adulthood combined with register-based information on post-compulsory education, the aim of this study was to examine whether adolescent physical activity is associated with academic achievement at the end of compulsory basic education and with educational attainment later in life. The results provided evidence that physical activity in adolescence was positively associated with educational outcomes: The physical activity level at age 15 and an increase in the physical activity level between the ages of 12 and 15 were positively related to GPA at age 15 and years of subsequent education in adulthood. The results were robust to the inclusion of additional covariates, including individual and family background factors

The linked data and longitudinal setting of the study contribute to and extend the previous literature in four important ways. First, the longitudinal setting allowed tracking the same individuals' educational outcomes starting from compulsory basic education until the end of post-compulsory graduation. Second, instead of a single measure of physical activity, the study included four measures to illustrate physical activity: leisure-time physical activity level at age 15, change in the physical activity level between the ages of 12 and 15, participation in sports club training sessions, and participation in sports competitions. However, physical activity details were self-reported; thus, some measurement error may exist (Sallis and Saelens, 2000; Shephard, 2003). Third, instead of self-reported information on post-compulsory education, this study used the years of completed education obtained from Statistics Finland. This mitigated the possible measurement error in the outcome variable. Fourth, to alleviate possible endogeneity of physical activity, omitted variable bias, and measurement error, an IV approach was employed. Following Pfeifer and Cornelißen (2010), Rees and Sabia (2010), and Eide and Ronan (2001), individual's body height was used as an instrument. The data also allowed to tackle parents' physical activity details as an instrument to explain variations in their children's sports participation.

The result provided evidence that adolescent physical activity is positively related to educational outcomes during the life course, but the explanation for this association is unclear. Therefore, future research should explore the potential mechanisms behind the findings of this study. To uncover these mechanisms, future studies need informative data sets covering, for example, health endowments, cognitive ability, personality, and family background factors (e.g., parental involvement in youth sports, family support). Additionally, more research is needed to clarify the longitudinal relationship between physical activity and educational outcomes. For now, we are persuaded to think that the findings of this study are generalizable to other developed countries with similar physical activity behavior as well as educational attainment. More specifically, as in many other countries (Hallal et al., 2012; Tremblay et al., 2016; WHO, 2010), the physical activity levels are low among Finnish children (Tammelin et al., 2016). Regarding educational attainment, the cross-country comparisons, reveal that, in terms of educational level, Finns aged 25 to 64 years are ranked seventh among OECD countries (OECD, 2015). To further increase understanding of this longitudinal association between physical activity and educational outcomes, it would be valuable to replicate this study with data drawn from other countries than Finland.

The choice of post-compulsory education is one of the most important investments in human capital (Becker, 2009). Apart from the well-known health effects of physical activity (Lee et al., 2012; Murray and Lopez, 1997; WHO, 2010), the positive association found in the present study provides evidence that physical activity may predict better learning outcomes starting in compulsory basic education and continuing until the end of post-compulsory graduation.

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Appendix A

TABLE A.1 The original scoring and recoding of the items included in the physical activity index (PAI) in 1980–989, range from 5 to 14.

Items	Original Score	Code for PAI
How often do you engage in leisure-time physical activity at least half an hour per time?		
Not at all	1	1
Less than once a month	2	1
Once a month	3	1
2–3 times a month	4	1
Once a week	5	2
2–6 times a week	6	2
Every day	7	3
How much are you breath-taking and sweating when you engage in physical activity and sport?		
Not at all	1	1
Moderately	2	2
Lot of	3	3
How many times a week do you usually engage in the training sessions of sports club?		
Not at all	1	1
Occasionally	2	1
Less than once a month	3	1
Once a month or more	4	2
Once a week	5	2
Many hours and times a week	6	3
Do you participate in regional or national level competitions?		
No	1	1
Yes	2	2
What do you usually do in your leisure time?		
I am usually indoors and read or do something like that	1	1
I spend my time indoors and outdoors, outdoors I usually walk or spend time with my friends.	2	2
I am usually outdoors and exercise rather much.	3	3

Appendix B

TABLE B.1 Descriptive statistics.

		All		Women		Men		
	Data Source	*N*	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)	*p* value[a]
Physical activity								
PAI at 12 y	YFS	1723	9.57 (1.80)	886	9.06 (1.63)	837	10.11 (1.82)	$p < 0.001$
PAI at 15 y[b]	YFS	2445	8.97 (1.97)	1271	8.61 (1.77)	1174	9.37 (2.10)	$p < 0.001$
ΔPAI at 12–15 y[c]	YFS	1723	–0.52 (1.84)	886	–0.37 (1.80)	837	–0.70 (1.88)	$p < 0.001$
+ΔPAI 12–15 y[d]	YFS	1723	0.27 (0.45)	886	0.31 (0.46)	837	0.23 (0.42)	$p < 0.001$
-ΔPAI 12–15 y[e]	YFS	1720	0.50 (0.50)	886	0.46 (0.50)	837	0.53 (0.50)	$p < 0.004$
Participation in sports club training at 15 y[f]	YFS	2445	0.28 (0.45)	1271	0.24 (0.43)	1174	0.32 (0.47)	$p < 0.001$
Participation in sports competitions at 15 y[g]	YFS	1854	0.24 (0.43)	981	0.19 (0.39)	873	0.30 (0.46)	$p < 0.001$
Educational attainment								
Grade point average at 15 y[h]	YFS	1941	7.82 (0.93)	1022	8.08 (0.88)	919	7.53 (0.90)	$p < 0.001$
Years of education[i]	FLEED	2445	13.53 (2.88)	1271	13.88 (2.82)	1174	13.23 (2.86)	$p < 0.001$
Control variables								
Health[j]	YFS	2437	0.19 (0.40)	1266	0.21 (0.41)	1171	0.18 (0.38)	$p = 0.076$
Body fat	YFS	2409	16.44 (7.33)	1254	4.42 (4.93)	1155	11.30 (5.91)	$p < 0.001$
GPA 12	YFS	1729	7.87 (0.73)	899	8.07 (0.68)	830	7.64 (0.73)	$p < 0.001$
Income, Mother	LPC	2429	4563 (3492)	1262	4420 (3324)	1167	4718 (3658)	$p = 0.036$
Income, Father	LPC	2335	8573 (5693)	1213	8604 (6063)	1122	8538 (5265)	$p = 0.781$
Education, Mother	YFS	2445	0.08 (0.27)	1271	0.07 (0.26)	1174	0.08 (0.27)	$p = 0.309$
Education, Father	YFS	2445	0.10 (0.30)	1271	0.10 (0.30)	1174	0.10 (0.31)	$p = 0.514$
Family size	YFS	2441	4.40 (1.44)	1269	4.42 (1.45)	1172	4.38 (1.44)	$p = 0.492$

Notes. Cardiovascular Risk in Young Finns Study (YFS), and Finnish Longitudinal Employer-Employee Data (FLEED) from Statistics Finland. [a] *P* values for gender differences (*t*-test). [b] The physical activity index (PAI) (min. 5 to max. 14) at the age of 15 is a summary of five variables that illustrate the frequency and intensity of leisure-time physical activity, frequency of participation in sports clubs training sessions, participation in sports competitions, and the most common activity during leisure time. [c] ΔPAI illustrates the change in the PAI level between the ages of 12 and 15 years, when controlling for the physical activity index at the age of 12. [d] +ΔPAI is a binary variable that gets value 1 if the individual has increased his or her physical activity level between the ages of 12 and 15 years, and 0 otherwise. [e] -ΔPAI is a binary variable that gets value 1 if the individual has decreased his or her physical activity level between the ages of 12 and 15 years, and 0 otherwise. [f] Participation in sports club training sessions at the age of 15 is a binary variable that gets value 1 if an individual participates in organized sports clubs training sessions, and 0 otherwise. [g] Participation in sports competitions at the age of 15 is a binary variable that gets value 1 if the individual participates in national- or regional-level competitions, and 0 otherwise. The sample size varies because in the 1992 follow-up the participation in sports competitions was not asked. [h] Grade point average (GPA) at the age of 15 refers to a self-reported numerical assessment on a scale of 4–10, where 4 denotes failing and 10 denotes excellent. [i] Register-based information on educational attainment based on the years of completed education. [j] Summary of the following diseases: allergy/asthma, diabetes, convulsions, heart defect, infectious and parasitic diseases, tumors, endocrine diseases/metabolic disorders/malnutrition, blood disorders, mental disturbances, nervous and sensory system diseases, circulatory system diseases, respiratory diseases, digestive system diseases, genital and urinary tract diseases, skin and subcutaneous tissue diseases, musculoskeletal disorders, and other unidentified symptoms.

Appendix C

TABLE C.1 Correlation coefficients.

	Academic achievement at the age of 15 years, grade point average[a]	Educational attainment at the age of 33–45 years, years of education[b]
Panel I: All		
PAI at 15 y[b]	0.100***	0.094***
ΔPAI at 12–15 y[c]	0.175***	0.125***
Participation in sports club training at 15 y[d]	0.122***	0.090***
Participation in sports competitions at 15 y[e]	0.103***	0.069***
Panel II: Women		
PAI at 15 y	0.213***	0.135***
ΔPAI at 12–15 y	0.187***	0.121***
Participation in sports team training at 15 y[d]	0.152***	0.104**
Participation in sports competitions at 15 y[e]	0.183***	0.081***
Panel III: Men		
PAI at 15 y	0.142***	0.105***
ΔPAI at 12–15 y	0.137***	0.106***
Participation in sports club training at 15 y[d]	0.146***	0.097**
Participation in sports competitions at 15 y[e]	0.116***	0.083***

The level of statistical significance: *** p <0.001. [a] GPA at the age of 15 refers to a self-reported numerical assessment on a scale of 4–10, where 4 denotes failing and 10 denotes excellent. [b] Register-based information on educational attainment based on the years of completed education. [b] The physical activity index at the age of 15 years. [c] ΔPAI illustrates the change in the PAI level between the ages of 12 and 15 years. [d] Participation in sports club training is a binary variable that gets value 1 if the individual participates in organized sports clubs training sessions, and 0 otherwise. [e] Participation in sports competitions is a binary variable that gets value 1 if the individual participates in national- or regional-level competitions, and 0 otherwise.

3 CHILDHOOD PHYSICAL ACTIVITY AND ADULTHOOD EARNINGS[*]

Abstract[**]

Purpose: This study examined the associations between childhood physical activity level and adulthood earnings. Methods: The data were drawn from the ongoing longitudinal Young Finns Study, which was combined with register-based Finnish Longitudinal Employer–Employee Data and register-based parents' background information from the Longitudinal Population Census of Statistics Finland. The study consisted of children who were 9 yr (n = 1257, 52% boys), 12 yr (n = 1662, 51% boys), and 15 yr (n = 1969, 49% boys) of age at the time when physical activity was measured. The children were followed until 2010, when they were between 33 and 45 yr old. Leisure-time physical activity in childhood was self-reported, whereas earnings in adulthood were register-based and covered over a 10-yr period from 2000 to 2010. Ordinary least squares models were used to analyze the relationship between physical activity and earnings. Results: Childhood physical activity level was positively associated with long-term earnings among men ($P < 0.001$). In more detail, a higher level of leisure-time physical activity at the age of 9, 12, and 15 yr was associated with an approximate 12%–25% increase in average annual earnings over a 10-yr period. The results were robust to controlling, e.g., an individual's chronic conditions and body fat, parents' education and physical activity, and

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family income. Among women, no relation was observed. Conclusions: The findings provide evidence that childhood physical activity can have far-reaching positive effects on adulthood earnings. Possibilities for improving physical activity during childhood may not only promote health but also affect long-term labor market outcomes.

3.1 Introduction

According to current physical activity recommendations for health, only one-third of the youth are estimated to be sufficiently active (Ekelund et al., 2011; Hallal et al., 2012). Besides the widely acknowledged positive health effects of physical activity (Lee et al., 2012; Luepker et al., 1996; Murray and Lopez, 1997; Raitakari et al., 1997; Yang et al., 2008), physical inactivity has been identified as the fourth leading risk factor for global mortality (World Health Organization, [WHO], 2010), and several studies have reported increasing healthcare costs due to physical inactivity (Colditz, 1999; Katzmarzyk et al., 2000; Katzmarzyk and Janssen, 2004; Kohl et al., 2012; Lechner, 2015).

In addition to the positive correlation with health, physical activity has also been linked to positive returns in the labor market. There is evidence that former high school and college athletes (Barron et al., 2000; Ewing, 1998; Ewing, 2007; Long and Caudill, 1991; Stevenson, 2010) as well as those who are physically active in adulthood (Hyytinen and Lahtonen, 2013; Kavetsos, 2011; Kosteas, 2012; Lechner, 2009; Lechner, 2015; Rooth, 2011) typically perform better in the labor market in terms of wages (Barron et al., 2000; Ewing, 1998; Ewing, 2007; Kosteas, 2012; Long and Caudill, 1991; Rooth, 2011) and employment probability (Kavetsos, 2011; Stevenson, 2010. For example, using information from a long-term perspective, Lechner (2009) and Rooth (2011) showed that physical activity was positively related to monthly earnings and hourly wages, and Hyytinen and Lahtonen (2013) reported similar results for men on the basis of twin data. According to a field experiment conducted by Rooth (2011), employees also interpreted physical activity as a positive signal; that is, the probability of receiving a callback for a job interview was higher for those who announced to be physically active. Stevenson (2010), in turn, argued that the positive association between physical activity and wages existed solely because of the increase in labor force participation.

Although a positive connection between physical activity and labor market outcomes has been established, the reason for this correlation is unclear. One possibility is that higher physical activity leads to health gains, which, in turn, increase worker productivity and, therefore, labor market returns (Lechner, 2009; Lechner, 2015). Productivity gains can arise, for example, from decreased absences due to sickness or from better performance by workers. It is also possible that physical activity facilitates networking, which promotes career development (Lechner, 2009). Additionally, physical activity may develop non-cognitive skills, such as teamwork skills, sociability, or discipline (Alchian and Harold, 1972; Bailey, 2005; Bailey et al., 2009; Ewing, 1998), which are rewarded in the labor market. Finally, physical activity can cause positive discrimination (McCormick and Maurice, 1987; Rooth, 2011), which may explain success in individuals' work lives.

Increasing evidence suggests that physical activity is related to substantial economic and noneconomic returns. The benefits of physical activity not only are confined to health but may also cover other areas such as labor market performance. The purpose of this study was to examine the associations between childhood physical activity and earnings in adulthood. We hypothesized that higher physical activity level in childhood is associated with higher earnings in adulthood. Previous literature concerning the relationship between physical activity and labor market outcomes has mainly focused on physical activity during adulthood or adolescence. However, the role of physical activity in childhood is particularly relevant for two reasons. First, because childhood physical activity is measured before any labor market experience, the potential problem of reverse causality is eliminated. Second, if physical activity in childhood has far-reaching implications for future work life, this could be taken into account by policy makers. In general, possibilities for improving labor force's productivity are important because higher productivity increases economic welfare and strengthens competitiveness (Lechner, 2015).

3.2 Methods

3.2.1 Study population

The data were drawn from the ongoing longitudinal Young Finns Study (YFS), which was launched in 1980, when 3596 (82.3%) of the 4326 invited individuals in six age cohorts (age 3, 6, 9, 12, 15, and 18 yr) participated in the baseline study. The participants were randomly chosen boys (51%) and girls (49%) from five Finnish university cities (Helsinki, Turku, Tampere, Oulu, and Kuopio) and their rural surroundings. The study has been conducted in seven follow-up phases, and the most recent follow-up was performed in 2011/2012. The examinations included comprehensive data collection using questionnaires, physical measurements, and blood tests as previously described (Raitakari et al., 2008). The research protocol for the YFS was approved by the ethics committees of the five universities (Helsinki, Turku, Tampere, Oulu, and Kuopio), and written informed consent was obtained before respondents participated in the study. Moreover, data protection issues have been taken into account as specified in current Finnish legislation.

The YFS was then linked to register-based Finnish Longitudinal Employer–Employee Data (FLEED) from Statistics Finland. FLEED records detailed information on labor market outcomes, and covers the period from 1990 to 2010. Register-based information on family background was obtained from the Longitudinal Population Census of Statistics Finland from 1980. FLEED and the

Longitudinal Population Census were linked to the YFS based on unique personal identifiers. This is exact matching and therefore avoids problems created by errors in record linkages (Ridder and Moffitt, 2007).

The present study consisted of children who were 9 yr (n = 1257, 52% boys), 12 yr (n = 1662, 51% boys), and 15 yr (n = 1969, 49% boys) of age when the information about physical activity was collected. These individuals were followed until 2010, when they were between 33 and 45 yr old. The original 9-yr-old participants were born in 1971–1977, the 12-yr-old participants in 1968–1977, and the 15-yr-old participants in 1965–1977.

3.2.2 Self-reported physical activity

Leisure-time physical activity at the age of 9, 12, and 15 yr was measured with a self-reported questionnaire. The questions concerned the frequency and intensity of leisure-time physical activity, participation in sports club training, participation in sport competitions, and habitual way of spending leisure-time (Telama et al., 1996; Telama et al., 2014).The response alternatives were coded from 1 to 3, except participation in sport competition, which was coded from 1 to 2, and thereafter summed to form a physical activity index (PAI) with scores ranging from 5 to 14 (see Appendix, Supplemental Digital Content, original scoring and recoding of the items included in PAI in 1980–1989, range from 5 to 14; Telama et al., 1996).

3.2.3 Register-based annual earnings

Information on annual earnings was drawn from FLEED, which records information on annual wage and salary earnings from tax authority registers. The earnings were measured as a logarithm of the average annual wages and salary earnings from 2000 to 2010. The values were deflated using the consumer price index (base year 2000).

3.2.4 Statistical analyses

STATA software, version 13.1, was used for the statistical analyses. The analysis was based on the ordinary least squares (OLS) models, where the associations between childhood physical activity and later labor market returns were regressed by using the logarithm of the average annual wages and salaries as the dependent variable and the PAI at the age of 9, 12, or 15 yr as an explanatory variable. All baseline models controlled for the birth cohort and the birth month, which are both predetermined variables. Before the OLS models, the correlation coefficients were calculated to illustrate the unconditional connections between childhood physical activity and earnings in adulthood.

The consistency and the robustness of the OLS estimator require that the physical activity variable and observed confounding variables are uncorrelated with the error term and that unobserved individual heterogeneity is uncorrelated with the physical activity variable. We supported these assumptions with several methods. First, following Angrist and Pischke (2009, p. 68), all confounding variables in the baseline models were obtained before labor market entry. Thus, future labor market outcomes cannot have an effect on the confounders measured before labor market entry. Second, it is possible that childhood physical activity reflects omitted variables without having an independent effect on later labor market outcomes. To alleviate this problem, the models were extended by several additional covariates. First, the models were augmented with individuals' chronic diseases and body fat obtained in 1980 (Slaughter et al., 1988). Second, several family background variables obtained in 1980 (parents' education, family income, parents' health, and parents' physical activity) were added as controls.

As a robustness check, the baseline models were extended in three ways. First, the sample size of the baseline models varied depending on the age when the PAI was measured. Thus, the difference between the point estimates at the age of 9, 12, and 15 yr might partly reflect the differences in the sample. To control for this possibility, the sample size was locked up to those born in 1971 (n = 447 men and n = 437 women) and whose physical activity levels were measured at all three time points (at the age of 9, 12, and 15 yr). Although this method reduced the sample size, the same participants could be tracked during the entire period. Second, we investigated whether the association between physical activity and earnings is due to more intense labor market attachment of individuals who were more physically active. This was done by controlling individual average employment months during 2000–2010, and thereby the possibility that the results are driven by unemployment or labor market inactivity could be considered. Finally, we tested whether taking into account the quality of the leisure-time physical activity affects the results. This was done by dividing the original PAI into two parts: a variable that indicated participation in sport competitions (1 = participates in national or regional level sport competitions, 0 = does not participate in sport competitions) and the original PAI subtracted from the sport competition variable. The original PAI was replaced with these two new variables in the wage equation.

3.3 Results

3.3.1 Baseline results

In all age groups (9, 12, and 15 yr), girls had lower physical activity levels compared with boys ($P < 0.001$, Table 1). Similarly, the average annual earnings in 2000–2010 were lower among women compared with men ($P < 0.001$).

TABLE 1 Sample characteristics according to gender

	Women		Men		
	n	Mean (SD)	*n*	Mean (SD)	*P* value[a]
PAI at 9 years (5–14)[b]	608	8.9 (1.415)	649	9.9 (1.534)	$P < 0.001$
PAI at 12 years (5–14)	818	9.1 (1.637)	844	10.1 (1.823)	$P < 0.001$
PAI at 15 years (5–14)	1002	8.7 (1.807)	967	9.4 (2.127)	$P < 0.001$
Earnings in 2000–2010 (€)[c]	1579	18075 (11089)	1563	24589 (17632)	$P < 0.001$

[a] P values for gender differences (t-test). [b] The physical activity index (PAI) (scale 5 to 14) is a summary of five variables that illustrate the frequency and intensity of leisure-time physical activity, frequency of participation in sports clubs training, participation in sport competitions, and the most common activity during leisure time. [c] Earnings illustrate the logarithm of the average of the annual wage and salary earnings over the period 2000–2010. The values are deflated using the consumer price index (base year 2000).

According to the correlation coefficients, among men, the physical activity level in childhood was positively associated with earnings in adulthood ($P < 0.001$, Table 2), whereas no significant correlation was observed among women.

TABLE 2 Correlation coefficients

	PAI 9[a]	PAI 12[b]	PAI 15[c]	Earnings 2000-2010[d]
Women				
PAI 9	–			
PAI 12	0.490***	–		
PAI 15	0.261***	0.456***	–	
Earnings 2000-2010	0.032	0.012	0.028	–
Men				
PAI 9	–			
PAI 12	0.530***	–		
PAI 15	0.424***	0.574***	–	
Earnings 2000–2010	0.127**	0.080*	0.120***	–

The level of statistical significance: $^{***}P < 0.001$, $^{**}P < 0.01$, $^{*}P < 0.05$. [a] The physical activity index at the age of 9 years. [b] The physical activity index at the age of 12 years. [c] The physical activity index at the age of 15 years. [d] Earnings illustrate the logarithm of the average of the annual wage and salary earnings over the period of 2000–2010. The values are deflated using the consumer price index (base year 2000).

The baseline OLS estimates (Table 3, column 1) indicated that, among men, higher physical activity at the age of 9, 12, and 15 yr was associated with higher earnings. In terms of standardized coefficients, one SD increase in the PAI at the age of 9 yr was related to approximately 38% higher long-term earnings, over a 10-yr period, whereas the standardized coefficient for the PAI at the age of 12 and 15 yr was approximately 29%. Unlike what was hypothesized, among women (Table 4, column 1), no such relation was observed.

The inclusion of a comprehensive set of potential confounding factors (Tables 3 and 4, columns 2, 3, and 4) kept the physical activity estimate by and large intact. When individual and family background factors were controlled (Table 3, column 4), one SD increase in the PAI at the age of 9, 12, and 15 yr was related to an approximate 30% increase in adulthood earnings among men.

TABLE 3 Regression analysis of long-term earnings among men

	Ln(Earnings 2000–2010)[a]				
	1	2	3	4	5 (*N* = 447)
PAI 9[b] *N* = 649	0.246*** (0.059)	0.204*** (0.055)	0.236*** (0.062)	0.194*** (0.058)	0.202*** (0.064)
R^2	0.04	0.14	0.06	0.16	0.23
PAI 12 *N* = 844	0.159*** (0.048)	0.148*** (0.047)	0.165*** (0.048)	0.160*** (0.046)	0.175*** (0.053)
R^2	0.03	0.012	0.05	0.14	0.23
PAI 15 *N* = 967	0.135*** (0.035)	0.124*** (0.034)	0.138*** (0.036)	0.126*** (0.035)	0.152*** (0.052)
R^2	0.02	0.12	0.03	0.13	0.23
Control variables					
Cohort[c]	x	x	x	x	x
Month of birth	x	x	x	x	x
Individual characteristics[d]		x		x	x
Family characteristics			x	x	x

The level of significance: ***$P < 0.001$. Unstandardized coefficients. Robust standard errors are in the parentheses. [a] Earnings are deflated using the consumer price index (base year 2000). [b] PAI 9, PAI 12, and PAI 15 illustrate the self-reported leisure-time physical activity at the age of 9, 12, and 15 years. [c] Cohort dummies illustrate the year of birth: Cohort 1 = born in 1962, Cohort 2 = born in 1965, Cohort 3 = born in 1968, Cohort 4 = born in 1971, Cohort 5 = born in 1974, Cohort 6 = born in 1977. [d] Individual characteristics include health and body fat (Slaughter equation). Health was controlled by using indicators for the following diseases: allergy/asthma, diabetes, convulsions, heart defect, infectious and parasitic diseases, tumors, endocrine diseases/metabolic disorders/malnutrition, blood disorders, mental disturbances, nervous and sensory system diseases, circulatory system diseases, respiratory diseases, digestive system diseases, genital and urinary tract diseases, skin and subcutaneous tissue diseases, musculoskeletal disorders, and other unidentified symptoms. [e] Family background factors included parents' education, family income, parents' health, and parents' physical activity obtained in 1980.

TABLE 4 Regression analysis of long-term earnings among women

	Ln(Earnings 2000–2010)[a]				
	1	2	3	4	5 (*N* = 437)
PAI 9 *N* = 608	0.060 (0.048)	0.058 (0.049)	0.056 (0.047)	0.056 (0.048)	0.061 (0.055)
R^2	0.03	0.06	0.07	0.09	0.10
PAI 12 *N* = 818	0.026 (0.034)	0.023 (0.034)	0.020 (0.035)	0.017 (0.034)	0.014 (0.045)
R^2	0.03	0.05	0.05	0.07	0.09
PAI 15 *N* = 1002	0.045 (0.029)	0.052 (0.027)	0.022 (0.029)	0.029 (0.028)	0.016 (0.035)
R^2	0.03	0.07	0.06	0.10	0.09
Control variables					
Cohort	x	x	x	x	x
Month of birth	x	x	x	x	x
Individual characteristics		x		x	x
Family characteristics			x	x	x

Unstandardized coefficients. Robust standard errors are in the parentheses. [a] Earnings are deflated using the consumer price index (base year 2000). [b] PAI 9, PAI 12, and PAI 15 illustrate the self-reported leisure-time physical activity at the age of 9, 12, and 15 years. [c] Cohort dummies illustrate the year of birth: Cohort 1 = born in 1962, Cohort 2 = born in 1965, Cohort 3 = born in 1968, Cohort 4 = born in 1971, Cohort 5 = born in 1974, Cohort 6 = born in 1977. [d] Individual characteristics include health and body fat (Slaughter equation). Health was controlled by using indicators for the following diseases: allergy/asthma, diabetes, convulsions, heart defect, infectious and parasitic diseases, tumors, endocrine diseases/metabolic disorders/malnutrition, blood disorders, mental disturbances, nervous and sensory system diseases, circulatory system diseases, respiratory diseases, digestive system diseases, genital and urinary tract diseases, skin and subcutaneous tissue diseases, musculoskeletal disorders, and other unidentified symptoms. [e] Family background factors included parents' education, family income, parents' health, and parents' physical activity obtained in 1980.

3.3.2 Robustness checks

The results remained intact when the sample size was restricted to individuals (n = 447 boys and 437 girls) whose physical activity levels were followed at three time points (at the age of 9, 12, and 15 yr) during childhood. Among men, one SD increase in the PAI at the age of 9, 12, and 15 yr was related to an approximate 30% increase in long-term earnings over a 10-yr period. Among women, no association was observed, which is in line with the baseline OLS results.

After controlling for a person's employment months in 2000–2010, childhood physical activity at the age of 12 and 15 yr was positively related to men's earnings (Table 5, column 1). However, the point estimate decreased indicating that one SD increase in the PAI at the age of 12 and 15 yr was related to an approximate 6%–7% increase in long-term earnings. Among women, the physical activity level at the age of 15 yr turned significant after controlling for employment (Table 5, column 2). In this specification, one SD increase in the PAI was related to an approximate 6% increase in adulthood earnings.

TABLE 5 Robustness check, labor market attachment

	Ln(Earnings 2000–2010)[a]	
	Men	Women
PAI 9[b]	0.036	0.007
	(0.023)	(0.017)
R^2	0.53	0.61
PAI 12	0.036***	0.004
	(0.014)	(0.013)
R^2	0.53	0.56
PAI 15	0.026**	0.038***
	(0.012)	(0.011)
R^2	0.52	0.52
Control variables		
Cohort[c]	x	x
Month of birth	x	x
Employment months in 2000–2010[d]	x	x

The level of significance: ****P* < 0.001, ** *P* < 0.01. Unstandardized coefficients. Robust standard errors are in the parentheses. [a] Earnings are deflated using the consumer price index (base year 2000). [b] PAI 9, PAI 12, and PAI 15 illustrate the self-reported leisure-time physical activity at the age of 9, 12, and 15 years. [c] Cohort dummies illustrate the year of birth: Cohort 1 = born in 1962, Cohort 2 = born in 1965, Cohort 3 = born in 1968, Cohort 4 = born in 1971, Cohort 5 = born in 1974, Cohort 6 = born in 1977. [d] The average of the annual employment months in 2000–2010. Additionally, the results remained intact, when a predetermined variable (the average of the employment months in 1999) was added.

The results from the models where the original PAI was divided into leisure-time physical activity and participation in sport competitions are reported in Table 6. After controlling for leisure-time physical activity, participation in sport competitions at the age of 9 yr was related to higher earnings among men. At ages 12 and 15 yr, only the leisure-time physical activity remained significant and positive. Among women (Table 6, columns 3 and 4), no such relation was found. The results were robust to the inclusion of an individual's chronic diseases, body fat, and family background factors (Table 6, columns 2 and 4).

TABLE 6 Robustness check, leisure-time physical activity vs. target-oriented physical activity

	Ln(Earnings 2000–2010)[a]			
	Men		Women	
	1	2	3	4
PA 9[b]	0.133*	0.105	0.015	0.012
	(0.079)	(0.076)	(0.050)	(0.054)
COM 9[c]	0.402**	0.329*	0.184	0.188
	(0.186)	(0.076)	(0.156)	(0.175)
R^2	0.05	0.19	0.03	0.10
PA 12	0.143**	0.109*	–0.021	–0.020
	(0.062)	(0.063)	(0.045)	(0.052)
COM 12	0.037	0.174	0.143	0.095
	(0.195)	(0.205)	(0.132)	(0.146)
R^2	0.03	0.17	0.03	0.08
PA 15	0.128**	0.148**	0.058	0.028
	(0.058)	(0.063)	(0.038)	(0.043)
COM 15	0.175	0.018	–0.044	–0.033
	(0.235)	(0.234)	(0.171)	(0.174)
R^2	0.04	0.18	0.02	0.11
Control variables				
Cohort	x	x	x	x
Month of birth	x	x	x	x
Individual characteristics		x		x
Family characteristics		x		x

The level of significance: ** $P < 0.01$, * $P < 0.05$. Unstandardized coefficients. Robust standard errors are in the parentheses. [a] Earnings are deflated using the consumer price index (base year 2000). [b] PA 9, PA 12, and PA 15 illustrate the self-reported leisure-time physical activity at the age of 9, 12, and 15 years excluding the participation in sport competitions. [c] Participation in sports competitions (COM) is a binary variable that gets value 1 if individual participates in national or regional level sport competitions, and 0 otherwise. [d] Cohort dummies illustrate the year of birth: Cohort 1 = born in 1962, Cohort 2 = born in 1965, Cohort 3 = born in 1968, Cohort 4 = born in 1971, Cohort 5 = born in 1974, Cohort 6 = born in 1977.

3.4 Discussion

In summary, using a longitudinal population-based cohort study combined with register-based information on labor market outcomes, this study investigated the relationship between childhood physical activity and long-term earnings. The results showed that, among men, self-reported physical activity in childhood was related to higher long-term earnings in adulthood. Among women, no such relation was observed.

The linked data and longitudinal setting of the study extend the previous literature in three important ways. First, adulthood physical activity can be shaped by success or failure in the labor market, which can make the direction of the causality between physical activity and earnings unclear (e.g., Cutler and

Glaeser, 2005; Hyytinen and Lahtonen, 2013; Lechner, 2009). We overcame this problem by using measures of physical activity during childhood, before labor market entry. Second, instead of cross-sectional information on earnings, which contains idiosyncratic components and is often an inaccurate proxy for long-term earnings (e.g., Böhlmark and Lindquist, 2006; Haider and Solon, 2006), this study used the average earnings measured over a 10-yr period as the dependent variable. The information on earnings was also register based, and therefore, potential bias resulting from self-reported information can be ignored. However, the physical activity measurements were obtained with a self-reported questionnaire, and thus, there may be some measurement error (Sallis and Saelens, 2000; Shephard, 2003). Finally, to mitigate the possibility that unobserved characteristics, such as family background factors or pre-existing differences in health and physical features, drive the results, we used individuals' chronic diseases, body fat, and several indicators for family background as control variables.

Our results showed that the childhood physical activity level was positively related to earnings among men. The results were robust to controlling for individual and family background factors. Among women, no association between physical activity and earnings was observed. When an individual's employment months were controlled, the physical activity point estimate decreased. This implies that the connection between physical activity and earnings can be partly attributed to the more intense labor market attachment of physically active individuals; that is, they experience less unemployment or their labor market participation is higher. A possible explanation for the positive association between physical activity and earnings is that some unobserved traits are related to physical activity and earnings. Such traits could be ambition, competitiveness, or target orientations, which may be more prevalent among competitive athletes. To test this possibility, the original PAI was divided into leisure-time physical activity and participation in sport competitions. However, our results did not support the assumption that competitive children would receive higher earnings once the leisure-time physical activity was controlled.

Our findings are consistent with previous literature in which adulthood physical activity has been associated with higher earnings (Barron et al., 2000; Ewing, 1998; Ewing, 2007; Hyytinen and Lahtonen, 2013; Lechner, 2009; Long and Caudill, 1991; Rooth, 2011; Stevenson, 2010). However, all previous studies investigated the role of adulthood physical activity or physical activity in adolescence, and none focused on childhood physical activity, especially outside school hours. In addition, the questions concerning the level of physical activity were study specific. This study focused on leisure-time physical activity outside school hours, whereas most of the previous studies focused on the frequency of physical activity (Hyytinen and Lahtonen, 2013; Kavetsos, 2011; Kosteas, 2012; Lechner, 2009), or high school athletic participation (Barron et al., 2000; Ewing, 1998; Ewing, 2007; Long and Caudill, 1991; Stevenson, 2010). Therefore, the comparison between the results is not straightforward. Nevertheless, our results add to the current literature by showing that the association between physical activity and labor market performance may start to develop as early as in childhood.

One notable feature is the difference between the results for men and women. The association was significant only among men. This finding is in line with the study by Hyytinen and Lahtonen (2013) who reported 14%–17% higher long-term income of physically active men than that of the less active men. Similarly, a study by Long and Caudill (1991) showed that men who participated in intercollegiate athletics had higher annual income compared with non-athletes, whereas among women, no such income premium was found. Lechner (2009) and Kosteas (2012), in contrast, found a significant positive relationship between adulthood physical activity and earnings for men and women. Finally, Stevenson (2010) demonstrated a positive association between increased opportunities to participate in sports and subsequent wages among women. The connection between physical activity and earnings seems to be positive and robust among men, but for women, the results are less clear. The differences in the labor force participation between fertility-age men and women might partly explain the results. Our results indirectly support this hypothesis because a positive association between physical activity and earnings was found among women when the employment months were controlled.

Although the study demonstrated a positive association between physical activity and earnings, the causality cannot be interpreted. An apparent threat to the causal interpretation is that some unobserved characteristics are correlated with physical activity and earnings. Intuitively, however, childhood physical activity may promote adulthood labor market performance for four reasons. First, childhood physical activity can lead to health gains, which are rewarded later in working life with higher productivity and higher earnings. According to Smith (2009) and Lundborg et al. (2014), poor health in adolescence had a substantial effect on earnings in adulthood, whereas Lechner (2009) showed that adulthood physical activity had a sizable positive effect on health and long-term earnings. Second, physical activity in childhood (e.g., participation in sports competitions) may create networks, which promote career development (Lechner, 2009), and therefore is positively associated with earnings in adulthood. Third, physical activity may improve non-cognitive skills, such as teamwork skills, sociability, or discipline (Alchian and Harold, 1972; Bailey, 2005; Bailey et al., 2009; Ewing, 1998), which contribute later in the labor markets. Fourth, physical activity might serve as a signal to employers of good health, motivation, ambition, and productivity, and therefore causes positive discrimination (McCormick and Maurice, 1987; Rooth, 2011), which explains the wage gap.

Only one-third of the youth are sufficiently active and meet current physical activity guidelines (Ekelund et al., 2011; Hallal et al., 2012). As this study suggests, the consequences of childhood physical activity can be far-reaching. Physical activity might not only promote health but also affect labor market outcomes later in life. From policy perspective, the findings are twofold: If childhood physical activity can boost an individual's labor productivity, increasing participation in physical activities during the life course may constitute an important policy goal. Second, encouraging children to be physically active, providing children equal possibilities to participate in physical activities regardless of their socioeconomic background, and targeting interventions to children and youth with the lowest physical activity levels should become an important policy objective. To further increase understanding of this association, it would be valuable to explore the potential mechanism in more detail. In addition, understanding the role of physical activity in other dimensions of labor market performance, such as unemployment and occupational sorting, could shed light on the results.

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Appendix

Supplemental Digital Content. The original scoring and recoding of the items included in physical activity index (PAI) in 1980–989, range from 5 to 14 (Telama et al., 1996).

Items	Original Score	Code for PAI
How often do you engage in leisure-time physical activity at least half an hour per time?		
Not at all	1	1
Less than once a month	2	1
Once a month	3	1
2–3 times a month	4	1
Once a week	5	2
2–6 times a week	6	2
Every day	7	3
How much are you breath-taking and sweating when you engage in physical activity and sport?		
Not at all	1	1
Moderately	2	2
Lot of	3	3
How many times a week do you usually engage in the training sessions of sports club?		
Not at all	1	1
Occasionally	2	1
Less than once a month	3	1
Once a month or more	4	2
Once a week	5	2
Many hours and times a week	6	3
Do you participate in regional or national level competitions?		
No	1	1
Yes	2	2
What do you usually do in your leisure time?		
I am usually indoors and read or do something like that	1	1
I spend my time indoors and outdoors, outdoors I usually walk or spend time with my friends.	2	2
I am usually outdoors and exercise rather much.	3	3

4 CHILDHOOD PHYSICAL ACTIVITY AND LONG-TERM LABOR MARKET OUTCOMES

Abstract[*]

This study examines the relationship between physical activity in childhood and long-term labor market outcomes in adulthood. To address this important but under-researched theme, we analyze data drawn from longitudinal research, the Cardiovascular Risk in Young Finns Study and from registries compiled by Statistics Finland. Labor market outcomes include individuals' employment status, average employment months, and average unemployment months calculated over the period from 1997 to 2010. Information on childhood leisure-time physical activity is obtained at ages 9 and 15 years. Based on the changes in physical activity level between the ages of 9 and 15 years, participants are classified into five activity groups: persistently active, increasingly active, moderately active, decreasingly active, and persistently inactive. The results provide evidence that the consequences of childhood physical activity may be far-reaching, as higher childhood physical activity increases the probability of employment, is positively related to employment months, and is negatively related to unemployment months. Regarding changes in physical activity level, we find that persistently active individuals have the highest level of employment and the lowest level of unemployment compared with other activity groups. These results are robust to the use of covariates, such as pre-existing health endowment, family income, and parents' education.

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4.1 Introduction

The World Health Organization estimates that only one-fifth of children worldwide are sufficiently physically active and meet the current physical activity recommendations for health (WHO, 2014)[19]. The health benefits of physical activity and the health detriments of physical inactivity are widely acknowledged. Among children and youth, physical activity has been linked with improved cardiorespiratory and muscular fitness, cardiovascular and metabolic health biomarkers, bone health, and body mass (Physical Activity Guidelines Advisory Committee, 2008; Lee et al., 2012; Murray and Lopez, 1997). Physical inactivity, in contrast, has been identified as the fourth leading risk factor for global mortality (WHO, 2010); it is a principal cause for approximately 21%–25% of breast and colon cancer burden, 27% of diabetes burden, and 30% of ischemic heart disease burden (Lee et al., 2012; WHO, 2009).

Given the established connection between physical activity and health, research concerning the labor market returns of physical activity has increased in recent years (see Table A1 for a summary of the literature). Essentially, studies in this field find that former athletic participation in high school and physical activity in adulthood are positively related to earnings (e.g., Cabane, 2010; Hyytinen and Lahtonen, 2013; Kosteas, 2012; Lechner, 2009; Lechner and Downward, 2017; Lecher and Sari, 2015; Long and Caudill, 1991; Rooth, 2011; Stevenson, 2010) and probability of employment (Cabane, 2014; Kavetsos, 2011; Lechner and Downward, 2017) (Table A1).

Besides a positive association between cardiovascular fitness and earnings among Swedish men, Rooth (2011) shows that individuals who indicate in job applications that they are physically active have a higher probability of receiving callbacks to job interviews. Cabane (2014) finds that physical activity is related to quicker transitions from unemployment to employment, especially among women. Additionally, using cross-sectional data from 25 European countries, Kavetsos (2011) shows that physically active individuals are more likely to be employed, and Lechner and Downward (2017) document a negative association between sports participation and unemployment. Unlike Cabane (2014) and Kavetsos (2012), Barron et al., (2000) do not find an association between high school athletic participation and the likelihood of being employed. Instead, Barron et al. (2000) suggest that employed athletes typically receive higher earnings than their non-athlete counterparts. Moreover, Lechner (2009) shows that physical activity is positively related to monthly earnings and hourly wages among men and women. In terms of labor supply, however, no association is found among men, whereas among women, the results suggest that an increase in the probability of full-time employment corresponds to a decline

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19 The recommended levels of physical activity for children (ages 5–11) and youth (ages 12–17) is to accumulate at least 60 minutes of moderate to vigorous-intensity physical activity daily. Additionally, vigorous-intensity activities should be incorporated at least three times per week including activities that strengthen the muscles and bones. (Physical Activity Guidelines Advisory Committee, 2008; WHO, 2010.)

in the number of women who are considered as being out of the labor force (Lechner, 2009).

Finally, Cabane and Clark (2015) and Kari et al., (2016) examine the relationship between childhood leisure-time physical activity, rather than high school athletic participation or physical activity in adulthood, and labor market outcomes. Cabane and Clark (2015) find a positive association between childhood sporting activities, managerial responsibilities, and the level of autonomy at work. Regarding earnings, job satisfaction, and the probability of being a worker, however, no association is found. Kari et al. (2016), in contrast, show that childhood physical activity is positively related to long-term earnings in adulthood, especially in men.

Previous studies provide consistent findings that physical activity is related to more favorable labor market outcomes, but the mechanism between these variables is unclear. The literature outlines four potential explanations for the correlation between physical activity and labor market outcomes. First, physical activity improves health, which may lead to better worker performance, thereby increasing labor productivity and earnings (Lechner, 2009; Lechner, 2015). Second, participation in physical activity facilitates social and professional networks, which may promote career development and eventually increase labor market returns (Lechner, 2009). The third explanation is that physical activity may develop cognitive (Åberg et al., 2009; Barron et al., 2000) and non-cognitive skills (Bailey, 2005; Bailey et al., 2009; Ewing, 1998), which are rewarded later in the labor market. Finally, employers may perceive that individuals who are physically active are also in good health and have stronger motivations, ambitions, and productivity, resulting in a type of positive discrimination (Rooth, 2011); this can explain the professional success experienced by individuals who are physically active.

Despite this research, very little is known about the longitudinal associations between physical activity and labor market outcomes. An important limitation of the existing empirical literature is the lack of data that contains detailed, longitudinal information regarding both physical activity and labor market outcomes. In particular, many of the previous studies examine physical activity in adulthood only and include self-reported labor market details. As earlier literature suggests, the labor market variables themselves may be related to physical activity behaviors (see e.g., Kari et al., 2015; Meltzer and Jena, 2010; Hyytinen and Lahtonen, 2013). This raises the potential problem of reverse causality. Moreover, using self-reported and cross-sectional information on labor market outcomes may produce measurement error, which yields inaccurate estimates. The aim of this paper is to address these problems. Here we ask whether childhood physical activity, which is measured prior to any labor market experience, is related to long-term labor market outcomes, the data for which is drawn from administrative registries. Specifically this study seeks to answer the following: Can childhood physical activity and the changes in physical activity from childhood to youth explain the differences in individuals' employment probability, average employment months, and average unemployment months calculated over a 10-year period?

4.2 Methods

4.2.1 Data sources and sample

The data were drawn from three data sets and covers the period from 1980 to 2010: 1) the ongoing longitudinal research, Cardiovascular Risk in Young Finns Study (YFS); 2) the Finnish Longitudinal Employer-Employee Data (FLEED) of Statistics Finland; and 3) the Longitudinal Population Census (LPC) of Statistics Finland.

YFS was launched in the late 1970s to study cardiovascular risk in adolescence (Raitakari et al., 2008). In 1980, 3,596 children from six age cohorts (3, 6, 9, 12, 15, and 18 years) participated in the baseline study. The participants were boys (51% boys) and girls (49%) randomly selected from five Finnish university cities with medical schools (Helsinki, Turku, Tampere, Kuopio, and Oulu) and their rural surroundings. Since 1980, seven follow-ups (1983, 1986, 1989, 1992, 2001, 2007, and 2011/2012) have been conducted. Each follow-up has included comprehensive methods for data collection, including questionnaires, physical measurements, and blood tests (see Raitakari et al., 2008 for additional details). The YFS research protocol was approved by the ethics committees of the five universities (Helsinki, Turku, Tampere, Oulu, and Kuopio), and written informed consent was obtained before respondents participated in the study. Moreover, the study complied with data protection measures as specified in the current Finnish law.

Register-based FLEED is an annual panel, and in this study covers the years from 1997 to 2010. FLEED records detailed information on labor market outcomes, such as employment relationships, periods of unemployment, and income[20]. The data derives directly from tax and other administrative registers (e.g., employer's enterprise code, establishment code) and is maintained by Statistics Finland. FLEED covers the entire working-age population of Finland. LPC, in turn, includes register-based information on family background factors, including parental education and family income since the year 1980. Similar to Böckerman et al., 2015 and Pehkonen et al., 2015, the YFS data has been linked to FLEED and LPC using unique, personal identifiers. This process involves exact matching, without misreported ID codes, and therefore avoids problems created by errors in record linkages (Ridder and Moffitt, 2007). Moreover, labor market details do not suffer under-reporting, over-reporting, or recall errors.

[20] Additional details of FLEED can be found here: http://stat.fi/tup/mikroaineistot/me_kuvaus_henkilo_en.pdf#_ga=1.220003225.1830176940.1490362424.

Combining these three data sets enables tracking of the individuals who participated in the YFS in the baseline year (1980) from childhood to adulthood.

The empirical analysis focused on the YFS participants who were 9 (*n*=1565) and 15 (*n*=2445) years at the time when physical activity was measured[21]. Labor market details were obtained for a 14-year period of 1997 to 2010 (see Table A2 for additional details). Table 1 provides the mean characteristics of the sample. Depending on the model specifications, the study sample varies with a range from 1183 to 2427 participants[22].

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21 Physical activity was measured in the baseline year, 1980, and in the follow-ups in 1983, 1986, 1989, and 1992.

22 The number of observations depends on the outcome variable of interest (employment status, employment months, or unemployment months) and the period used (1997–2010, 2005–2010, 2000, 2005, or 2010).

TABLE 1 Mean characteristics of the sample

	Mean	Std.	Source
Individual characteristics			
Female	0.51	0.50	FLEED
Age (in 2010)	40.43	4.99	FLEED
Health endowments in 1980	0.19	0.40	YFS
Body fat (%) in 1980	16.87	7.70	YFS
Labor market outcomes			
Labor market participation			
2005–2010	0.83	0.30	FLEED
2010	0.84	0.37	FLEED
Employment months			
1997–2010	9.52	2.89	FLEED
2005–2010	10.85	2.17	FLEED
2000	9.62	3.67	FLEED
2005	10.86	2.69	FLEED
2010	11.26	2.24	FLEED
Unemployment months			
1997–2010	0.86	1.59	FLEED
2005–2010	0.70	1.68	FLEED
2000	0.94	2.46	FLEED
2005	0.75	2.24	FLEED
2010	0.81	2.46	FLEED
Physical activity index (PAI)			
PAI at 9 years	9.40	1.56	YFS
PAI at 15 years	8.97	1.97	YFS
Change in physical activity level from 9 to 15 years			
Persistently active	0.12	0.32	YFS
Increasingly active	0.22	0.42	YFS
Moderately active	0.17	0.37	YFS
Decreasingly active	0.33	0.47	YFS
Persistently inactive	0.16	0.37	YFS
Other variables obtained in 1980			
Family income (€)	13133	7599	LPC
Education high, Father	0.10	0.30	LPC
Education high, Mother	0.07	0.26	LPC
Family size	4.38	1.45	YFS

Notes: YFS — Cardiovascular Risk in Young Finns Study; FLEED — Finnish Longitudinal Employer-Employee Data; LPC — Longitudinal Population Census.

4.2.2 Measures

Individuals' labor market outcomes were measured using three variables: employment status, employment months, and unemployment months. Employment status was formulated as a binary variable, which equals 1 if an individual was employed throughout the observational year and 0 if otherwise (i.e., the individuals was unemployed, retired, or out of the labor force throughout the observational year). Employment months refers to the average number of employment months per year over the periods of 1997–2010 and 2005–2010, and unemployment months refers to the average number of unemployment months per year over the sample periods of 1997–2010 and 2005–2010. The period from 1997 to 2010 covers the entire working history of the YFS participants. The period from 2005 to 2010 covers the prime working age of the YFS participants, because the mean age varies from 28 to 45 years. In the baseline analysis, employment and unemployment details were also calculated for single years in 2000, 2005, and 2010.

Leisure-time physical activity outside school hours at ages 9 and 15 years was measured using a self-reported questionnaire. From 1980 to 1989, the questions concerned the frequency and intensity of leisure-time physical activity, participation in sports club training sessions, participation in sports competitions, and most common ways of spending leisure-time (Telama et al., 1996; Telama et al., 2014; Table A3). In 1992, the questions concerned the intensity of leisure-time physical activity, frequency of intensive physical activity, hours per week of intensive physical activity, average duration of physical activity sessions, and membership with a sports club (Telama et al., 1996; Table A4). Following Telama et al., (1996), the response alternatives were coded 1, 2, or 3—except membership with a sports club, which was coded 1 or 2—and then summed to yield a physical activity index (PAI) with scores ranging from 5 to 14.

To study the change in physical activity level from 9 to 15 years, participants were first divided into three groups according to their PAI values at age 9: physically active (PAI values ≥ 11), moderately active (PAI values = 9–10), and physically inactive (PAI values ≤ 8). Then, at age 15, participants were classified into five activity groups based on the three aforementioned activity levels: 1) persistently active, 2) increasingly active, 3) moderately active, 4) decreasingly active, and 5) persistently inactive[23].

[23] The participants were first divided into three groups according to their PAI values at age 9: physically active (PAI values ≥11), moderately active (PAI values = 9–10), and physically inactive (PAI values ≤8). At age 15, the participants were divided into five activity groups: persistently active, increasingly active, moderately active, decreasingly active, and persistently inactive. Persistently active individuals had PAI values of ≥ 11 at ages 9 and 15. The increasingly active participants raised their physical activity level from "physically inactive" to "moderately active" or "physically active" or from "moderately active" to "physically active". Moderately active individuals had PAI values of 9 or 10 at both ages. Decreasingly active individuals physical activity level fell from "physically active" to "moderately active" or "physically inactive" or from "moderately active" to "physically inactive". Persistently inactive individuals have PAI values of ≤ 8 at both ages.

4.2.3 Statistical method

The analysis was based on the ordinary least squares (OLS) model, in which the associations between physical activity and labor market outcomes were regressed using the average employment months and the average unemployment months as the dependent variables and the PAI at the ages of 9 and 15 years as explanatory variables. The baseline models include only exogenous and predetermined controls: gender, birth cohort, and birth month. The baseline analysis was extended in three ways. First, the robustness of the baseline results was evaluated to the addition of various controls, including individuals' chronic diseases[24], body fat[25], family income, family size, and parents' education in 1980. Second, the associations were examined separately for women and men. Third, the relationship between changes in physical activity level from 9 to 15 years of age and long-term employment and unemployment months was examined. Before developing OLS models, the association between childhood physical activity and the probability of employment was illustrated using a probit model.

4.3 Results

4.3.1 Probability of being employed during prime working age

Table 2 reports the probit results of childhood physical activity and adulthood employability. In all cases, the childhood physical activity estimate was positive and statistically significant. On average, a one-unit increase in PAI at ages 9 and 15 years is related to approximately 1% higher probability of being employed during the prime working-age period. The cross-sectional estimates for PAI at ages 9 and 15 years were relatively similar: a one-unit increase in PAI at age 9 increased the probability of being employed in 2010 by approximately 2.4%. The marginal effect for PAI at age 15 years was approximately 1.3%.

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24 Individuals' chronic conditions include allergy/asthma, diabetes, convulsions, heart defect, infectious and parasitic diseases, tumours, endocrine diseases/metabolic disorders/malnutrition, blood disorders, mental disturbances, nervous and sensory system diseases, circulatory system diseases, respiratory diseases, digestive system diseases, genital and urinary tract diseases, skin and subcutaneous tissue diseases, musculoskeletal disorders, and other unidentified symptoms.

25 Percentage body fat is estimated using the Slaughter skinfold-thickness equation, which is based on sex, maturation, and skinfold thicknesses (Slaughter et al., 1988).

TABLE 2 Childhood physical activity (PAI) at ages 9 and 15 years and the probability of employment.

	Employment (2005-2010)		Employment (2010)	
		ME[a]		ME
PAI at 9 years	0.096***	0.012	0.099***	0.024
	(0.033)		(0.027)	
Pseudo R^2	0.04		0.02	
N	1529		1529	
PAI at 15 years	0.077***	0.009	0.057***	0.013
	(0.022)		(0.017)	
Pseudo R^2	0.03		0.02	
N	2386		2386	

Notes: Regressions are probits. The dependent variable is a binary variable indicating whether an individual is employed. ME are the marginal effects calculated for the case of binary independent variables. All models include controls for cohort (1–5) and birth month. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, and Cohort 5= born in 1965. Heteroscedasticity-robust standard errors are in parenthesis. ***Statistically significant at least at the 1% level.

4.3.2 Baseline OLS results –long-term labor market outcomes

The estimates of the relationships between childhood physical activity and average employment and unemployment months are reported in Table 3. Regarding long-term estimates (Table 3, Left-hand-side; Column 1), the baseline OLS results suggested a positive association between childhood PAI and employment months. On average, a one-unit increase in PAI at 9 and 15 years was associated with approximately 0.12 and 0.08 more months of yearly employment, respectively. The results did not change much when focusing on the prime working-age period calculated over the years 2005 to 2010 (Table 3, Column 2). On average, a one-unit increase in PAI at ages 9 and 15 years was associated with approximately 0.07 more months of yearly employment. Regarding unemployment, the associations were negative (Table 3, Right-hand-side; Columns 1 and 2). On average, a one-unit increase in PAI at age 9 years was associated with approximately 0.05 less months of yearly unemployment, while the coefficient for PAI at 15 years varied from -0.08 (Table 3, Right-hand-side, Column 1) to -0.09 (Table 3, Right-hand-side, Column 2). The cross-sectional estimates (Table 3, Columns 3, 4, and 5) were more volatile than the corresponding long-term estimates; the sign and the significance depended on the measurement year. However, the sample characteristics reported in Table 1 indicate that there is an annual variation in terms of employment and unemployment months. Therefore, the use of cross-sectional variables might yield inaccurate estimates and the results should be treated with a caution.

TABLE 3 Baseline OLS regression results of physical activity index (PAI) at ages 9 and 15 years and long-term labor market outcomes

	Average Employment Months					Average Unemployment Months				
	1	2	3	4	5	1	2	3	4	5
	1997–2010	2005–2010	2000	2005	2010	1997–2010	2005–2010	2000	2005	2010
PAI at 9 years	0.124***	0.074**	0.025	-0.042	0.110**	-0.053**	-0.055**	-0.018	-0.078**	-0.077*
	(0.047)	(0.036)	(0.067)	(0.052)	(0.045)	(0.024)	(0.026)	(0.035)	(0.035)	(0.042)
R^2	0.06	0.03	0.09	0.04	0.02	0.01	0.01	0.01	0.01	0.02
N	1555	1555	1555	1555	1555	1565	1565	1565	1565	1565
PAI at 15 years	0.080***	0.078***	0.049	0.055**	0.062***	-0.082***	-0.092***	-0.045*	-0.090***	-0.110***
	(0.027)	(0.020)	(0.039)	(0.028)	(0.022)	(0.014)	(0.015)	(0.023)	(0.022)	(0.024)
R^2	0.09	0.04	0.09	0.04	0.02	0.02	0.02	0.01	0.01	0.02
N	2427	2427	2427	2427	2427	2445	2445	2445	2445	2445

Notes: Heteroscedasticity-robust standard errors are in parenthesis. All models include controls for cohort (1-6) and birth month. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, Cohort 5= born in 1965, and Cohort 6 = born in 1962. ***, **, * Statistically significant at least at the 1%, 5% and 10% levels, respectively.

4.3.3 Long-term labor market outcomes with additional covariates

Childhood physical activity may reflect omitted variables without having an independent effect on labor market outcomes. Therefore, the robustness of the baseline results was evaluated to the addition of various controls. In particular, the models were adjusted with variables that could contribute to subsequent labor market outcomes and correlate with childhood physical activity; that is, the models accounted for individuals' chronic diseases and body fat, family income, family size, and parents' education. The inclusion of family background factors from the baseline year 1980 provided controls for unobserved heterogeneity, such as innate ability and preferences, thus alleviating possible biases in the estimated correlation. To rule out the problem of reverse causality, all control variables were predetermined and obtained before any labor market experience, as future labor market outcomes cannot affect controls measured before labor market entry.

The inclusion of a comprehensive set of controls keep the physical activity estimate largely intact (Table 4). The coefficients for employment months remained positive and significant and the coefficients for unemployment months remained negative and significant. The results were consistent regardless of the period used, that is, whether focusing on the YFS participants' entire working history (period from 1997 to 2010) or the participants' prime working age calculated over the sample period of 2005 to 2010.

TABLE 4 OLS regressions results of physical activity index (PAI) at ages 9 and 15 years and long-term labor market outcomes with additional co-variates

	Average Employment Months						Average Unemployment Months					
	1997–2010			2005–2010			1997–2010			2005–2010		
	1	2	3	1	2	3	1	2	3	1	2	3
PAI at 9 years	0.113**	0.111**	0.107**	0.071*	0.072**	0.073**	-0.051**	-0.048**	-0.048**	-0.049*	-0.048*	-0.047*
	(0.048)	(0.048)	(0.048)	(0.037)	(0.037)	(0.037)	(0.024)	(0.024)	(0.024)	(0.027)	(0.027)	(0.027)
R^2	0.07	0.07	0.08	0.04	0.04	0.04	0.01	0.01	0.04	0.01	0.01	0.02
N	1468	1468	1468	1385	1385	1385	1477	1477	1477	1477	1477	1477
PAI at 15 years	0.076***	0.076***	0.069***	0.075***	0.076***	0.069***	-0.084***	-0.083***	-0.072***	-0.091***	-0.091***	-0.083***
	(0.027)	(0.028)	(0.027)	(0.020)	(0.020)	(0.021)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)	(0.015)
R^2	0.09	0.09	0.11	0.04	0.04	0.05	0.02	0.02	0.04	0.02	0.02	0.03
N	2263	2263	2263	2136	2136	2136	2278	2278	2278	2278	2278	2278
Control variables												
Cohort and birth month	x	x	x	x	x	x	x	x	x	x	x	x
Individual characteristics		x	x		x	x		x	x		x	x
Family characteristics			x			x			x			x

Notes: Heteroscedasticity-robust standard errors are in parenthesis. All models include controls for cohort (1-6) and birth month. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, Cohort 5= born in 1965, and Cohort 6 = born in 1962. ***, **, * Statistically significant at least at the 1%, 5% and 10% levels, respectively. Additional controls are summary of individual's chronic conditions, body fat, family income, parent's education, and family size.

4.3.4 Long-term labor market outcomes–gender differences

To examine the potential gender heterogeneity, the models were stratified by gender (Table 5). The models controlled for health endowments and several family background factors. In line with the baseline OLS results, the results indicated a positive association between childhood PAI and employment months and a negative association between childhood PAI and unemployment months among men. However, the point estimates were larger compared with those of the pooled sample of women and men. For example, in the extended model (Table 5, Left-hand-side, Column 3) a one-unit increase in PAI at 9 years of age was associated with approximately 0.18 more months of yearly employment. The results remained intact regardless of the period used (e.g., 1997–2010 vs. 2005–2010). Among women, in contrast, no association between childhood PAI and employment months was found. Instead, PAI at 15 years was negatively related to unemployment months (Table 5, columns 1, 2, and 3): a one-unit increase in PAI at 15 years was associated with approximately 0.06 less months of yearly unemployment.

The specificity of women's career paths, especially women of childbearing age, is an issue that must be considered when interpreting the results. The age range of the study sample varied from 20 to 45. Thus, women's choices regarding childbearing and how those decisions impact labor market outcomes are important for understanding the study results. This specificity may lead to a more complex labor supply and more complex occupational choices among women compared to men of the same age. Some earlier studies, including Cabane (2010), Hyytinen and Lahtonen (2013), Barron et al. (2000), and Ewing (1998), address this problem by excluding women from the sample and focusing only on men, while Lechner and Downward (2017), Lechner (2009), and Kavetsos (2011) stratify the models by gender. In contrast to the study by Lechner and Downward (2017), who find a negative association between sports participation and unemployment, especially among men, our results indicated a negative association between those variables among men and women. Lechner (2009), in turn, shows that the labor supply effects (full-time work, part-time work, unemployed, and out of the labor force) of sports participation exist only among women, while Kavetsos (2011) shows that physically active individuals are more likely to be employed regardless of gender. However, in line with our results, Kavetsos (2011) finds that the marginal effects of physical activity on labor market outcomes are stronger among men compared to those of women.

TABLE 5 Regression results of physical activity index (PAI) at ages 9 and 15 years and long-term labor market outcomes by gender

	Average Employment Months						Average Unemployment Months					
	1997–2010			2005–2010			1997–2010			2005–2010		
	1	2	3	1	2	3	1	2	3	1	2	3
Panel A: Women												
PAI at 9 years	0.150	0.012	0.026	-0.070	-0.067	-0.056	-0.028	-0.025	-0.027	-0.0003	-0.001	-0.001
	(0.074)	(0.074)	(0.073)	(0.062)	(0.062)	(0.062)	(0.028)	(0.028)	(0.028)	(0.034)	(0.035)	(0.035)
R^2	0.04	0.04	0.06	0.02	0.02	0.03	0.02	0.03	0.06	0.02	0.02	0.03
N	739	739	739	691	691	691	742	742	742	742	742	742
PAI at 15 years	0.039	0.040	0.034	0.033	0.034	0.016	-0.085***	-0.085***	-0.065***	-0.071***	-0.071***	-0.055***
	(0.044)	(0.044)	(0.044)	(0.034)	(0.034)	(0.035)	(0.018)	(0.018)	(0.018)	(0.021)	(0.021)	(0.021)
R^2	0.07	0.07	0.08	0.03	0.03	0.04	0.03	0.04	0.06	0.02	0.03	0.04
N	1179	1179	1179	1109	1109	1109	1184	1184	1184	1184	1184	1184
Panel B:Men												
PAI at 9 years	0.202***	0.201***	0.187***	0.188***	0.188***	0.184***	-0.072*	-0.069*	-0.069*	-0.081**	-0.090**	-0.089**
	(0.063)	(0.064)	(0.062)	(0.045)	(0.045)	(0.044)	(0.039)	(0.039)	(0.038)	(0.041)	(0.041)	(0.040)
R^2	0.06	0.06	0.08	0.04	0.04	0.05	0.01	0.02	0.04	0.02	0.02	0.04
N	729	729	729	694	694	694	735	735	729	735	735	735
PAI at 15 years	0.109***	0.108***	0.101***	0.106***	0.104***	0.103***	-0.083***	-0.083***	-0.078***	-0.105***	-0.106***	-0.103***
	(0.035)	(0.035)	(0.035)	(0.025)	(0.025)	(0.025)	(0.022)	(0.022)	(0.022)	(0.023)	(0.023)	(0.023)
R^2	0.08	0.08	0.10	0.03	0.03	0.04	0.03	0.03	0.05	0.03	0.03	0.04
N	1084	1084	1084	1027	1027	1027	1094	1094	1094	1094	1094	1094
Control variables												
Cohort and birth month	x	x	x	x	x	x	x	x	x	x	x	x
Individual characteristics		x	x		x	x		x	x		x	x
Family characteristics			x			x			x			x

Notes: Heteroscedasticity-robust standard errors are in parenthesis. All models include controls for cohort (1-6) and birth month. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, Cohort 5= born in 1965, and Cohort 6 = born in 1962. ***, **, * Statistically significant at least at the 1%, 5% and 10% levels, respectively. Additional controls are summary of individual's chronic conditions, body fat, family income, parent's education, and family size.

4.3.5 Changes in childhood physical activity level and long-term labor market outcomes

Typically, overall physical activity level and sports participation decreases during childhood and youth (Inchley et al., 2016; Nader et al., 2008; Tomkinson and Olds, 2007). A similar trend can be seen in YFS data; approximately 33% of children are decreasingly active between the ages of 9 and 15 (Table 1), while the percentage of increasingly active children is 22%. An open question is whether these changes are related long-term labor market outcomes.

Table 6 presents descriptive statistics regarding the relationship between changes in physical activity level and labor market outcomes. From here on, childhood physical activity was divided into five activity groups based on the changes in physical activity level between the ages of 9 and 15 years. In this model specification, the three youngest cohorts were included in the analysis (see Table A2 for the cohorts and the design of the study). Labor market outcomes, as measured by average employment and unemployment months, varied by activity group[26]. In particular, the average employment months were higher and the average unemployment months were lower among individuals who were classified as persistently active compared to individuals categorized in the other activity groups.

TABLE 6 Long-term employment and unemployment months by activity group

	%-Share	Average Employment Months (2005–2010)	%-Share	Average Unemployment Months (2005–2010)
Persistently active	12.0	11.31	11.5	0.28
Increasingly active	22.2	10.70	22.4	0.54
Moderately active	16.4	10.70	16.6	0.44
Decreasingly active	33.1	10.64	33.3	0.76
Persistently inactive	16.3	10.59	16.5	0.83
F-test statistics		3.10 (p=0.015)		3.85 (p<0.01)
N		1183		1257

Heteroscedasticity robust F-test statistics for the null hypothesis of equal group means.

26 In Table A5, the average employment and unemployment months are calculated over the period 1997–2010.

Figures 1 and 2 illustrate the average yearly employment and unemployment months by activity group from 2005 to 2010[27]. In general, it appears that the labor market outcomes were more favorable among the persistently active group on a yearly basis (Figures 1 and 2). More specifically, from 2005 to 2010, the average employment months of persistently active individuals are at the highest level in each year (Figure 1). Among the other activity groups, the average employment months are relatively similar. Interestingly, even after the financial crisis in 2008, the trend has been increasing among persistently active individuals, whereas persistently inactive individuals have experienced downward sloping trend (Figure 1). Regarding unemployment, the yearly level is lowest among persistently active individuals (Figure 2). Unlike in Figure 1, Figure 2 displays a certain order among the other activity groups. For example, in 2010, persistently inactive individuals have the highest level of unemployment, decreasingly active individuals have the second highest, and moderately active individuals are in the middle, while increasingly active individuals have the second lowest and persistently active individuals have the lowest level of unemployment.

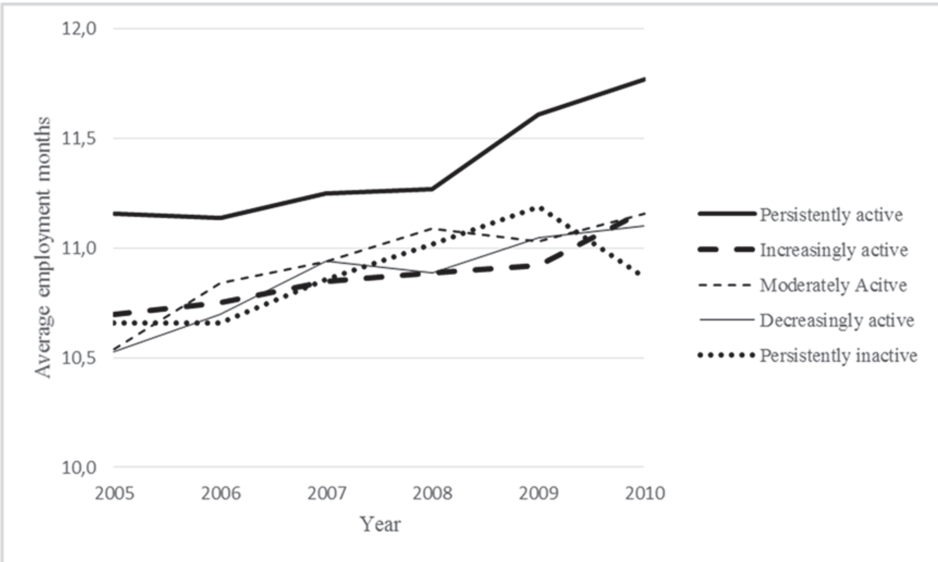

FIGURE 1 Average employment months by activity group over the period 2005–2010.

27 Figures A1 and A2 in Appendix demonstrate the period from 1997 to 2010.

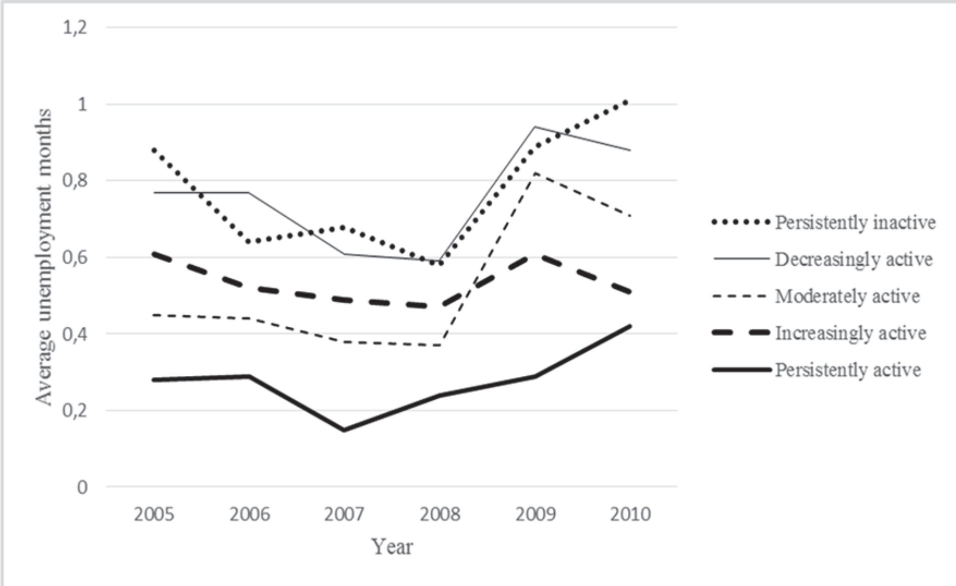

FIGURE 2 Average unemployment months by physical activity group over the period 2005–2010

4.3.6 Long-term labor market outcomes by activity group

The estimates regarding the relationship between changes in childhood physical activity level and labor market outcomes are reported in Table 7. The baseline estimates using the standard OLS specification revealed that, compared with persistently active group, all other activity groups had lower employment and higher unemployment. For example, persistently inactive individuals have, on average, approximately 0.8 less months of employment than persistently active individuals each year (β = -0.80, 95% Cl: -1.33 to 0.27) over the period from 1997 to 2010. Regarding unemployment, persistently inactive individuals had, on average, approximately 0.5 more months of unemployment regardless of the time period (β = 0.57, 95% Cl: 0.32 to 0.82 over the period 1997–2010 and β = 0.52, 95% Cl: 0.25 to 0.78 over the period 2005–2010). The results align with the graphical illustration presented in Figures 1 and 2.

The raw data (Figures A1 and A2) suggest that some of the differences in labor market outcomes may have been already present in 1997. In the case of unemployment, for example, those who were classified as persistently inactive already had the highest level of unemployment, and those who were classified as persistently active had the lowest level of unemployment in 1997. In the case of employment, in contrast, it appears that two groups already formed by 1997: those who were persistently inactive and increasingly active belonged to one group and those who were decreasingly active, moderately active, and persistently active belonged to another group. These differences imply that childhood physical activity may reflect omitted variables without having an independent effect on adulthood employment and unemployment months. To mitigate the possibility that unobserved characteristics, such as family background factors or pre-existing differences in health and physical features drive the results, the models were extended with individuals' health endowments and several family background factors. As a result, the coefficients remained largely intact (Table 8).

TABLE 7 Long-term labor market outcomes by activity group, Reference category: Persistently active.

	Average Employment months						Average Unemployment months					
	1997–2010			2005–2010			1997–2010			2005–2010		
	β	95% CI		β	95% CI		β	95% CI		β	95% CI	
Persistently inactive	-0.799***	-1.330	-0.269	-0.395*	-0.826	0.036	0.572***	0.324	0.820	0.515***	0.248	0.782
	(0.270)			(0.220)			(0.127)			(0.136)		
Decreasingly active	-0.652***	-1.077	-0.226	-0.519***	-0.866	-0.171	0.572***	0.365	0.779	0.548***	0.336	0.761
	(0.217)			(0.177)			(0.105)			(0.108)		
Moderately active	-0.616**	-1.107	-0.124	-0.456**	-0.859	-0.053	0.361***	0.123	0.598	0.290**	0.049	0.530
	(0.250)			(0.205)			(0.121)			(0.123)		
Increasingly active	-0.626***	-1.109	-0.163	-0.436**	-0.798	-0.073	0.323***	0.131	0.517	0.345***	0.142	0.548
	(0.236)			(0.185)			(0.098)			(0.103)		
N	1186			1123			1191			1191		

Notes: Heteroscedasticity-robust standard errors are in parenthesis. OLS models include controls for cohort (1-6) and month of birth. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, Cohort 5 = born in 1965, Cohort 6 = born in 1962. ***, **, * Statistically significant at least at the 1%, 5% and 10% levels, respectively. Reference category: Persistently active.

TABLE 8 Long-term labor market outcomes by activity group with additional controls, Reference category: Persistently active.

	Average Employment months						Average Unemployment months					
	1997–2010			2005–2010			1997–2010			2005–2010		
	β	95% CI		β	95% CI		β	95% CI		β	95% CI	
Persistently inactive	-0.740***	-1.270	-0.210	-0.398*	-0.826	0.031	0.516***	0.275	0.757	0.480***	0.217	0.744
	(0.270)			(0.218)			(0.123)			(0.134)		
Decreasingly active	-0.617***	-1.043	-0.190	-0.512***	-0.862	-0.162	0.520***	0.317	0.723	0.520***	0.310	0.731
	(0.217)			(0.179)			(0.103)			(0.107)		
Moderately active	-0.600**	-1.090	-0.110	-0.458**	-0.864	-0.052	0.333***	0.098	0.568	0.283**	0.040	0.525
	(0.250)			(0.207)			(0.120)			(0.124)		
Increasingly active	-0.600**	-1.065	-0.135	-0.455**	-0.822	-0.088	0.336***	0.145	0.528	0.360***	0.154	0.566
	(0.237)			(0.187)			(0.098)			(0.105)		
N	1186			1123			1191			1191		

Notes: Heteroscedasticity-robust standard errors are in parenthesis. OLS models include controls for cohort (1-6) and month of birth. Cohort dummies indicate the year of birth: Cohort 1 = born in 1977, Cohort 2 = born in 1974, Cohort 3 = born in 1971, Cohort 4 = born in 1968, Cohort 5 = born in 1965, Cohort 6 = born in 1962. ***, **, * Statistically significant at least at the 1%, 5% and 10% levels, respectively. Reference category: Persistently active. Additional controls are summary of individual's chronic conditions, body fat, family income, parent's education, and family size.

4.4 Discussion

This study examined the relationship between childhood physical activity and long-term labor market outcomes. The baseline data was obtained from ongoing, longitudinal research know as YFS and from registries compiled by Statistics Finland. Two main findings emerged from the results. First, higher childhood physical activity increases the probability of being employed, is positively related to employment months, and is negatively related to unemployment months. Second, persistently active individuals between the ages of 9 and 15 years have a higher level of employment and lower level of unemployment compared to other activity groups. These results were robust to the use of covariates, such as pre-existing health endowment, family income, and parents' education.

The existing empirical literature investigating the role of childhood physical activity for improving individual's labor market outcomes is limited. Recently, more studies have been analyzing the relationship between adulthood physical activity and labor market outcomes (see e.g., Cabane, 2014; Kavetsos, 2011; Lechner, 2009; Hyytinen and Lahtonen, 2013; Lechner and Sari, 2015; Lechner and Downward, 2017) and to our knowledge, only two studies focus specifically on determining whether childhood leisure-time physical activity is related to future labor market outcomes (Cabane and Clark, 2015; Kari et al., 2016). Cabane and Clark (2015) use information on physical activity measured at grades 7 and 12, and the information on labor market outcomes are obtained 13 years later. The study includes five labor market outcomes: the probability of being employed, wages, managerial responsibilities, autonomy at work, and job satisfaction. Kari et al. (2016) analyzes the role of physical activity at ages 9, 12, and 15 years in long-term earnings calculated over a 10-year period. Contrary to our results, Cabane and Clark (2015) do not find an association between childhood sporting activities and employment. Instead, their results suggest that childhood sporting activities predicts managerial responsibilities and autonomy at work. Kari et al. (2016), in turn, show that childhood physical activity is positively related to adulthood earnings.

The linked data and the longitudinal study design allowed us to contribute to and extend the previous literature in four important ways. First, as earlier studies have suggested (see e.g,. Kari et al., 2015; Meltzer and Jena, 2010; Hyytinen and Lahtonen, 2013), physical activity in adulthood can be partly explained by individuals' economic resources. This can make the direction of the causality between physical activity and labor market outcomes unclear. Our study overcame this problem by measuring physical activity during childhood, a period in which subjects do not yet have any labor market experience. To consider the changes in physical activity behavior from childhood to adulthood, the models were extended by adulthood physical activity[28]. As a result, the estimates for childhood PAI decreased but remained significant. Therefore, our

[28] The results are available upon request.

findings suggest that the relationship between childhood physical activity and long-term labor market outcomes exists irrespective of changes in physical activity throughout life.

Second, to mitigate the concern of idiosyncratic fluctuations related to short-term measures, the labor market outcomes were calculated over the periods of 1997–2010 and 2005–2010. The former period constituted the entire working history of the YFS participants, and the latter period focused on the prime working age of the YFS participants. Additionally, the labor market details were obtained from registers maintained by Statistics Finland, and therefore, potential biases resulting from self-reported information could be avoided.

Third, to alleviate the possibility that unobserved characteristics, such as pre-existing differences in individuals' health and family background factors, drive the results, the baseline models were extended with individuals' chronic conditions, body fat, family income, family size, and parents' education.

Finally, as stated by Lechner (2009), the impact of physical activity on labor market outcomes may take time to materialize. The longitudinal study design and the inclusion of childhood physical activity details combined with longitudinal labor market information enabled us to address this problem. We were able to investigate whether the consequences of childhood physical activity on labor market outcomes start to develop as early as childhood, and whether we can explain the differences in adulthood labor market outcomes by childhood physical activity behavior.

We are persuaded to believe that the findings of the current study can be generalized to other developed European countries. This is because physical activity behavior and labor market participation are similar among Europeans; the employment rates and female labor market participation are high across European countries; and Europeans have similar labor market institutions (OECD, 2016). As in many other countries (Ekelund et al., 2011; Hallal et al., 2012; WHO, 2010; Tremblay et al., 2016), physical activity levels are low also among Finnish children (Tammelin et al., 2016). Along with the widely-acknowledged health benefits of physical activity, this study recognizes the role of childhood physical activity in determining long-term labor market outcomes; the consequences of childhood physical activity on subsequent labor market outcomes may begin to develop as early as childhood. Thus, childhood physical activity not only promotes health but may also contribute positively to labor market outcomes later in life.

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TABLE A1 Summary of the literature

Author(s) and publication year	Data	Labor Market Outcome	Physical activity measure	Methods	Main findings
Long and Caudill (1991)	Continuing study of higher education by the American Council of Education	Annual income	Dummy variable for athlete. Equals one if varsity letter is earned in college and zero otherwise.	MLE	Athletic participation is positively related to annual income in men. No income premium is found among women.
Ewing (1998)	National Longitudinal Surveys of Youth	Work attainment	Dummy variable for athlete. Equals one if participates in high school athletics and zero otherwise.	Logistic and Tobit regression; only men included in the analysis.	Athletes more likely belong to a union; are employed in jobs, which are paid based on performance; and are occupied in positions that have more workers to supervise.
Barron et al. (2000)	National Longitudinal Survey of Youth, National Longitudinal Study of the High School Class of 1972	Employment and weekly wage	Participation in high school athletics.	OLS, Probit, IV; only men included in the analysis.	Athletes are no more likely to be employed. Those athletes who are employed receive higher wages than non-athletes.
Eide and Ronan (2001)	High School and Beyond data set (National Center for Education Statistics)	Annual earnings	Dummy variable for sports participation in the sophomore year and in the senior year. Equals one if the respondent participates and zero otherwise.	OLS, IV	A positive effect on earnings is found among black men athletes. No effect on earnings among Hispanic men or Black and Hispanic women is found.
Lechner (2009)	German Socio-Economic Panel study 1984–2006	Monthly earnings, accumulated average earnings, wage, and employment status	Frequency of sports participation divided into two levels: being active at least monthly and being active less than monthly.	Semiparametric Propensity Score Matching (SPM)	Positive effect on earnings and wages among women and men. An increase in the probability of full-time employment corresponds with a decline in the share of women considered as being out of the labor force.

Stevenson (2010)	National Longitudinal Survey of Youth, 1979, National Center for Education Statistics, National Federation of State High School Associations (National High School Athletic Participation Survey), Public Use Micro Sample	Employment status, occupation, and wages	The number of sport participants in each sport, by gender, (for each state).	IV	Participation in high school sports is related to higher wages among women. Increase in female sports participation increases the probability of being employed, working full-time, being employed in sports-related occupations, being in a "mixed" occupation, and being employed in a male-dominated occupation.
Cabane (2010)	German Socio Economic Panel Data	Hourly wage and the level of autonomy at work	A dummy variable sporty corresponds to "practicing sports at least once a week".	OLS, Probit model; only men included in the analysis.	Practicing sports is positively associated with hourly wage and level of autonomy.
Kosteas (2011)	National Longitudinal Surveys of Youth, 1979	Supervisory status and responsibilities	High school sports club participation.	Household fixed effect (HFE), IV	Positive association between club participation and being a supervisor is found.
Kavetsos (2011)	Eurobarometer 2004, wave 62	Employment	Frequency of physical activity.	Probit model, IV	Physical activity increases the probability of being employed
Rooth (2011)	Integrated registers from Statistics Sweden, Swedish National Service Administration, selected occupations found on the webpage of the Swedish employment agency	Annual earnings and callbacks for job interviews	Cardiovascular fitness, signaling physical activities in a job application.	Sibling fixed effects model, Probit model	Cardiovascular fitness positively associated with earnings. Signaling participation in physical activity in a job application related to a higher probability of receiving a callback for a job interview.

Kosteas (2012)	National Longitudinal Surveys of Youth, 1979	Weekly earnings	Frequency of vigorous physical activity divided into four categories: rarely exercise (less than once a month), infrequent exercise (1–3 times each month), moderate exercise (1–2 times per week) and frequent exercise (3 or more times per week).	Propensity Score Matching (PSM), OLS, FE	Physical activity positively is associated with wages.
Cabane and Clark (2013)	National Longitudinal Study of Adolescent Health	Having a paid job for at least 10 hours per week, job satisfaction, managerial responsibilities, freedom to make important decisions, and annual earnings	The type and the frequency of sports.	OLS with school fixed effect, within-sibling estimation	Childhood sporting activities are associated with the level of autonomy and managerial responsibilities. No association between sports and the probability of being a worker, job satisfaction, or earnings is found.
Cabane (2014)	German Socio Economic Panel Data	Unemployment duration	Frequency of practicing sports, divided into three groups: sporty, not sporty, and inactive.	Survival analysis	Sports participation is related to a quicker exit from unemployment to employment for specific subsamples (inactive, not sporty).
Hyytinen and Lahtonen (2013)	Older Finnish Twin Cohort Study (1975, 1981, 1990), Finnish Longitudinal Employer-Employee Data	Annual income	Three category dummies for physical activity: conditioning exercisers (exercising at least 6 times per month), sedentary exercisers (not partaking leisure-time physical activi-	OLS, within MZ twin-pair estimations; only men included in the analysis.	Physical activity is positively associated with long-term income.

			ty), and occasional exercisers (all the others).		
Lechner and Sari (2015)	National Population Health Survey	Individual and household earnings, employment status, and working hours	Leisure-time physical activity divided into three groups: moderately active (daily energy expenditure between 1.5–3 kcal/kg), active (daily energy expenditure >3 kcal/kg), and inactive (daily energy expenditure < 1.5 kcal/kg).	Semiparametric matching estimation	Positive earnings effect (10% to 20%) is found, but no systematic effect on employment status or hours of work is found.
Kari et al. (2016)	Young Finns Study, Finnish Longitudinal Employer-Employee Data	Annual earnings	Childhood leisure-time physical activity including frequency and intensity of physical activity, participation in sports club training sessions, participation in sports competitions, and the habitual way of spending leisure-time.	OLS	Childhood physical activity is positively associated with long-term earnings among men. Among women, no relation is observed.
Lechner and Downward (2017)	Active People Survey (APS), Annual Population Survey (APopS), Active Places Survey (APLS)	Household income, employment, unemployment, and retirement	Participation, frequency, and the intensity of physical activity; aggregated into five groups; team sports, keep fit activities, racquet sports leisure activities, and outdoor activities.	Propensity-score radius matching with regression adjustment	Sports participation is positively associated with earnings. Association is strongest for fitness and outdoor sports. Sports participation is negatively associated with unemployment among men. Team sports participation is positively associated with employability.

TABLE A2 The cohorts and the study design

	Data source								
	YFS					FLEED			
	1980 baseline	1983 follow-up	1986 follow-up	1989 follow-up	1992 follow-up	1997	2000	2005	2010
Cohort 1 (born in 1977)	3	6	9	12	15	20	23	28	33
Cohort 2 (born in 1974)	6	9	12	15	18	23	26	31	36
Cohort 3 (born in 1971)	9	12	15	18	21	26	29	34	39
Cohort 4 (born in 1968)	12	15	18	21	24	29	32	37	42
Cohort 5 (born in 1965)	15	18	21	24	27	32	34	40	45
Cohort 6 (born in 1962)	18	21	24	27	30	35	38	43	48

Notes: YFS — Cardiovascular Risk in Young Finns Study; FLEED — Finnish Longitudinal Employer-Employee Data. YFS was launched in 1980, with follow-ups conducted in 1983, 1986, 1989, 1992, 2001, 2007, and 2011. FLEED covers 1997–2010.

TABLE A3 The original scoring and recoding of physical activity index (PAI) in 1980–989, (range 5–14) (Telama et al., 1996).

Items	Original Score	Code for PAI
How often do you engage in leisure-time physical activity at least half an hour per time?		
Not at all	1	1
Less than once a month	2	1
Once a month	3	1
2–3 times a month	4	1
Once a week	5	2
2–6 times a week	6	2
Every day	7	3
How much are you breath-taking and sweating when you engage in physical activity and sport?		
Not at all	1	1
Moderately	2	2
Lot of	3	3
How many times a week do you usually engage in the training sessions of sports club?		
Not at all	1	1
Occasionally	2	1
Less than once a month	3	1
Once a month or more	4	2
Once a week	5	2
Many hours and times a week	6	3
Do you participate in regional or national level competitions?		
No	1	1
Yes	2	2
What do you usually do in your leisure time?		
I am usually indoors and read or do something like that	1	1
I spend my time indoors and outdoors, outdoors I usually walk or spend time with my friends.	2	2
I am usually outdoors and exercise rather much.	3	3

TABLE A4 The original scoring and recoding of physical activity index (PAI) in 1992, (range 5–14) (Telama et al., 1996).

Items	Original Score	Code for PAI
How much are you breath-taking and sweating when you engage in physical activity and sport?		
Not at all	1	1
Moderately	2	2
Lot of	3	3
How often do you engage in intensive physical activity?		
Not at all	1	1
Once a month or more	2	1
Once a week	3	2
2-3 times a week	4	2
4-6 times a week	5	2
Every day	6	3
How many hours a week do you engage in intensive physical activity?		
Not at all	1	1
½ hour a week	2	1
1 hour a week	3	2
2-3 hours a week	4	2
4-6 hours a week	5	2
Over 7 hours a week	6	3
How long time do you usually spend for physical activity		
Less than 20 min	1	1
20-40 min.	2	2
40-60 min.	3	2
More than 60 min.	4	3
Are you a member of the sports club?		
No	1	1
Yes	2	2

TABLE A5 Long-term labor market outcomes by activity group

	%-Share	Average Employment Months (1997-2010)	Average Unemployment Months (1997-2010)
Persistently active	11.5	9.82	0.42
Increasingly active	22.4	8.88	0.67
Moderately active	16.6	9.10	0.75
Decreasingly active	33.0	9.16	0.93
Persistently inactive	16.5	8.76	0.94
F-test statistics		3.76 (p<0.01)	4.97 (p<0.01)
N		1251	1251

Heteroscedasticity robust F-test statistics for the null hypothesis of equal group means.

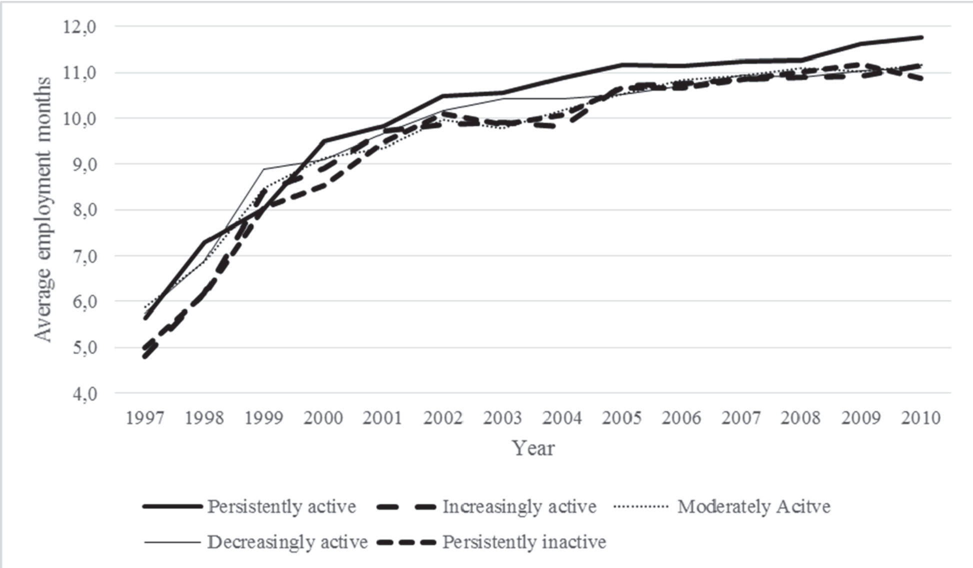

FIGURE A1 Average employment months by activity group over the period of 1997–2010

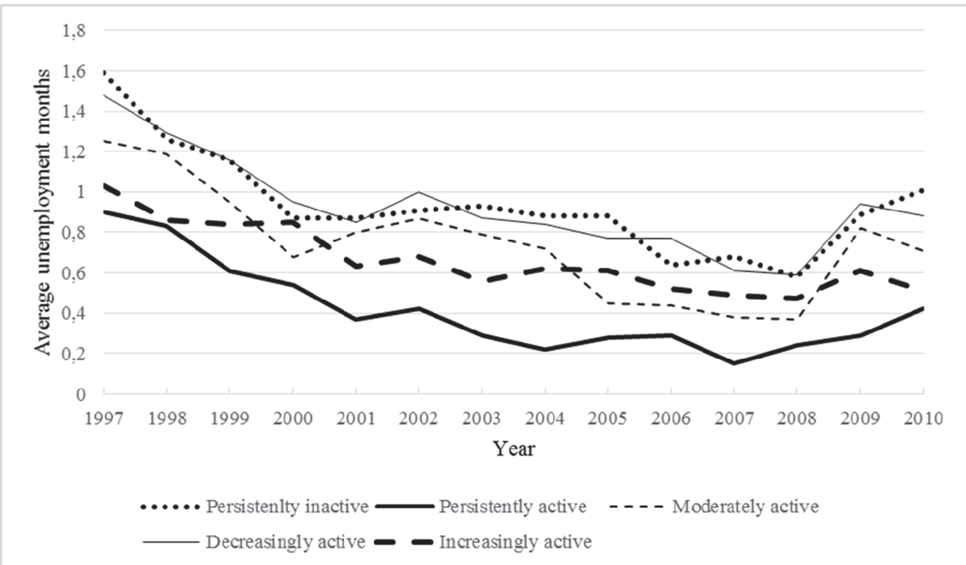

FIGURE A2 Average unemployment months by activity group over the period of 1997–2010.

5 INCOME AND PHYSICAL ACTIVITY AMONG ADULTS: EVIDENCE FROM SELF-REPORTED AND PEDOMETER-BASED PHYSICAL ACTIVITY MEASUREMENTS*

Abstract**

This study examined the relationship between income and physical activity by using three measures to illustrate daily physical activity: the self-reported physical activity index for leisure-time physical activity, pedometer-based total steps for overall daily physical activity, and pedometer-based aerobic steps that reflect continuous steps for more than 10 min at a time. The study population consisted of 753 adults from Finland (mean age 41.7 years; 64% women) who participated in 2011 in the follow-up of the ongoing Young Finns study. Ordinary least squares models were used to evaluate the associations between income and physical activity. The consistency of the results was explored by using register-based income information from Statistics Finland, employing the instrumental variable approach, and dividing the pedometer-based physical activity according to weekdays and weekend days. The results indicated that higher income was associated with higher self-reported physical activity for both genders. The results were robust to the inclusion of the control variables and the use of register-based income information. However, the pedometer-based results were gender-specific and depended on the measurement day

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(weekday vs. weekend day). In more detail, the association was positive for women and negative or non-existing for men. According to the measurement day, among women, income was positively associated with aerobic steps despite the measurement day and with totals steps measured on the weekend. Among men, income was negatively associated with aerobic steps measured on weekdays. The results indicate that there is an association between income and physical activity, but the association is gender-specific and depends on the measurement type of physical activity.

5.1 Introduction

The detrimental health consequences of physical inactivity are well-established (Luepker et al., 1996; Murray and Lopez, 1997; Blair and Brodney, 1999; Tudor-Locke and Bassett, 2004; Warburton et al., 2006; Lee et al., 2012). Physical inactivity has been identified as the fourth-leading risk factor for global mortality (World Health Organization, 2010), and several studies have reported increasing healthcare costs due to physical inactivity (Lee et al., 2012; Colditz, 1999; Katzmarzyk et al., 2000; Katzmarzyk and Janssen, 2004; Kohl et al., 2012). Nevertheless, a substantial part of the population is not physically active (Kohl et al., 2012; Hallal et al., 2012).

The empirical literature that has examined the relationship between economic determinants and physical activity is large and yet increasing (Brown and Roberts, 2011; Ruhm, 2000; Farrell and Shields, 2002; Laaksonen et al., 2003; Parks et al., 2003; Humphreys and Ruseski, 2006; Humphreys and Ruseski, 2007; Eberth and Smith, 2010; Meltzer and Jena, 2010). In general, the evidence suggests a positive association between an individual's economic resources and physical activity. Meltzer and Jena (2010), for example, found a positive association between income and self-reported participation in physical activity. People in the highest income group tended to have a 26% higher exercise energy expenditure and a 3% higher exercise intensity than those in the lowest income group. Similarly, Humphreys and Ruseski (2006; 2007) found a positive association between income levels and participation in physical activity. Individuals with higher incomes were more likely to participate in any type of physical activity than those with lower incomes. Humphreys and Ruseski (2011) also implied that income is an important determinant of physical activity: Individuals with higher incomes were more likely to participate in physical activities, but depending on participation, individuals spend less time on physical activities. Brown and Roberts (2011), in turn, contended that the marginal effects of non-labor income and hourly wage on participation in physical activity may be relatively small. Moreover, the results suggested that monetary subsidies to promote participation in physical activity by working individuals may lead to a less than 1% increase in the frequency of participation in physical activity compared to the base category with no physical activity (Brown and Roberts, 2011).

However, the relationship between income and participation in physical activities can be more complex than expected. This view is based on the simple assumption of utility maximization. In short, given time and budget constraints, individuals allocate their time in order to maximize a given utility function comprising the consumption of commodities and leisure (Gronau, 1977). This behavior suggests that although higher incomes provide more opportunities for physical activity (the income effect), higher incomes may also increase the opportunity cost of leisure time and, as a result, decrease the amount of time spent on such activities (the substitution effect). According to Special Eurobarometer on Sport and Physical Activity (2014), the main barrier to physical activity was lack of time (42%). Additionally, McConnell's (1992) and Humphreys and Ruseski's (2006; 2011) models are examples in which the effect of changes in income and the opportunity cost of time have opposite effects on the time spent on physical activity and overall participation in physical activity. Melzer and Jena (2010) and Brown and Roberts (2011) provided two recent empirical contributions that support this view. These studies indicated that higher incomes may lead to more intense physical exercise (Meltzer and Jena, 2010) as well as decrease the overall intention to exercise (Brown and Roberts, 2011). Economy-level income measures provided similar findings. Ruhm (2000) indicated that physical activity decreased when the economy strengthened, and higher joblessness was related to higher levels of physical activity. In general, Ruhm (2000) illustrated that a temporary deterioration in the economy was associated with health improvements.

In recent years, a growing number of population-based studies have used objectively measured physical activity (e.g., pedometers and accelerometers) (Hallal et al., 2012; Hendelman et al., 2000; Tudor-Locke et al., 2002; Tudor-Locke and Bassett, 2004; Vanhees et al., 2005), apart from self-reported questionnaires. However, to our knowledge, studies that investigate the relationship between income and physical activity by using self-reported as well as objective measures of physical activity have not been conducted. In a broader context, a better understanding of how income is associated with different dimensions of physical activity can aid health promoters in implementing efficient tools for increasing participation in physical activity for individuals with different socioeconomic backgrounds. The purpose of the present study was to examine the associations between an individual's income and physical activity in adulthood by using data from the Young Finns Study (YFS). In particular, the study extended the previous literature by using three measures of physical activity: the self-reported leisure-time physical activity index, pedometer-based daily total steps, and pedometer-based aerobic steps reflecting continuous activity for more than 10 min at a time. We hypothesized that income is positively associated with physical activity.

5.2 Materials and methods

5.2.1 Ethics statement

The study was approved by the local ethics committees (The Ethics Committee of the Hospital District of Southwest Finland), and each participant gave written informed consent before participating in the study.

5.2.2 Study population

The data were drawn from the ongoing longitudinal YFS, which was launched in 1980 (Raitakari et al., 2008). The population of the YFS consisted of a random sample of boys and girls from six age cohorts (3, 6, 9, 12, 15, and 18 years at the baseline year in 1980) from five university towns in Finland with medical schools (Helsinki, Turku, Tampere, Oulu, and Kuopio) and the surrounding rural areas. In 1980, of the 4326 invited individuals, 3596 participated in the baseline study. The study has been conducted in seven follow-up phases (1983, 1986, 1989, 1992, 2001, 2007, and 2011). The examinations have included comprehensive data collection using questionnaires, physical measurements, and blood tests. The most recent follow-up was performed in 2011, when 2060 of the original participants, aged 34 to 49 years, participated in the examinations. Valid self-reported and pedometer-based physical activity details were obtained from 1155 (715 women and 440 men) individuals. Of those, 753 individuals (mean age 41.7 years; 64% women) were included in the present study sample. In 2008, a detailed description of the cohort profile was formed (Raitakari et al., 2008). Overall, participation has been evolved over time. Some of those who were lost to follow-up early in the study returned later. Those who dropped out were more often men and younger than those who remained in the study. A comparison of the physical activity levels showed no difference between the participants and the dropouts (Hirvensalo et al., 2011).

5.2.3 Physical activity

Three variables illustrated daily physical activity in 2011: the self-reported leisure-time physical activity index (PAI), total steps per day, and aerobic steps per day. Self-reported leisure-time physical activity, expressed as the PAI, ranging from 5 to 15, was collected with a questionnaire. The PAI was formed as the sum of five variables that describe the frequency and intensity of physical activity, the frequency and average duration of moderate to vigorous physical activity sessions, and participation in organized physical activity during leisure time (Telama et al., 2005). Physical activity was also measured with a pedometer (Omron Walking Style One HJ-152R-E) for 7 consecutive days (Hirvensalo et al., 2011), and the results were expressed as total steps per day and aerobic steps per day. Total steps per day contained every step that was taken during the day including leisure time and working time. Since physical activity recommendations suggest that for optimal health benefits a minimum of moderate intensity aerobic physical activity should be performed in periods of at least 10 min (World Health Organization, 2010; Haskell et al., 2007), the aerobic steps were calculated automatically for continuous walking ≥10 min without interruption at a pace of >60 steps/min. The steps measured with the Omron Walking Style pedometer were comparable to the steps measured with the ActiGraph accelerometer (GT1M) with a correlation coefficient of 0.942 ($P < 0.001$) (Hirvensalo et al., 2011).

5.2.4 Income

The information on an individual's annual income was collected with a self-reported questionnaire in 2007 and 2011 and information on household income in 1980, 1983, and 1986. From those years, three years (1980, 2007, and 2011) were chosen in the present study to illustrate an individual's income. In 2011, the variable contained 13 response categories, and in 2007 eight categories. In the baseline year 1980, household income contained eight categories, and the values were converted into euros by using monetary value coefficients from Statistics Finland.

5.2.5 Statistical analysis

STATA SE/13.1 for Windows was used for the statistical analyses. Correlation coefficients between the measures of physical activity were calculated. In addition, the following ordinary least squares (OLS) regression model was formed to explore the association between income and physical activity:

$$PHYSICAL\ ACTIVITY_{ijt} = \alpha_i + \beta \times INCOME_{ijt} + \mu \times X_{ijt} + \varepsilon_{ijt}\ , \quad (1)$$

where the subscript i describes the individual, t describes the study year, and j captures the alternative physical activity dimensions: the physical activity index [PAI_{it}], total steps per day [$STEPS_{it}$], and aerobic steps per day [$ASTEPS_{it}$]. α_i indicates the unobserved but time-invariant differences in physical activity between individuals, and ε_{ij} is the stochastic error term with constant variance. β is the main parameter of interest, measuring the association between physical activity and income at the given vector of the control variables (X_{it}). The data provided several possible controls (i.e., potential confounding factors), consisting of observed socioeconomic characteristics (age, neighborhood, marital status, number of children, years of education, work status [working/not working], and workload), health status (summary of the self-reported number of diseases and body mass index [BMI]), and family background factors (parental education and parental physical activity measured in 1980). Information on family background factors from the baseline year 1980 provided controls for unobserved heterogeneity, such as innate ability and preferences, thus alleviating possible biases in the estimated correlation with physical activity and income.

The consistency and robustness of the OLS estimator of our model (Eq. 1) require that the income variable and the observed control variables are uncorrelated with the error term (ε_{ijt}) and that unobserved individual heterogeneity is uncorrelated with the income variable. We supported as well as to scrutinized the robustness of these assumptions with the following ways. First, following Angrist and Picshke (2009), we used predetermined values for all observable controls (X_{it}). Assuming that individuals do not make forward-looking plans for physical activity, future physical activity cannot have an effect on the control variables measured before the level of physical activity is chosen. Therefore, future physical activity cannot have an effect on the control variables measured before physical activity. Second, we controlled unobserved individual heterogeneity by using data on individuals' family background; that is, we controlled parental education and parental physical activity observed in the baseline year 1980.

5.3 Results and discussion

5.3.1 Sample attrition

Table 1 presents the mean and standard deviations of the study sample, N = 753 according to gender (see the comparisons of the full sample and the study sample from Appendix S1 Table 1). The size of the full sample varied depending on the number of missing values (S1 Table 1). For example, valid self-reported and pedometer-based physical activity details were observed from 1155 (N = 715 women and N = 440 men) individuals. The study sample locked up the number of individuals (N = 753), where all subjects with missing observations were excluded from the analysis. This enables the comparison between the models. Although the differences between the samples were modest, some features required attention. First, the means of physical activity measurements were higher in the study sample than in the full sample ($P \leq 0.001$–0.025), except the self-reported physical activity among men. Second, there were no differences in the income means in the study sample compared to the full sample.

One general feature of the data was that women tended to be more physically active compared to men based on all three physical activity measures (Table 1). However, this is in line with national studies that have examined physical activity levels among Finnish adults (Helldan et al., 2013). In addition, interesting details were found when the focus was on the type of the self-reported physical activity (Table 1). First, the average duration ($P = 0.041$) as well as the intensity ($P = 0.012$) of physical activity sessions were higher among men, whereas women participated more often in organized sports ($P < 0.001$). Second, the frequency of physical activity was higher among women compared to men ($P = 0.018$). Finally, no differences were found in the frequency of vigorous physical activity. Based on the previous studies, in turn, men were typically more active compared to women (Brown and Roberts, 2011; Humphreys and

Ruseski, 2006; Humphreys and Ruseski, 2007; Humphreys and Ruseski, 2011; Eberth and Smith, 2010; Meltzer and Jena, 2010). For example, men tended to exercise longer, more intensively (Meltzer and Jena, 2010), and more frequently (Brown and Roberts, 2011) and had higher tendency to participate in physical activity (Eberth and Smith, 2010) compared to women.

TABLE 1 Descriptive statistics of the study sample N = 753 (N = 479 women and N = 274 men).

Variable	Women		Men		P-value[a]
	Mean	SD	Mean	SD	
Physical activity					
Physical Activity Index (PAI)[b]	9.36	1.77	8.98	1.83	0.005
Frequency of PA	1.92	0.01	1.86	0.02	0.018
Intensity of PA	2.12	0.02	2.20	0.03	0.012
Duration of PA	2.09	0.02	2.16	0.03	0.041
Frequency of MVPA	1.66	0.02	1.63	0.03	0.401
Organized sports	1.51	0.03	1.16	0.02	<0.001
Total Steps / Day	8865	2811	8101	2874	<0.001
Aerobic Steps / Day	2789	2174	2005	2004	<0.001
Socioeconomic characteristics					
Age (years)	41.75	4.98	41.68	5.12	0.837
Income[c]	6.72	2.69	8.63	3.10	<0.001
Education (years)	16.27	3.31	15.50	3.33	0.002
Work status[d]	0.92	0.28	0.98	0.16	<0.001
Light sedentary work	0.34	0.47	0.33	0.47	0.911
Heavy physical work	0.01	0.07	0.02	0.12	0.184
Number of children	1.75	0.44	1.69	0.46	0.101
Married	0.79	0.41	0.83	0.38	0.153
Suburb	0.49	0.50	0.49	0.50	0.956
Health status					
Number of diseases[e]	1.13	1.23	0.85	1.02	0.001
Body Mass Index	24.76	4.42	26.17	3.96	<0.001
Family background factors					
Education (years) Mother	10.06	3.05	10.27	3.31	0.381
Education (years) Father	9.90	3.81	9.88	3.79	0.944
Physical activity Mother[f]	1.67	1.51	1.62	1.48	0.698
Physical activity Father[f]	1.88	1.70	1.81	1.61	0.565

PA, physical activity; MVPA, moderate to vigorous physical activity. [a] P-values for gender differences (T-test). [b] Physical Activity Index (PAI) is a summary of five variables that illustrate the frequency and the intensity of physical activity, the average duration of physical activity sessions, the frequency of moderate to vigorous physical activity sessions, and participation in organized sports during leisure time. Each response alternatives were coded from 1 to 3, and thereafter added up to form a PAI with a scores ranging from 5 to 15. [c] Income categories: 1 = < €5000, 2 = €5000–10000, 3 = €10001–15000, 4 = €15001–20000, 5 = €20001–25000, 6 = €25001–30000, 7 = €30001–35000, 8 = €35001–40000 9 = €40001–45000, 10 = €45001–50000, 11 = €50001–55000, 12 = €55001–60000, 1 3= > €60000. [d] Dummy-variable, which gets value 1 if working, and value 0 if not working. [e] Self-reported number of diseases. [f] Self-reported parental physical activity obtained in 1980. The question contained the frequency of physical activity (1= Never, 2 =Once a month, 3 = 2-3 times/month, 4 = Once a week , 5 = 2-6 times/week 6 = Daily).

5.3.2 Preliminary Results

The variation in three physical activity measures with income tertiles (Low, Middle, and High) is described in Table 2. The self-reported physical activity varied significantly with income for both sexes (P = 0.001 and 0.027); individuals with higher income had a higher PAI. However, total steps per day varied by income only in men (P = 0.004). Men with higher income had fewer mean total steps per day; that is, men in the high-income group had on average 1400 fewer steps than those in the low-income group. Aerobic steps, in turn, varied significantly with income only in women (P = 0.008). Women in the high-income group had on average 460 more aerobic steps per day than those in the low-income group.

TABLE 2 Summary statistics: Physical activity level with income tertiles: Low, Middle, and High[a] among women (N = 479) and among men (N = 274).

Income Group	Self-reported Physical Activity		Pedometer-based Physical Activity			
	Physical Activity Index (PAI)		Total Steps		Aerobic Steps	
	Women	Men	Women	Men	Women	Men
Low	9.02	8.61	8566	8707	2328	2159
	(1.71)	(1.78)	(2988)	(3124)	(1879)	(2024)
Middle	9.30	9.05	9038	8193	2948	1998
	(1.75)	(1.67)	(2696)	(2574)	(2370)	(1948)
High	9.77	9.32	8947	7311	3049	1835
	(1.78)	(1.99)	(2764)	(2701)	(2133)	(2044)
F-test	6.92	3.68	1.24	5.75	4.93	0.60
P-value[b]	0.001***	0.027**	0.289	0.004***	0.008***	0.547

Robust standard errors are in the parentheses. [a] Income divided into tertiles: Low, Middle, and High by gender. Each group contains a third of the study sample. [b] Significant at *10%, **5%, and ***1% level.

The correlation analysis (Table 3) illustrates the associations between the measures of physical activity. In general, the correlation coefficients were higher in women than in men. Moreover, as in the study by Tudor-Locke et al. (2002), the correlation coefficient between the self-reported PAI and pedometer-based measures depended on how the pedometer outputs were expressed (e.g., total or aerobic steps), that is, the correlations were stronger between the PAI and aerobic steps compared to those of the PAI and total steps. Since the correlations between the self-reported and pedometer-based measures were modest, the results suggest that each physical activity variable may illustrate a different dimension of physical activity: The PAI reflects leisure-time physical activity, total steps the overall daily physical activity, and aerobic steps continued and intensive activity that lasts more than 10 min.

TABLE 3 Correlation between different physical activity measures among women (N = 479) and among men (N = 274).

	Physical Activity Index (PAI)	Total Steps	Aerobic Steps
Women			
Physical Activity Index (PAI)	1.000		
Total Steps	0.213***	1.000	
Aerobic Steps	0.303***	0.712***	1.000
Men			
Physical Activity Index (PAI)	1.000		
Total Steps	0.138***	1.000	
Aerobic Steps	0.286***	0.575***	1.000

*** Significance at the 1% level.

5.3.3 OLS results

Table 4 reports the OLS estimates for alternative physical activity measures and two alternative model specifications. For the PAI, the income coefficient measured the impact of a unit change in income level on the index of self-reported physical activity. Total steps and aerobic steps were expressed in natural logs, so the income estimate depicted a percent change in steps. To ensure comparisons between the specifications, all individuals with missing values were excluded from the analysis, and the total number of observations used in the analysis was 753.

According to the results (Table 4), higher income was associated with higher physical activity in women. The relationship was statistically significant and robust across alternative physical activity measures as well as the inclusion of control variables. Having a one-unit higher income level was associated with a 0.11-unit higher PAI, approximately 1% more total steps, and approximately 4% more aerobic steps. Similarly, in men, the results indicated that higher income was related to higher self-reported physical activity. The income estimate was robust regarding the inclusion of control variables. However, unlike as hypothesized, for the pedometer-based measures (total steps or aerobic steps), the estimates were negative, and their statistical significance depended on the model specifications. In the case of total steps, the inclusion of observable controls made the income estimate statistically insignificant. For aerobic steps, the inclusion of controls, in turn, provided a negative and statistically significant estimate. Therefore, in men, having one unit higher income was associated with higher self-reported physical activity but a lower number of total and aerobic steps.

TABLE 4 Regression of the self-reported physical activity index and the pedometer-based physical activity (total steps and aerobic steps), study sample (N = 753), women (N = 479), men (N = 274).

	Self-reported physical activity		Pedometer-based physical activity			
	Physical activity index		Total steps		Aerobic steps	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Women						
Income	0.11***	0.11***	0.01*	0.01**	0.05***	0.04**
	(0.029)	(0.033)	(0.006)	(0.006)	(0.016)	(0.017)
R^2	0.03	0.08	0.01	0.07	0.03	0.07
Men						
Income	0.11***	0.09*	–0.02***	–0.01	–0.02	–0.04*
	(0.034)	(0.047)	(0.007)	(0.008)	(0.020)	(0.025)
R^2	0.04	0.12	0.04	0.16	0.01	0.11
Control variables	No	Yes	No	Yes	No	Yes
Socioeconomic Characteristic	-	x	-	x	-	x
Health Status	-	x	-	x	-	x
Family Back-ground factors	-	x	-	x	-	x

Significant at *10%, **5%, and ***1% level. Robust standard errors are in the parentheses. Total steps and aerobic steps are transformed with natural logs. Added control variables: the vector of socioeconomic characteristics (neighborhood, marital status, number of children, years of education, work status, and physical workload), health status (self-reported number of diseases and BMI) observed in 2007, and family background factors (parental education and parental physical activity) observed in 1980.

The results in case of the self-reported physical activity were consistent with the previous literature, which has suggested income as a determinant of physical activity, and that the association between the variables is positive (Brown and Roberts, 2011; Farrell and Shields, 2002; Humphreys and Ruseski, 2007; Eberth and Smith, 2010; Meltzer and Jena, 2010; Cauley et al., 1991). In agreement with our results, Brown and Roberts (2011) showed that the magnitude of income was similar among women and men. Eberth and Smith (2010), in turn, showed that the magnitude of household income was slightly higher among men, whereas in studies conducted by Farrell and Shields (2002), Humphreys and Ruseski (2007), and Meltzer and Jena (2010), gender differences were not analyzed. In addition, the OLS results were in line with the study by Brown and Roberts (2011), which reported a relatively small association between income and participation in physical activity. According to the present study, one-unit higher income was associated with a 0.09–0.11 higher mean PAI value. The estimates implied that the difference between the mean PAI in the lowest (< €5000) and in the highest (> €60000) income categories was 1.08 to 1.32 units, depending on the model specifications. The explanatory power (R^2) of the models varied between 0.01 and 0.16. This implies that although the results demonstrated an association between income and physical activity, in overall, the magnitude of income in predicting physical activity is relatively modest. Nevertheless, the results were in line with the previous literature; see, for example, studies by Eberth and Smith (2010), R2 = 0.07 and Humphreys and Ruseski (2007), where the R^2 varied between 0.04 and 0.09.

The pedometer-based results were less clear-cut in men. Limitations related to pedometer-based measurements are known, and part of the inconsistency between the self-reported and objectively measured results may be due to the pedometer method itself. Although pedometers are a relatively simple and affordable method for measuring physical activity (Tudor-Locke et al., 2002), they are not designed to distinguish the intensity of physical activity. However, because steps were divided into total steps per day and aerobic steps per day from which aerobic steps reflected continuous walking that lasted for more than 10 min at a pace of 60 steps/min, we may assume that aerobic steps represents a more intense exercise type of physical activity than total steps. In addition, pedometers are not sensitive to non-ambulatory activities such as swimming, gym workouts, cycling, or similar activities. As shown in Table 1, the type of physical activity may also be gender-specific; that is, women and men may prefer different types of physical activity. Therefore, one possible explanation for the inconsistent results may be the type of physical activity itself. For example, Finnish women typically participate more often in walking, cycling, and aerobics/gymnastics, whereas men participate more often in running, ball games, and gym training (Tammelin et al., 2003). Finally, men and women may also under- or overestimate their self-reported levels of physical activity (Sebastiao et al., 2012), which, may be related to health-enhancing awareness (van Sluijs et al., 2007). Therefore, the mismatch between the self-reported and the pedometer-based results may reflect a possible exaggeration of the self-reported measurements.

5.3.4 Sensitivity analysis

The OLS results suggested that the estimate of the association between physical activity and income did not suffer from omitted variable bias: The inclusion of a comprehensive set of control variables kept the income estimate by and large intact. However, there are other issues that may bias the results and tamper our conclusions. First, the association between income and physical activity might be spurious, and stemmed from unobserved factors that correlate with income and physical activity. An individual's personality and ability are such factors. However, these variables are hard to come by, and typically, unobserved heterogeneity is accounted for by using panel data and fixed-effects models. In our case, the individual income measures obtained in 2007 and 2011 were based on different categorization, and therefore ruined the possibility of using fixed effects-models. Second, the findings may be biased by reverse causality. As several earlier studies have shown, physical activity has a positive impact on labor market returns. According to Long and Caudill (1991), Ewing (1998), and Stevenson (2010), the labor market returns of former high school athletes were higher than those of their non-athlete counterparts. Similarly, Kosteas (2012) showed that frequent exercise was associated with a 6% to 10% increase in wages, and Lechner (2009) and Hyytinen and Lahtonen (2013) reported positive long-term labor market effects in terms of monthly earnings and hourly wages. Therefore, if physical activity is a determinant of income, then estimates might reflect two-way causality, the impact running from physical activity to income. Third, the variables obtained with a self-reported questionnaire may contain errors that bias the coefficients (Sebastiao et al., 2012).

The consistency of the OLS results was tested several ways. First, we used register-based earnings from Statistics Finland, to scrutinize the potential misclassification in self-reported income. Second, we used the instrumental variable (IV) approach to alleviate possible omitted variable bias and measurement error. Finally, the pedometer-based physical activity was divided according to the measurement day. This enabled us to test the possible role of time constraint; that is, we examined whether the association varied according to the day physical activity was measured.

To alleviate possible misclassification in the self-reported income measures, the physical activity details from the YFS were combined with the register-based Finnish Longitudinal Employer-Employee Data (FLEED) from Statistics Finland. The FLEED records detailed information on labor market variables over the period from 1990 to 2010. The link was based on unique personal identifiers and therefore avoided problems created by errors in record linkages (Ridder and Moffitt, 2007). In the combined data, YFS + FLEED, income referred to the average of the annual wages and salaries in 2010, where the mean income was €22504 among women, and €27617 among men ($P < 0.001$). In order to ensure the comparison between the register-based and self-reported income measures, the register-based income details were divided into 13 categories (see footnote c in Table 1). Moreover, only the baseline models (in correspondence to Table 4, Model 1) were formulated. One general advantage in the combined data was that income details were obtained for each participant with physical activity details ($N = 1155$) and therefore did not contain missing information.

As a result (Table 5), the estimates were consistent with the corresponding baseline results (see Table 4, Model 1). Among women, the association between income and physical activity was positive despite of the measurement type of physical activity. Amon men, as before, the sign and the significance of the association varied according to the measurement type of physical activity. In overall, the estimates were smaller than the corresponding baseline results obtained with the self-reported income measures.

TABLE 5 Regression of the register-based income and physical activity measures in women (N = 715) and men (N = 440).

	Self-reported Physical Activity	Pedometer-based Physical Activity	
	Physical Activity Index (PAI)	Total Steps	Aerobic Steps
Women			
Income	0.08***	0.01*	0.04***
	(0.024)	(0.005)	(0.013)
R^2	0.01	0.01	0.02
Men			
Income	0.06**	-0.01**	-0.002
	(0.026)	(0.006)	(0.015)
R^2	0.02	0.02	0.01

Significant at *10%, **5%, and ***1% level. Robust standard errors are in the parentheses. Total steps and aerobic steps are transformed with natural logs. Income information based on FLEED from Statistics Finland. The income referred to the average of the annual wages and salaries in 2010 and was divided into 13 categories (see footnote c in Table 1).

The results from the combined data provided evidence that the self-reported income measure did not suffer errors created by misclassification. However, to alleviate the possible measurement error in other variables, omitted variable bias, and test the robustness of the OLS results, we employed the IV estimation method (Kuehnle, 2014). The IV approach exploits the variation in income generated by a factor that, holding other things constant, affects only physical activity through income. The model requires two conditions to hold. First, the instrument needs to correlate with the income, and second, the instruments should be uncorrelated with the error term of the Eq. (1). Our data included two possible instruments: income measured in 2007 and household income measured in the baseline year 1980.

In general, the IV results (Table 6) were consistent with the baseline OLS results suggesting a positive and statistically significant association between income and self-reported physical activity for both genders. However, the IV estimates for the self-reported physical activity were slightly larger than the corresponding OLS estimates. This suggests that the observed association between income and physical activity is not driven by omitted variables such as personality, ability, and unobserved family background factors (Angrist and Pischke, 2009). In the case of pedometer-based measurements, only the unconditioned baseline specification (Model 1) suggested a statistically significant, and negative, association between income and total steps in men. Among women, in line with the OLS results, higher income was associated with an increasing number of aerobic steps.

TABLE 6 IV approach, study sample (N = 753), women (N = 479), men (N = 274).

	Self-reported physical activity		Pedometer-based physical activity			
	Physical activity index		Total steps		Aerobic steps	
	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Women						
Income	0.15***	0.14***	0.01	0.01	0.07***	0.06**
	(0.041)	(0.050)	(0.008)	(0.010)	(0.021)	(0.025)
Summary of the first-stage statistics						
Sargan statistic	0.12	0.05	1.61	0.30	1.21	0.03
p-value	0.725	0.826	0.205	0.583	0.271	0.867
First-stage F	166.07	102.45	166.07	102.45	166.07	102.45
Men						
Income	0.12***	0.12**	–0.03***	–0.01	–0.01	–0.02
	(0.042)	(0.062)	(0.008)	(0.011)	(0.024)	(0.033)
Summary of the first-stage statistics						
Sargan statistic	4.85**	0.66	2.04	1.79	4.67**	1.39
p-value	0.028	0.418	0.153	0.181	0.031	0.238
First-stage F	287.28	170.18	287.28	170.18	287.28	170.18

Significant at *10%, **5%, and ***1% level. Heteroskedasticity-robust standard errors are shown in the parentheses. Total steps and aerobic steps are transformed with natural logs. Two model specifications, one without control variables, excluding age (Model 1), and one with full set of control variables (Model 2). Added control variables: the vector of socioeconomic characteristics and health status observed in 2007, and family background factors observed in 1980. Instruments used: Income, obtained in 2007 and household income obtained in 1980. Because the Sargan test is not available with cluster robust standard errors, the test was executed with non-robust errors. Thus, the results should be treated with a care.

The pedometer-based results indicated that the relationship between income and physical activity may be more complex than previous studies, which have used only self-reported measures of physical activity, have suggested (Angrave et al., 2015). According to the Special Eurobarometer on Sport and Physical Activity (2014), lack of time has been reported as the main barrier to physical activity among Finnish adults (32%). In addition, Meltzer and Jena (2010) speculated the role of time as an important determinant of exercise patterns. Similarly, in the present study, the negative sign of income in men suggests that there may be a trade-off between work and physical activity. The time constraint may be more important than the budget constraint. Men with higher income had more self-reported physical activity during leisure time, but fewer daily total steps and continuous (>10 min) physical activity (aerobic steps) compared to those with lower income.

To test the role of time constraint, the baseline models were extended by dividing the pedometer-based physical activity on weekdays and weekends, assuming that on weekends working individuals may have more time to spend on physical activities. The results are presented in Table 7. The findings confirmed our previous results with some interesting details. Among women, income was positively associated only with the total steps measured during the weekend. Having a one-unit higher income level was associated with approximately 2% more total steps during the weekend. Income, in turn, was positively associated with aerobic steps, despite the measurement day, such that having a one-unit higher income level was associated with approximately 4–8% more aerobic steps. Among men, income was negatively associated only with aerobic steps measured on weekdays. In more detail, having a one-unit higher income level was associated with approximately 5% fewer aerobic steps on weekday.

TABLE 7 Regression of the pedometer-based physical divided into weekdays and weekend days, study sample (N = 753), women (N = 479), men (N = 274).

	Total Steps		Aerobic Steps	
	Weekday	Weekend day	Weekday	Weekend day
Women				
Income	0.01	0.02**	0.04**	0.05***
	(0.007	(0.010)	(0.018)	(0.017)
R^2	0.01	0.01	0.01	0.03
Men				
Income	–0.02	-0.01	–0.05**	–0.01
	(0.010)	(0.011)	(0.024)	(0.024)
R^2	0.04	0.01	0.03	0.01

Significant at *10%, **5%, and ***1% level. Robust standard errors are in the parentheses. Total steps and Aerobic steps are transformed with natural logs. Added control variables: the vector of socioeconomic characteristics and health status observed in 2007, and family background factors observed in 1980.

5.3.5 Summary of the results

The results provided evidence about the relationship between income and physical activity. In the case of self-reported measures, the association was positive despite the model specifications and the inclusion of control variables. The pedometer-based results, in turn, were gender-specific and depended on the measurement type of physical activity and the day physical activity was measured.

The results suggest a possible role for time constraint. This was particularly marked in case of pedometer-based results when the steps were divided into weekdays and weekends. Among women, income was positively associated with the total steps measured during the weekend, and among men income was negatively associated with the aerobic steps measured on weekdays. Therefore, among men, higher incomes may increase the opportunity costs of leisure time and, as a result, reduce the time spent on such activities, that is, the time constraint becomes more important than the budget constraint. However, to confirm this, more research is needed. Therefore, for future research, it would be valuable to divide daily physical activity into leisure time, occupational, and commuting physical activity. Moreover, analysis consisting of the types of physical activity, measured with self-reported and objective measures, would extend the current knowledge about the association between income and physical activity. Are there types of physical activity preferred by individuals with lower/higher income? Is this association gender-specific? Then the interplay between the opportunity costs and income effects could be explored in more detail. This information would also be useful to employers when they target workplace physical activity programs for workers with limited leisure-time resources. Furthermore, this information would benefit policy makers in order to implement effective methods for increasing overall daily physical activity for individuals with different socioeconomic backgrounds.

5.4 Conclusion

The study examined the associations between income and physical activity among Finnish adults. The study extended the previous literature by including self-reported and pedometer-based physical activity in the analysis. Two main findings emerged from the results. First, higher income was associated with higher self-reported leisure-time physical activity for women and men. The results were robust to the inclusion of control variables, as well as the use of a register-based income measure. Second, the pedometer-based results differed by gender: The association was negative or non-existent for men and positive for women. The study suggests that the measurement type of physical activity should be taken into account when possible income effects of physical activity are analyzed and further policy implications proposed.

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Appendix

S1 TABLE 1. Descriptive statistics of the Study Sample and the Full Sample.

Variable	Study Sample (N=753)		Full Sample				P-value[a]	
	Women	Men	Women		Men		Women	Men
	Mean (SD)	Mean (SD)	Mean (SD)	N	Mean (SD)	N		
Physical activity								
Physical Activity Index (PAI)[b]	9.36 (1.77)	8.98 (1.83)	9.11 (1.87)	1064	8.91 (1.89)	846	0.003	0.541
Total Steps / Day	8865 (2811)	8101 (2874)	8318 (3007)	887	7586 (3044)	633	<0.001	0.003
Aerobic Steps / Day	2789 (2174)	2005 (2004)	2247 (2167)	887	1450 (1904)	633	<0.001	<0.001
Socioeconomic characteristics								
Age	47.75 (4.98)	41.68 (5.12)	41.53 (4.99)	1832	41.36 (4.99)	1764	0.318	0.302
Income[c]	6.72 (2.69)	8.63 (3.10)	6.56 (2.80)	1067	8.36 (3.15)	874	0.183	0.147
Education (years)	16.27 (3.31)	15.5 (3.33)	15.78 (3.37)	1226	14.84 (3.56)	998	0.001	0.001
Work status[d]	0.92 (0.28)	0.98 (0.16)	0.88 (0.32)	1226	0.96 (0.20)	1002	0.011	0.109
Light sedentary work	0.34 (0.47)	0.33 (0.47)	0.30 (0.46)	1226	0.28 (0.45)	1002	0.131	0.089
Heavy physical work	0.01 (0.07)	0.02 (0.12)	0.01 (0.07)	1226	0.03 (0.18)	1002	0.808	0.018
Number of children	1.75 (0.44)	1.69 (0.46)	1.76 (0.43)	1228	1.68 (0.47)	987	0.397	0.708
Married	0.79 (0.41)	0.83 (0.38)	0.77 (0.42)	1225	0.79 (0.41)	998	0.342	0.055
Suburb	0.49 (0.50)	0.49 (0.50)	0.48 (0.50)	1218	0.47 (0.50)	995	0.678	0.402
Health status								
Number of diseases[e]	1.13 (1.23)	0.85 (1.02)	1.18 (1.31)	1179	0.86 (1.01)	959	0.342	0.860
Body Mass Index	24.76 (4.42)	26.17 (3.96)	25.38 (5.06)	1183	26.75 (4.24)	987	0.002	0.016
Family background factors								
Education (years) Mother	10.06 (3.05)	10.27 (3.31)	9.94 (3.13)	1774	10.04 (3.28)	1705	0.371	0.602
Education (years) Father	9.90 (3.81)	9.88 (3.79)	9.71 (3.65)	1600	9.78 (3.66)	1507	0.273	0.824
Physical activity Mother[f]	1.67 (1.51)	1.62 (1.48)	1.64 (1.47)	1780	1.65 (1.49)	1700	0.630	0.817
Physical activity Father[f]	1.88 (1.70)	1.81 (1.51)	1.86 (1.67)	1601	1.81 (1.63)	1518	0.725	0.979

[a] P-values for the differences between the study sample and the full sample (T-test). [b] Physical Activity Index (PAI), ranging from 5 to 15, is a summary of five variables that illustrates the frequency and the intensity of physical activity, the average duration of physical activity session, the frequency of moderate to vigorous physical activity sessions, and participation in organized sports during leisure time. [c] Income categories: 1 = < €5000, 2 = €5000–10000, 3 = €10001–15000, 4 = €15001–20000, 5 = €20001–25000, 6 = €25001–30000, 7 = €30001–35000, 8 = €35001–40000 9 = €40001–45000, 10 = €45001–50000, 11 = €50001–55000, 12 = €55001–60000, 1 3= > €60000. [d] Dummy-variable which gets value 1 if working, and value 0 if not working. [e] Self-reported number of diseases. [f] Self-reported parental physical activity obtained in 1980. The question contained the frequency of physical activity (1= Never, 2 =Once a month, 3 = 2-3 times/month , 4 = Once a week , 5 = 2-6 times/week 6 = Daily).

YHTEENVETO (FINNISH SUMMARY)

Liikunta elämänkulussa ja työmarkkinatulemat

Tässä tutkimuksessa tarkastellaan liikunta-aktiivisuuden, koulutuksen ja työurien välisiä yhteyksiä elämänkulun eri vaiheissa. Tutkimus koostuu johdantoluvusta ja neljästä osajulkaisusta. Kolmessa ensimmäisessä tutkimuksessa tarkastellaan, miten lapsuuden ja nuoruuden liikunta-aktiivisuus on yhteydessä koulumenestykseen peruskoulun päättyessä sekä koulutustasoon, ansiotuloihin, työllisyyteen ja työttömyyteen aikuisuudessa. Neljännessä osajulkaisussa tarkastellaan ansiotulojen ja aikuisuuden liikunta-aktiivisuuden välisiä yhteyksiä. Osajulkaisuja edeltää johdantoluku, jossa määritellään liikunta-aktiivisuuskäsite, esitellään lyhyesti taloustieteellinen teoriatausta liikuntaan valikoitumisen taustalta ja kootaan yhteen aikaisempi tutkimuskirjallisuus koskien liikunnan, koulutuksen ja työurien välisiä yhteyksiä. Johdantoluvun loppuosa esittelee tutkimuskysymykset ja tutkimuksen päätulokset.

Tutkimusaineistona käytettiin Lasten Sepelvaltimotaudin Riskitekijät (LASERI) -pitkittäistutkimusta yhdistettynä Tilastokeskuksen yhdistettyyn työntekijä–työnantaja-aineistoon (FLEED). LASERI-tutkimus käynnistyi vuonna 1980, jolloin yli 3 500 lasta ja nuorta kuudesta ikäkohortista (3, 6, 9, 12, 15 ja 18 vuotta) eri puolilta Suomea osallistui ensimmäiseen kenttätutkimukseen. Tämän jälkeen tutkimushenkilöitä on seurattu yli 30 vuoden ajan. Viimeisin kenttätutkimus toteutettiin vuosina 2010–2012. Rekisteripohjainen FLEED sisältää tietoja yksilön koulutus- ja työurien kehityksestä. Tässä väitöstutkimuksessa FLEEDin tietoja hyödynnettiin vuosilta 1997–2010.

Luvussa 2 tarkastellaan, miten nuoruuden liikunta-aktiivisuus on yhteydessä koulutukseen elämänkulun eri vaiheissa. Tutkimuksessa hyödynnetään 12- ja 15-vuotiaana mitattuja liikuntatietoja: vapaa-ajan liikunta-aktiivisuus koulutuntien ulkopuolella, osallistuminen urheiluseuran harjoituksiin, osallistuminen urheilukilpailuihin sekä muutos liikunta-aktiivisuudessa 12 ja 15 ikävuoden välillä. Koulutustietojen osalta hyödynnetään itseraportoitua koulukeskiarvoa 15-vuotiaana sekä rekisteripohjaista tietoa koulutusvuosien määrästä aikuisuudessa. Tulosten mukaan nuoruuden liikunta-aktiivisuus, niin liikunta-aktiivisuus 15-vuotiaana kuin muutos liikunta-aktiivisuudessa 12-vuotiaasta 15-vuotiaaksi, ovat positiivisesti yhteydessä sekä koulutodistuksen kaikkien aineiden keskiarvoon peruskoulun päättyessä että koulutusvuosien määrään aikuisuudessa.

Luvussa 3 tarkastellaan lapsuuden liikunta-aktiivisuuden yhteyttä pitkän aikavälin ansiotuloihin. Tutkimuksessa vapaa-ajan liikunta-aktiivisuus on mitattu 9-, 12- ja 15-vuotiaana ja FLEEDin ansiotulotiedoista hyödynnetään vuosia 2000–2010. Tulosten mukaan liikunta-aktiivisuus on yhteydessä korkeampiin ansiotuloihin aikuisuudessa. Yhteys on nähtävissä erityisesti pojilla. Kun muun muassa perheen tulotaso, vanhempien koulutus ja vanhempien liikunta-aktiivisuus on huomioitu, lapsuuden liikunta-aktiivisuus on yhteydessä keskimäärin 10–20 % korkeampiin ansiotuloihin aikuisuudessa.

Luvussa 4 tarkastellaan, onko lapsuuden liikunta-aktiivisuus yhteydessä pitkän aikavälin työmarkkinoille kiinnittymiseen. Lapsuuden liikuntaa kuvaa kaksi muuttujaa: vapaa-ajan liikunta-aktiivisuus 9- ja 15-vuotiaana sekä muutos liikunta-aktiivisuudessa 9-vuotiaasta 15-vuotiaaksi. Tutkittavat on ryhmitelty viiteen luokkaan: paljon liikkuva (12 %), liikunta lisääntyy (22 %), keskivertoliikkuja (17 %), liikunta vähenee (33 %) ja vähän liikkuva (16 %). Työmarkkinoille kiinnittymistä vuosina 1997–2010 kuvataan kolmella muuttujalla: työllistymisen todennäköisyys, keskimääräiset työllisyyskuukaudet ja keskimääräiset työttömyyskuukaudet. Tulosten perusteella lapsuuden liikunta-aktiivisuus on yhteydessä parempaan työmarkkinoille kiinnittymiseen. Tämä ilmenee positiivisena yhteytenä sekä liikunta-aktiivisuuden ja työllistymisen todennäköisyyden että liikunta-aktiivisuuden ja keskimääräisten työllisyyskuukausien välillä, ja negatiivisena yhteytenä liikunta-aktiivisuuden ja keskimääräisten työttömyyskuukausien välillä. Kun tarkastellaan muutosta liikunta-aktiivisuudessa 9-vuotiaasta 15-vuotiaaksi, paljon liikkuvilla on tulosten perusteella parempi työmarkkinoille kiinnittyminen verrattuna muihin liikuntaryhmiin: paljon liikkuvilla on keskimäärin eniten työllisyyskuukausia ja vähiten työttömyyskuukausia pitkällä aikavälillä.

Viimeisessä luvussa tarkastellaan ansiotulojen yhteyttä itseraportoituun ja objektiivisesti (askelmittarilla) mitattuun liikunta-aktiivisuuteen aikuisuudessa. LASERI-tutkimuksen kahdessa viimeisimmässä seurannassa, vuosina 2007 ja 2011, liikunta-aktiivisuutta on kyselyiden lisäksi mitattu askelmittarilla. Ansiotulotiedoista hyödynnetään sekä itseraportoituja tulotietoja vuosilta 2007 ja 2011 että FLEEDin ansiotulotietoja vuodelta 2010. Tutkimuksessa havaitaan, että ansiotulojen ja itseraportoidun liikunnan välinen yhteys on positiivinen sekä miehillä että naisilla: mitä korkeammat ansiotulot, sitä enemmän miehet ja naiset raportoivat harrastavansa liikuntaa. Tulos ei kuitenkaan ole yksiselitteinen, kun käytetään askelmittarilla mitattua liikunnan määrää. Naisilla ansiotulojen ja askelmittarilla mitatun liikunnan välinen yhteys on positiivinen, mutta miehillä yhteys on joko negatiivinen tai sitä ei ole havaittavissa.