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OPEN

Longitudinal Associations between Physical Activity and Educational Outcomes

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[1]LIKES Research Centre for Physical Activity and Health, Jyväskylä, FINLAND; [2]Jyväskylä University School of Business and Economics, Jyväskylä, FINLAND; [3]Department of Pediatrics, University of Tampere and Tampere University Hospital, Tampere, FINLAND; [4]Research Centre of Applied and Preventive Cardiovascular Medicine, University of Turku, Turku, FINLAND; and [5]Department of Clinical Physiology and Nuclear Medicine, Turku University Hospital, Turku, FINLAND

ABSTRACT

KARI, J. T., J. PEHKONEN, N. HUTRI-KÄHÖNEN, O. T. RAITAKARI, and T. H. TAMMELIN. Longitudinal Associations between Physical Activity and Educational Outcomes. *Med. Sci. Sports Exerc.*, Vol. 49, No. 11, pp. 2158–2166, 2017. **Purpose**: This longitudinal study examined the role of leisure-time physical activity in academic achievement at the end of compulsory basic education and educational attainment in adulthood. **Methods**: 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 study consisted of children who were 12 yr (n = 1723, 49% boys) and 15 yr (n = 2445, 48% boys) of age at the time when physical activity was measured. The children were followed up until 2010, when their mean age was 40 yr. Physical activity was self-reported and included several measurements: overall leisure-time physical activity outside school hours, participation in sports club training sessions, and participation in sports competitions. Individuals' educational outcomes were measured with the self-reported grade point average at age 15 yr and register-based information on the years of completed postcompulsory education in adulthood. Ordinary least squares models and the instrumental variable approach were used to analyze the relationship between physical activity and educational outcomes. **Results**: Physical activity in adolescence was positively associated with educational outcomes. Both the physical activity level at age 15 yr and an increase in the physical activity level between the ages of 12 and 15 yr were positively related to the grade point average at age 15 yr and the years of postcompulsory education in adulthood. The results were robust to the inclusion of several individual and family background factors, including health endowments, family income, and parents' education. **Conclusion**: The results provide evidence that physical activity in adolescence may not only predict academic success during compulsory basic education but also boost educational outcomes later in life. **Key Words:** ACADEMIC ACHIEVEMENT, EDUCATIONAL ATTAINMENT, PHYSICAL ACTIVITY, REGISTER-BASED DATA

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Postcompulsory education is one of the most important investments in human capital (4). Besides 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 (8,12,28), employability (22), earnings (4,7), and economic growth (14).

Apart from the well-known health benefits of physical activity (18,20,25,39,40), previous studies have linked physical activity with positive returns in terms of academic achievement (11,16,17,31,33) and educational attainment (3,19,23). For example, Stevens et al. (33) found that physical activity had a positive association with mathematics and reading achievement among boys and girls, whereas Fox et al. (11) reported that physical activity and sports team participation were positively associated with grade point average (GPA). According to Long and Caudill (19), athletes who attended

colleges and universities had higher graduation rates than nonathletes, whereas Barron et al. (3) found that athletic participation was associated with a higher postsecondary level of education. Similarly, Pfeifer and Cornelißen (23) showed that nonprofessional physical activity during childhood and youth increased the probability of attaining a higher school degree.

Although the relationship between physical activity and educational outcomes has been established, some of the research findings are mixed and suggest the existence of unmeasured heterogeneity, selection issues, and the potential endogeneity of physical activity (3,10,26,34). Additionally, a recent systematic review by Donnelly et al. (9) indicated that much of the previous research explored the relationship between physical activity and academic achievement only through cross-sectional studies. Therefore, little is known about the longitudinal consequences of leisure-time physical activity during adolescence for academic achievement and subsequent educational attainment among the same individuals.

The purpose of the present study was to examine whether physical activity in adolescence is associated with academic achievement at the end of compulsory basic education and with postcompulsory education later in life. The study augmented the previous literature in three ways: First, we investigated whether the physical activity level at age 15 yr or a change in the physical activity level between the ages of 12 and 15 yr are associated with the GPA at age 15 yr and the years of postcompulsory education in adulthood. Second, we examined the role of participation in organized sports in academic achievement and educational attainment. Third, we used an instrumental variable (IV) approach to deal with the potential endogeneity of physical activity, omitted variable bias, and measurement error. We hypothesized that a higher physical activity level and an increase in the physical activity level in adolescence are associated with higher educational outcomes.

METHODS

Study population. The data were drawn from the ongoing longitudinal Cardiovascular Risk in Young Finns Study (YFS), which was launched in 1980, when 3596 individuals 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 with medical schools (Helsinki, Turku, Tampere, Oulu, and Kuopio) and their rural surroundings. Since 1980, seven follow-up phases (1983, 1986, 1989, 1992, 2001, 2007, and 2011) have been conducted. The examinations have included comprehensive data collection using blood tests, physical measurements, and questionnaires (24).

To obtain register-based information on educational attainment, the YFS data were linked with the register-based Finnish Longitudinal Employer–Employee Data (FLEED) from Statistics Finland. Finnish Longitudinal Employer–Employee Data 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, including family income and parents' education, was obtained from the Longitudinal Population Census (LPC) of Statistics Finland from 1980. To avoid problems created by errors in record linkages (27), FLEED and LPC data were combined with the YFS data based on the unique personal identifiers.

The present study consisted of individuals who were age 12 to 15 yr when the information about physical activity was collected; that is, the sample consisted of 2445 individuals (48% boys) who were born between 1965 and 1977. Thereafter, the individuals were followed until 2010, when the participants' mean age was 40 yr. Depending on the model specification, the sample size varied from 1126 to 1628.

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

Self-reported physical activity. Leisure-time physical activity at the ages of 12 and 15 yr was measured with a self-reported questionnaire. The participants were asked the following questions: "How often do you engage 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 sports competitions?." 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 (Table, Supplemental Digital Content 1, The original scoring and recoding of PAI; 37, http://links.lww.com/MSS/A969).

Educational outcomes. Two measures were used to illustrate individuals' educational outcomes: self-reported GPA at age 15 yr and years of completed postcompulsory education. The information on GPA was provided by the YFS; the variable referred to a numerical assessment on a scale of 4 to 10, where 4 denotes *failed*, and 10 denotes *excellent*. Information on postcompulsory educational attainment 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.

Statistical analyses. The analysis was based on ordinary least squares (OLS) models stratified by sex. The models used the GPA at age 15 yr and the years of completed education as the dependent variables and the PAI at age 15 yr as an explanatory variable. All models were adjusted by birth cohort and birth month, which were predetermined variables (2). Before running, the OLS models, the correlation coefficients

were calculated to illustrate the unconditional connections between adolescent physical activity and educational outcomes (Table, Supplemental Digital Content 2, Correlation coefficients, http://links.lww.com/MSS/A970).

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 (32); 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 yr (see Table, Supplemental Digital Content 3, Descriptive statistics with covariates, for additional details, http://links.lww.com/MSS/A971).

Typically, during childhood and youth, participation in sports decreases with age (15,21). 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 yr 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 age 7–18 yr report participation in sports club activities at least once a week (36). 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.

To alleviate the possible endogeneity of physical activity, omitted variable bias, and measurement error, an IV approach was used. The approach requires instruments that are correlated with the included endogenous regressor and uncorrelated with the error term of the explanatory equation (2,35). Therefore, the selected instruments should affect educational outcomes only through their effects on physical activity (5). Following Pfeifer and Cornelißen (23), Rees and Sabia (26), and Eide and Ronan (10), we used the individual's body height as an instrument. Following a recent study by Cabane et al. (6) in which parental artistic activities were used as an instrument to examine the role of playing music or sports during adolescence in education and health outcomes, we also included parents' physical activity details as an instrument. As suggested by Cabane et al. (6), parental artistic activities are a strong predictor of an adolescent's participation in music and are unlikely to influence the outcome directly. Because the IV estimates can differ systematically from the target parameter if the sample size is small (2), 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.

RESULTS

Baseline results. Regardless of the used measures of physical activity and sports participation, at the ages of 12 and 15 yr, boys had higher values than girls ($P < 0.001$; Table 1). The average PAI was approximately one unit higher among boys compared with girls. Relative to girls, boys more

TABLE 1. Sample characteristics.

	All		Women		Men		
	n	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)	*P*[a]
Physical activity in adolescence							
PAI at 12 yr (range, 5–14 yr)[b]	1723	9.57 (1.80)	886	9.06 (1.63)	837	10.11 (1.82)	$P < 0.001$
PAI at 15 yr (range, 5–14 yr)	2445	8.97 (1.97)	1271	8.61 (1.77)	1174	9.37 (2.10)	$P < 0.001$
ΔPAI at 12–15 yr[c]	1723	−0.52 (1.84)	886	−0.36 (1.80)	837	−0.70 (1.88)	$P < 0.001$
+ΔPAI at 12–15 yr[d]	1723	0.28 (0.45)	886	0.31 (0.46)	837	0.23 (0.42)	$P < 0.001$
−ΔPAI at 12–15 yr[e]	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 yr[f]	2445	0.28 (0.45)	1271	0.24 (0.43)	1174	0.32 (0.47)	$P < 0.001$
Participation in sports competitions at 15 yr[g]	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 yr[h] (range 4–10)	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]	2445	13.53 (2.88)	1271	13.88 (2.82)	1174	13.23 (2.86)	$P < 0.001$

[a]*P* values for sex differences (*t*-test).
[b]PAI (minimum 5 to maximum, 14) at the age of 12 and 15 yr 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 at 12–15 yr illustrates the change in physical activity level (PAI) between the ages of 12 and 15 yr.
[d]+ΔPAI at 12–15 yr 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 yr, and 0 otherwise.
[e]−ΔPAI at 12–15 yr 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 yr, 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 sports 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 yr 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.

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 yr, 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 yr was approximately 0.6 units higher among girls compared with boys ($P < 0.001$; Table 1). Similarly, the level of postcompulsory 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).

The baseline OLS estimates (Table 2, column 1) suggested that a higher PAI at age 15 yr was associated with a higher GPA at age 15 yr 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, column 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 yr) 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 yr). In terms of educational attainment, the most physically active girls and boys (PAI = 14 at the age of 15 yr) had approximately 1.5 more years of education in adulthood compared with their least physically active counterparts (PAI = 5 at the age of 15 yr).

Robustness checks. Among men, the inclusion of a comprehensive set of potential confounding factors (Table 2, columns 2–4) kept the physical activity estimate statistically significant but decreased the point estimates. In the extended model (Table 2, column 4), a one-unit increase in the PAI was related to a 0.03 unit 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, column 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%.

The results from the baseline OLS models were qualitatively and quantitatively similar for women and men. Therefore, from Table 3 onward, the results are presented for women and men combined and the models were adjusted by sex. In line with the baseline OLS results, change in the physical activity level in adolescence (ΔPAI at 12–15 yr) was positively associated with academic achievement at age 15 yr and educational attainment in later life (Table 3, panel 1). When the models were adjusted by individual characteristics, family background factors, and prior academic achievement (Table 3, panel 1, columns 2–4), 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 yr (+ΔPAI at 12–15 yr), the results implied a positive association between the variables (Table 3, panel 2). For academic achievement, the point estimates of physical activity were approximately 0.3 (Table 3, panel 2, column 1) and 0.16 in the extended model (Table 3, panel 2, column 4). For educational attainment, the corresponding point estimates were approximately 0.7 (Table 3, panel 2, column 1) and 0.3 (Table 3,

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

	Academic Achievement at the Age of 15 yr, GPA				Educational Attainment at the Age of 33–45 yr, Years of Education			
	1	2	3	4	1	2	3	4
Panel 1: women								
PAI at 15 yr[a]	0.108***	0.108***	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 2: men								
PAI at 15 yr	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 birth month[b]	x	x	x	x	x	x	x	x
Individual characteristics[c]		x	x	x		x	x	x
Family background[d]			x	x			x	x
GPA at 12 yr[e]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

[a]PAI (minimum, 5 to maximum, 14) at the age of 15 yr 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.

[b]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.

[c]Individual characteristics: summary of an individual's chronic conditions and body fat.

[d]Family background factors: family income, parents' education, family size.

[e]GPA at the age of 12 yr refers to a self-reported numerical assessment on a scale of 4–10 (4 is failing and 10 is excellent).

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

	Academic Achievement at the Age of 15 yr, GPA				Educational Attainment at the Age of 33–45 yr, Years of Education			
	1	2	3	4	1	2	3	4
Panel 1: change in physical activity level								
ΔPAI at 12–15 yr[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 yr[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 2: increase in physical activity level								
+ΔPAI at 12–15 yr[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 yr	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 3: decrease in physical activity level								
−ΔPAI at 12–15 yr[d]	−0.263***	−0.264***	−0.201***	−0.123***	−0.696***	−0.696***	−0.537***	−0.362**
	(0.053)	(0.053)	(0.051)	(0.032)	(0.149)	(0.149)	(0.142)	(0.130)
PAI at 12 yr	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 birth month[e]	x	x	x	x	x	x	x	x
Sex	x	x	x	x	x	x	x	x
Individual characteristics[f]		x	x	x		x	x	x
Family background[g]			x	x			x	x
GPA at 12y[h]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

[a]ΔPAI at 12–15 yr illustrates the change in physical activity level (PAI) between the ages of 12 and 15 yr.

[b]PAI (minimum, 5 to maximum, 14) at the age of 12 yr 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 at 12–15 yr is a binary variable, which gets value 1 if the physical activity level increases, and 0 otherwise.

[d]−ΔPAI at 12–15 yr is a binary variable, which gets value 1 if the physical activity level decreases, and 0 otherwise.

[e]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.

[f]Individual characteristics: summary of an individual's chronic conditions and body fat.

[g]Family background factors: family income, parents' education, family size.

[h]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).

panel 2, column 4). For those, whose physical activity levels decreased between the ages of 12 and 15 yr (−ΔPAI at 12–15 yr), the associations were negative in all model specifications (Table 3, panel 2, columns 1–4).

The models that examined whether participation in organized sports at age 15 yr is related to educational outcomes are reported in Table 4. In the case of academic achievement (Table 4, left-hand side), the association was 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 relation 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 1, column 1), whereas the association between participation in sports competitions and educational attainment was statistically insignificant (Table 4, right-hand side, panel 2, 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.

The IV results are reported in Table 5. Regardless of the instrument, the IV estimates were positive and statistically significant, suggesting that adolescent physical activity is positively related to educational outcomes. When the individual's body height was used as an instrument (Table 5, columns 2), the *F* statistics varied from 4.67 to 6.23, indicating that body height is only weakly correlated with physical activity. Therefore, the IV estimator may be biased toward the OLS estimator, and the results should be treated with caution. In the case of parents' physical activity (Table 5, columns 3–4), 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.

DISCUSSION

Summary of the results. Using data from a population-based follow-up study from youth to adulthood combined with register-based information on postcompulsory education,

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

	Academic Achievement at the Age of 15 yr, GPA				Educational Attainment at the Age of 33–45 yr, Years of Education			
	1	2	3	4	1	2	3	4
Panel 1: participation in sports club training sessions								
Overall physical activity at 15 yr[a]	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 yr[b]	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 2: participation in sports competitions								
Overall physical activity at 15 yr[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 sports competitions at 15 yr[c]	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 birth month[d]	x	x	x	x	x	x	x	x
Sex	x	x	x	x	x	x	x	x
Individual characteristics[e]		x	x	x		x	x	x
Family background[f]			x	x			x	x
GPA 12y[g]				x				x

Robust standard errors are in parentheses. The level of statistical significance: ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.
[a]The original PAI subtracted from the participation in sports competitions and participation in sports club training session variables.
[b]A variable that indicated participation in sports club training sessions (1, participates in sport club training sessions; 0, does not participate in sports club training sessions).
[c]A variable that indicated participation in sports competitions (1, participates in national- or regional-level sports competitions; 0, does not participate in sports competitions).
[d]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.
[e]Individual characteristics: summary of an individual's chronic conditions and body fat.
[f]Family background factors: family income, parents' education, family size.
[g]GPA at the age of 12 yr refers to a self-reported numerical assessment on a scale of 4–10 (4 is failing and 10 is excellent).

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 yr and an increase in the physical activity level between the ages of 12 and 15 yr were positively related to GPA at age 15 yr and years of subsequent education in adulthood. The results were robust to the inclusion of additional covariates, including individual and family background factors.

Physical activity and educational outcomes. Our findings are consistent with previous literature showing that physical activity is positively related to academic achievement (11,16,17,31,33) and educational attainment (3,19,23). However, the questions concerning physical activity have been study specific, and therefore, a comparison of the results would not be straightforward. Moreover, to our knowledge, the longitudinal associations between youth physical activity and educational outcomes are far less studied. In terms of cardiovascular fitness, Swedish study demonstrated that the change in cardiovascular fitness between the ages of 15 and 18 yr predicts cognitive performance at age 18 yr, and that cardiovascular fitness at age 18 yr predicts higher subsequent education (1).

The possible self-selection into physical activities is an issue that has to be discussed while interpreting the results. As Stevenson (34) suggests, substantial self-selection into physical activities may exist, and without adequate covariates, the impact of physical activity on educational outcomes can be upwardly biased. Furthermore, individuals' academic achievement and educational attainment can be highly correlated with their parents' education level and socioeconomic status. Thus, the baseline OLS models were augmented with individuals' chronic conditions, body fat, prior academic

TABLE 5. IV estimates of the relationship between PAI at the age of 15 yr and educational outcomes.

	Academic Achievement at the Age of 15 yr, GPA				Educational Attainment at the Age of 33–45 yr, Years of Education			
	1	2	3	4	1	2	3	4
PAI at 15 yr	0.081*** (0.013)	0.966* (0.476)	0.285*** (0.063)	0.277*** (0.061)	0.169*** (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: ***$P < 0.001$, *$P < 0.05$.
All models include controls for cohort (1–5), birth month and sex. 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.
1, Baseline OLS.
Instruments used:
2, Height.
3, Physical activity, father.
4, Physical activity, father and mother.

achievement, parents' education, family size, and family income. In line with the findings of Barron et al. (3), the results supported the view that differences across individuals' abilities, especially prior academic achievement, partially explain the correlation between physical activity and educational outcomes: When the models were adjusted by individuals' prior academic achievement, in all model specifications, the strength of the association decreased. This result 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).

Changes in physical activity level and educational outcomes. Participation in sports during childhood and adolescence typically decreases with age (15,21). According to Nader et al. (21), at the age of 9 yr, almost all children met the recommended 60 min of moderate- to vigorous-intensity physical activity daily, whereas at the age of 15 yr, only 30% achieved the benchmark. A similar decline was seen in our data. An open question was whether this change is related to academic achievement and educational attainment. As an answer, a positive association between the change in physical activity level and educational outcomes was found. One notable feature in the results was that in the case of academic achievement, the physical activity level at age 12 yr as well as the change in physical activity between the ages of 12 and 15 yr were associated with higher GPA at age 15 yr. Regarding educational attainment, however, only the change, not the 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 policy-perspective, this finding could encourage developing programs and interventions targeted to school-age 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 (4,8).

Participation in organized sports and 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 (37). As prior analyses have shown, high school athletic participation, participation in organized sports, and participation in sports competitions (23,26) are related to educational outcomes. Moreover, almost half of Finnish children and adolescents participate in organized sports (36). Therefore, as a robustness check, we examined the role of participation in sports club training sessions and sports competitions in educational outcomes. 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 postcompulsory education, what matters is the overall physical activity level expressed as the PAI, not the single measures of organized sports.

Strengths and limitations. 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 postcompulsory 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 yr, change in the physical activity level between the ages of 12 and 15 yr, participation in sports club training sessions, and participation in sports competitions. However, physical activity details were self-reported; thus, some measurement error may exist (29,30). Third, instead of self-reported information on postcompulsory 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 used. Following Pfeifer and Cornelißen (23), Rees and Sabia (26), and Eide and Ronan (10), 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.

Future directions. 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 (13,38,39), the physical activity levels are low among Finnish children (36). Regarding educational attainment, the cross-country comparisons, reveal that, in terms of educational level, Finns age 25–64 yr are ranked

seventh among OECD (The Organization for Economic Co-operation and Development) countries (22). 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.

CONCLUSIONS

Educational attainment has been used as a measure of the skills available in the population and the labor force (4,22). Apart from the well-known health effects of physical activity (18,20,39), the positive association found in the present study provides evidence that adolescent physical activity may predict better learning outcomes starting from compulsory basic education and continuing until postcompulsory education in adulthood.

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The authors declare that the results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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