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The effect of school sports facilities on physical activity, health and socioeconomic status in adulthood

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ABSTRACT

This paper focuses on the long-term impacts of attending a high school with inadequate sports facilities. We use prospective data from the British National Child Development Study, a continuing panel of a cohort of 17,634 children born in Great Britain during a single week of March 1958. Our empirical approach exploits the educational system they were exposed to: children were sorted by educational ability at age 11, but conditional on educational ability, attended their closest school. This produces quasi-random variation in the quality of the school sports facilities across respondents. We use this variation between cohort members residing within the same local authority area, and focus on outcome measures of physical activity, health, health-related lifestyle activities, and socioeconomic status, collected at ages between 33 and 50 years. We control for any potential links between the inadequacy of sports facilities and inadequacy of other facility types, and test that allocation to school type is random with respect to pre-high school observables. We find that attending a school with inadequate sports facilities led to a statistically significant, modest decrease in the likelihood of physical activity participation during adulthood. In contrast, we find no evidence that inadequate sports facilities worsened adulthood measures of physical and mental health, lifestyle or socioeconomic status.

1. Introduction

The benefits of physical activity for health and wellbeing are well recognised (Penedo and Dahn, 2005). For example, there is strong evidence that physical inactivity contributes to chronic disease, and that if physical inactivity were decreased by just 10%, more than 533,000 deaths could be averted globally each year (Warburton et al., 2006; Lee et al., 2012). In response to global concerns over obesity levels and the growing burden of non-communicable diseases, global health organisations and government attention has been directed at increasing participation in physical activity (Kohl et al., 2012; WHO, 2004; Department of Culture Media and Sport, 2015).

Investment in physical activity before adulthood may be particularly beneficial if physical activity is habit-forming and linked to long-lasting benefits (Hallal et al., 2006). Some longitudinal studies have suggested that physical activity in childhood and adolescence may have an important role in predicting adult physical activity (Tammelin et al., 2003; Trudeau et al., 2004; Telama et al., 1997). But where participation is voluntary, individuals from better-off families, or with certain personalities or innate physical strengths, may self-select into physical activity in both adolescence and in adulthood (Telama et al., 2009; Powell et al., 2006; Schulkind, 2016). If this is the case, observed associations between childhood and later activity could be due to confounding, and therefore increasing voluntary activity may have little impact on adult physical activity.

One key channel for increasing activity during childhood and adolescence is schools. School-based sport tends to be compulsory, and so reduces the importance of self-selection. Schools not only provide opportunities for children to be physically active, but can also aid the development of sporting skills, knowledge and enthusiasm for physical activity that can be carried into adulthood (Morton et al., 2016). However, despite some promising trials of school-based interventions (Kriemler et al., 2010; van Sluijs et al., 2007), recent studies suggest there are small impacts of school programs on the contemporaneous body mass index and physical activity levels of children (Dobbins et al., 2009; Cawley et al., 2007, 2013; Metcalf et al., 2012). More generally, as pressures on school budgets grow, there are questions about the value of investment in school sports facilities (Roza, 2010). In the UK for example, where less than 1 in 5 children reach WHO Global Recommendations on Physical Activity for Health (HSCIC, 2012), the

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Government is increasing its rate of approval for sales of school playing fields in an effort to deal with tight cash budgets (Santry, 2016). It is noteworthy that at the same time, the UK Government is planning to inject £415 million into school facilities and healthy lifestyles (Department of Education, 2017). Understanding the benefits over a child's life-course of investing scarce public resources into school sports facilities is therefore of tremendous importance.

In this paper, we investigate the impact of school sports facilities at age 16 on the exercise levels, physical and mental health, lifestyle choices and socioeconomic status of individuals well into their adulthood. We directly address issues of selection bias and confounding. To do this we exploit an educational system in which children, conditional on educational ability, attended their closest school. We compare children with similar background characteristics within the same local authority area to control for local-area policies, resources and physical environments. This produced quasi-random variation in school sports facilities across respondents. We use the variation in the sports facilities of these schools, measured by contemporaneous teacher assessments, combined with information on adult outcomes between ages 33 and 50 years, to examine the impact on physical activity, health and socioeconomic status in adult life.

The closest research to this analysis are papers investigating the effects of the United States' Title IX reform from the Education Amendments of 1972 legislation, which mandated equal opportunities in school physical activities, thereby increasing opportunities for girls. These papers have shown that Title IX had short-term benefits of increasing immediate physical activity participation and post-school education and labour force participation in early adulthood among females (Stevenson, 2010). In terms of longer term outcomes, Title IX had modest positive effects on the physical activity and healthy body weight of women 20–25 years later (Kaestner and Xu, 2010), and improved the health of babies born to females who participated in these programmes (Schulkind, 2016). However, whilst being a natural experiment, Title IX involved a once-off legislative change. Our study focusses on an important and ongoing issue for schools – committing resources to ensure adequate facilities for sports and physical education. Relative to the existing literature, our research exploits variation in the inadequacy of sports facilities within a schooling system, follows individuals further into adulthood and examines the impact on a broader set of health and socioeconomic outcomes.

2. Data and methods

2.1. National Child Development Study

Our data comes from the National Child Development Study (NCDS), an ongoing longitudinal study of 17,415 babies born in Great Britain in one week in 1958. Since baseline at birth, the cohort have been followed up nine times, with the latest survey at age 55 in 2013. The NCDS study design and sample sizes are detailed elsewhere (Power and Elliott, 2006). Of the original sample, 13,917 were followed up at age 16, and 9790 respondents were interviewed at age 50. Non-response and attrition in the NCDS has been carefully examined by Hawkes and Plewis (2006), and it has been shown that although there are some differences between responders and non-responders, the discrimination is not marked. The sample eligible for this study consists of 12,653 cohort members with information on school sports facilities at age 16 (in 1974). We excluded 1198 who attended an independent (privately-funded) or special-needs school as they are likely to be highly selected in the UK. A further 1526 were missing key information from the age 11 (1969) survey (used as covariates), leaving 9929 cohort members in our main estimation sample.

The adequacy of high school sports facilities was reported when the cohort member was aged 16 (1974) by the school principal (head teacher). The principal was asked to rate the adequacy of several aspects of the school facilities. They were asked "Do you feel that the work of your school is limited by the lack or inadequacy of any of the following facilities?" The facilities included sports, library, science laboratories, domestic science/home economics, metalwork/woodwork, equipment for commercial subjects, and audio-visual equipment. If the principal responded yes to sports facilities, the cohort member was classified as attending a school with inadequate sports facilities; 35% of children attended such a school. Because our models control for local authority fixed effects, this variable is interpreted as the principal's rating of the inadequacy of school sports facilities relative to the rated inadequacy of sports facilities by principals at other schools within the same local authority area.

Physical activity in adulthood was measured by face-to-face interview at ages 33, 42 and 50 (in 1991, 2000 and 2008). Participants were shown a list of sports and leisure activities that involve physical exercise (e.g. aerobic classes, running, swimming, cycling) and asked if they take part in any of these "at least once a month, for most of the year". If they answered yes (77%), they were then asked their frequency of participation: every day (19%); 4–5 days/week (8%); 2–3 days/week (22%); 1 day/week (19%); 2–3 times a month (6%); less often (2%). From this information, we constructed two measures of activity: (1) *any exercise* (exercises at least 1 time/month), and (2) *frequently active* (exercises at least 4 days/week, conditional on being active). The latter level of activity is similar to that recommended by governments and international public health organisations (WHO, 2010; Department of Health, 2011). The proportion of adults active at age 33, 42 and 50 was 76.7%, 72.6% and 75.8% respectively. Averaged across the three adult time-points, 75.1% participated in any exercise, with a small difference observed between those who attended a school rated as having adequate (75.5%) and inadequate (74.1%) school sports facilities ($P = 0.061$). In contrast, there is no difference in the probability of being frequently active by adequacy of facilities (36.6%; 36.7%; $P = 0.913$).

We examine the effects of inadequate school sports facilities on five biological measures of health that have been linked to physical activity and chronic disease: Body Mass Index, systolic blood pressure, HDL cholesterol, Glycosylated haemoglobin (blood glucose) and lung function (Warburton et al., 2010). These health outcomes were sourced from nurse examinations and blood samples taken from the Age-45 Biomedical Survey (2003).

Self-reported health, mental wellbeing and health lifestyle were measured at ages 33, 42 and 50 (in 1991, 2000 and 2008) from interviews and self-report questionnaires. General health was measured from the single general self-assessed health question (binary indicator equals 1 if health is poor or very poor). Mental health was measured using a sub-set of nine questions from the Malaise Inventory; a series of questions designed to detect levels of emotional disturbance, well-being and stress (higher scores indicate more problems). Life satisfaction was measured on an 11-point scale (completely dissatisfied to completely satisfied with the way life has turned out). The lifestyle health-related measures are whether the respondent drinks alcohol daily and whether they smoke daily.

The three main measures of socioeconomic status (SES) are education level (binary indicator equals 1 if completed university degree), employment status (binary indicator equals 1 if employed) and income (in natural logs of real weekly wages). Education was measured at age 33 (1991), employment and income were measured at ages 33, 42 and 50 (in 1991, 2000 and 2008). An additional measure of SES is the cohort member's perceptions of 'living comfortably financially' at ages 42 (2000) and 50 (2008).

2.2. Identification strategy

Our methodological approach is based on a quasi-experiment. In the 1970's in the U.K., children faced two school systems, depending upon the geographical area in which they resided (called Local Authority). In some Local Authorities (LAs), children were allocated to either

academic-oriented schools (grammars) or vocational-oriented schools (secondary moderns), based on a cognitive test taken at age 11. The remaining LAs had abolished this split and created combined schools (comprehensives). The split between schools in our sample is comprehensive (58%), grammar (11%) and secondary modern high school (22%). The sample resided in 177 Local Authority (LA) areas at age 11. The minimum, median and maximum number of children in each of the LA's equal 1, 82 and 339, respectively. Most importantly, in both types of LAs, children went to their assigned school type that was closest to their home. Schools of the same type, located within the same LA, faced the same local policies, resources and community, and are consequently well-matched comparisons for one another. In other words, conditional on LA of residence and student ability, student allocation to schools was as-good-as random, and we can therefore exploit variation in the adequacy of school sports facilities across schools within LAs to identify causal effects. There is substantial variation in sports facility adequacy within LAs; 87% of LAs have at least one school with and one school without adequate facilities, and 97% of respondents in our sample resided in such LAs.

To test for non-random selection into schools, we first undertook pairwise *t*-tests of the differences in family, child and school characteristics measured at age 11 and 16 between respondents who attended schools with teacher-rated adequate and inadequate sports facilities. We included all measured characteristics that may have been associated with attending a school with better sports facilities. Child's socioeconomic status was measured by father's social class (six levels from professional to semi-skilled), mother and father's education levels (if in school after the minimum age), father's presence in the household, father and mother's employment status, and the number of child's siblings. To assess self-selection into schools with better sports facilities, we include the child's 'sportiness', measured by whether they often played non-school sports, or had poor physical coordination (teacher-rated). Early interest in sport or education was measured by the importance placed on educational attainment by parents (their interest in school progress and aspirations for child attainment), and a range of child characteristics. These include the child's gender, health-related school absences, weight (kg), height (m), cognitive ability (standardised test score) and social maladjustment (standardised test score).

Summary statistics of the family, child and school characteristics are provided in Table 1 along with the pairwise *t*-tests. The results show that there are no significant differences in any of the covariates by adequacy of school sports facilities, including playing sport outside school, cognitive ability and mental and physical health. The only statistically significant difference is the expected differences in school type: grammar schools are less likely to have adequate sports facilities, reflecting their focus on academic achievement. Appendix A1 shows the test results are the same if we use the smaller sample of respondents with complete information on physical activity at ages 33, 42 and 50.

We also tested whether the adequacy of other aspects of school facilities may have been correlated with both the adequacy of sports facilities and the decision to attend the school, by estimating pairwise correlations of the rated adequacy of different aspects of school facilities. Table 2 shows that there is relatively low correlation in the adequacy of school level facilities on the 7 domains rated by teachers, and that poorer sports facilities are relatively orthogonal to the adequacy of other facilities. Therefore, if parents (or children) did select on some aspect of school facilities, this would not be highly correlated with the adequacy of sports facilities.

In a further investigation of possible selection bias, we conducted placebo tests by regressing each of the age 11 child and family characteristics (reported in Table 1) on inadequate sports facilities at age 16, controlling for LA. A statistically significant coefficient on inadequate sports facilities in any of the childhood characteristic regression models would be indicative of non-random selection within LAs. Table 3 shows that there is no significant association between the adequacy of sports facilities and any of the child's characteristics. Appendix Table A2 shows that we obtain the same results when using the smaller sample of respondents with information on physical activity at ages 33, 42 and 50. These tests provide considerable support that students were not selected into schools with respect to adequacy of school sports facilities.

2.3. Modelling approach

To assess the long-term effect of inadequate school sports facilities on physical activity in adulthood, we estimated linear random-effects regression models. The regressions were estimated using a balanced sample of 5190 of the eligible sample who had information on physical activity at age 33, 42 and 50 (15,570 observations). A balanced sample was chosen to ensure equal weighting at each adult age. In all models, the age 11 child and family characteristics shown in Table 1 were included as covariates. To capture school resources and the teaching environment, we additionally included the following covariates measured at age 16: school type (comprehensive, grammar or secondary modern), student-teacher ratio, indicators for all-boys school and all-girls school, and principal-rated indicators for inadequate facilities in 6 domains other than sports (library, science laboratories, domestic science/home economics facilities, metalwork/woodwork facilities, equipment for commercial subjects and audio-visual equipment). To reduce potential selection bias even further, we conditioned on LA fixed-effects.

We additionally estimated the effects of inadequate school sports facilities on physical activity at each age separately (i.e. at ages 33, 42 and 50 years), and tested for gender differences in the effect of inadequate sports facilities on adulthood physical activity by including gender interaction terms in the models. We also tested the sensitivity of our results to the use of random effects probit and ordered probit models.

We examine the long term effect of attending a school with inadequate school sports facilities on health, lifestyle, and SES in adulthood by fitting OLS and linear random-effects regression models. Linear random-effects models are employed for outcomes which are measured at multiple time-points (i.e., self-assessed health, wellbeing, lifestyle, employment, wages and financial situation) and OLS models are used for outcomes which are only measured at a single time-point (i.e., biomedical outcomes and educational attainment).

3. Results

3.1. Effect of inadequate sports facilities on physical activity

Table 4 presents the random effects regression estimates of the impact of attending a school with inadequate sports facilities on adult physical activity at ages 33, 42 and 50. Presented are the results for whether the respondent does any exercise, and whether the respondent exercises four or more days per week, conditional on doing any exercise. Column 1 shows that attending a school with inadequate facilities significantly reduces the likelihood of doing any exercise by 2.7 percentage points. The estimates for a sub-set of the covariates in the random effects regression show that the effect of having inadequate facilities on physical activity is of similar magnitude to the effect of being female, of having a one-standard deviation higher cognitive ability, and of being a 'sporty' child. Column 2 of Table 4 shows that estimates are insensitive to the inclusion of LA fixed-effects, further supporting our key assumption of no selection into schools with inadequate sports facilities. Columns 3 and 4 show there is no effect of attending a school with inadequate sports facilities on the likelihood of being 'frequently active'.

The OLS regression results for the effects on physical activity at each age separately indicate an increase in the magnitude of the physical activity effect over time. Inadequate sports facilities reduces the likelihood of any exercise by 2.1 percentage points at age 33 ($P = 0.040$),

Table 1
Summary statistics for variables from the 1969 and 1974 NCDS surveys.

Variable	Adequate Sport Facilities		Inadequate Sport Facilities		Diff
	Mean	(Std Dev)	Mean	(Std Dev)	*t*-stat
Study Collected Information (Age 11)					
Female	0.50	(0.50)	0.48	(0.50)	−1.34
Height in meters	1.44	(0.07)	1.44	(0.07)	−0.42
Weight in kilograms	36.5	(7.29)	36.5	(7.11)	−0.11
Bristol Social Adjustment Guide std. score	0.06	(0.99)	0.09	(1.00)	1.11
Cognitive std. test score	−0.01	(0.95)	−0.05	(0.98)	−1.58
Parent Reported Information (Age 11)					
Number of siblings	1.97	(1.63)	1.99	(1.69)	0.64
Often play non-school sports	0.46	(0.50)	0.48	(0.50)	1.46
Health-related school absence < 1 month	0.32	(0.46)	0.32	(0.47)	0.48
Health-related school absence > 1 month	0.05	(0.22)	0.05	(0.22)	0.17
Parent aspiration - child in school past min	0.69	(0.46)	0.68	(0.47)	−0.52
Mother in school after min age	0.22	(0.41)	0.23	(0.42)	0.94
Mother employed part-time	0.28	(0.45)	0.27	(0.44)	−0.78
Mother employed full-time	0.18	(0.38)	0.19	(0.39)	1.03
Father not in household	0.04	(0.21)	0.04	(0.20)	−0.19
Father in school after min age	0.18	(0.39)	0.18	(0.38)	−0.62
Father unemployed in past year	0.06	(0.23)	0.06	(0.24)	0.37
Father social class - professional	0.05	(0.21)	0.04	(0.20)	−1.01
Father social class – managerial/other prof	0.17	(0.38)	0.16	(0.37)	−1.32
Father social class - non-manual skilled	0.10	(0.29)	0.10	(0.29)	−0.06
Father social class - manual skilled	0.45	(0.50)	0.45	(0.50)	−0.54
Father social class - semi-skilled	0.18	(0.38)	0.19	(0.39)	1.61
Father social class – unskilled	0.06	(0.23)	0.06	(0.24)	1.49
Teacher Reported Information (Age 11)					
Poor physical coordination	0.14	(0.35)	0.14	(0.35)	−0.29
Parent is very interested in child's education	0.37	(0.48)	0.37	(0.48)	−0.66
Teacher Reported Information (Age 16)					
Grammar school	0.13	(0.33)	0.11	(0.31)	−3.22
Secondary modern school	0.22	(0.42)	0.25	(0.43)	3.20
Comprehensive school	0.65	(0.48)	0.64	(0.48)	−0.72

Notes: Sample size equals 9929. t-stat refers to the t-statistic for testing the null hypothesis that the difference in means between adequate and inadequate sports facilities groups equals zero.

2.8 percentage points at age 42 ($P = 0.053$), and 3.2 percentage points at age 50 ($P = 0.040$). However, the differences in the estimates across ages are not statistically significant. Similarly, the difference in effects sizes across genders is not statistically significant: the effect on any exercise equals 2.6 percentage points for males and 2.8 percentage points for females. There is no significant effect for either gender for being frequently active (see Appendix Table A4).

Table 5 demonstrates the robustness of our main results to using alternative frequencies for 'any exercise'. Attending a school with inadequate school sport facilities also reduces the likelihood of exercising ≥ 2–3 times/month (by 2.6 percentage points) and ≥1 day/week (by 3.0 percentage points). However, there is no significant effect at exercise frequencies 2–3 days/week or greater. Conditional on exercising at least 1 time/month, there is no effect on exercising at any of the higher frequencies. These results reinforce our conclusion that inadequate school sports facilities impact upon the likelihood of doing any exercise, but not to levels of exercise that come close to meeting public health recommendations.

Sensitivity analyses using random-effects probit models (instead of OLS) confirm the findings of a negative association between attending a school with inadequate sports facilities and the probability of doing any exercise in adulthood. Estimates from a random-effects ordered probit model of categories of exercise frequency also support the findings in Table 4 (see Appendix Table A3).

3.2. Effects of inadequate sports facilities on health, lifestyle and SES

Table 6 examines the effect of inadequate school sports facilities on health, lifestyle, and SES in adulthood, with each row presenting the coefficient on inadequate facilities from a separate linear random-effects regression model. None of these estimates are statistically significant and all are small in magnitude relative to the mean of the

Table 2
Pair-Wise Correlation Coefficients between types of Inadequate School Facilities.

	Sports	Library	Science	Home Econ.	Metal/Wood	Comm.	AV.
Sports (35%)	1						
Library (21%)	0.24	1					
Science laboratories (23%)	0.23	0.27	1				
Domestic science/Home economics (15%)	0.22	0.19	0.26	1			
Metalwork/Woodwork (20%)	0.18	0.18	0.30	0.36	1		
Equipment for commercial subjects (26%)	0.13	0.17	0.14	0.19	0.19	1	
Audio-visual equipment (15%)	0.17	0.22	0.17	0.14	0.13	0.18	1

Notes: Sample size equals 9929. Figures in parentheses are % of cohort-members with a reported inadequacy.

Table 3
Coefficient estimates on inadequate school sport facilities from OLS placebo regression models.

Variable	Coef.	(Std Error)	[p-value]
Female	−0.017	(0.011)	[0.128]
Height in meters	0.001	(0.002)	[0.452]
Weight in kilograms	0.038	(0.163)	[0.815]
Bristol Social Adjustment Guide std. score	0.024	(0.023)	[0.296]
Cognitive std. test score	−0.040	(0.024)	[0.091]
Number of siblings	0.004	(0.038)	[0.913]
Often play non-school sports	0.014	(0.012)	[0.231]
Health-related school absence < 1 month	0.005	(0.013)	[0.710]
Health-related school absence > 1 month	−0.003	(0.005)	[0.578]
Parent aspiration - child in school past min	−0.011	(0.011)	[0.347]
Mother in school after min age	0.013	(0.009)	[0.153]
Mother employed part-time	−0.006	(0.008)	[0.447]
Mother employed full-time	0.005	(0.008)	[0.571]
Father not in household	−0.004	(0.005)	[0.384]
Father in school after min age	−0.005	(0.008)	[0.553]
Father unemployed in past year	0.000	(0.005)	[0.989]
Father social class - professional	−0.004	(0.004)	[0.417]
Father social class – managerial/other prof	−0.007	(0.009)	[0.412]
Father social class - non-manual skilled	0.001	(0.007)	[0.896]
Father social class - manual skilled	−0.010	(0.010)	[0.317]
Father social class - semi-skilled	0.013	(0.009)	[0.137]
Father social class – unskilled	0.007	(0.005)	[0.193]
Poor physical coordination	0.001	(0.009)	[0.927]
Parent is very interested in child's education	−0.006	(0.011)	[0.621]

Notes: Each presented coefficient is from a separate OLS regression model with dependent variable as listed in column 1. The covariate set includes inadequate school sport facilities and dummy variables for each local authority. Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Sample size equals 9929.

outcome variable. These results suggest that attending a school with inadequate school sporting facilities has no identifiable effects on later physical health, mental health, wellbeing or health-related lifestyle indicators in this cohort. There is also no evidence that attending a school with inadequate facilities is significantly related to adulthood socioeconomic outcomes, including education, employment and wages.

We also find small and statistically insignificant effects of inadequate school sports facilities in OLS regressions of general health, mental health, life satisfaction, regular drinking, smoking, employment, and wages estimated at each age separately (i.e. at ages 33, 42 and 50 years).

Models estimated that allow for differential effects by gender generally support the findings in Table 6 (see Appendix Table A4). Notable exceptions are for drink alcohol daily and log wages. For the former outcome, we find that inadequate school sports facilities significantly reduces daily drinking for men (2.2. percentage point reduction), but not for women. Conversely, we find that inadequate school sports facilities significantly increase wages for women (4.9% increase), but not for men. In each instance, the estimates are significantly different across genders.

3.3. Verifying the measure of inadequate sports facilities

Throughout the above analyses, we have relied upon assessments by principals of the adequacy of their schools' sporting facilities. It is reasonable to assume that the school principal's assessment is well informed and takes the functionality and student needs of sports facilities into account. However, this measure is subjective, and therefore likely to differ from objective measures of adequacy, possibly leading to attenuation bias in our estimates. In this subsection, we test the usefulness of our principal-reported measure by investigating the strength of the relationship between this variable and two additional measures of the cohort members' physical activity environment when aged 16.

The first measure is a binary indicator from the age 16 (1974) survey that equals 1 if cohort members were satisfied with the available sports fields and pitches in their neighbourhood in which they lived. This measure is not specifically concerned with school resources; however, school sports facilities usually constitute an important provider of sports fields within a neighbourhood.

The second measure is based on retrospective questions from the age 23 (1981) questionnaire. Cohort members were asked if it was a

Table 4
Estimated coefficients from random-effects linear regression models of exercise frequency.

	Any regular exercise (≥1 day/month)		Frequent exercise (≥4 days/week) conditional on any	
	(1)	(2)	(3)	(4)
Variable of primary interest				
Inadequate school sport facilities	−0.027***	−0.024***	0.003	0.009
	(0.009)	(0.009)	(0.011)	(0.011)
Selected variables for comparison				
Female	−0.027***	−0.023**	0.069***	0.069***
	(0.009)	(0.009)	(0.011)	(0.012)
Often play non-school sports	0.021**	0.022**	−0.003	−0.003
	(0.009)	(0.009)	(0.010)	(0.010)
Poor physical coordination	−0.005	−0.008	0.017	0.015
	(0.013)	(0.013)	(0.015)	(0.015)
BSAG standardised score	−0.005	−0.006	0.010	0.009
	(0.005)	(0.005)	(0.007)	(0.007)
Cognitive standardised test score	0.027***	0.027***	−0.021***	−0.024***
	(0.005)	(0.005)	(0.007)	(0.008)
Father social class - professional	0.020	0.025	−0.033	−0.018
	(0.029)	(0.030)	(0.038)	(0.040)
LA fixed-effects	✗	✓	✗	✓
Sample mean of outcome	0.751	0.751	0.356	0.356
Sample size	15570	15570	12045	12045

Notes: Dependent variable in columns 1 and 2 equals one if any regular exercise (≥1/month) and zero otherwise. Dependent variable in columns 3 and 4 equals one if respondents does frequent exercise (≥4 days/week) and zero otherwise, among those who participate in 'any exercise'. BSAG = Bristol Social Adjustment Guide. Regression models include all variables included in Table 1, plus student-teacher ratio, and indicators for all-boys school, all-girls school, and inadequate school facilities in 6 areas (library, science laboratories, domestic science, metalwork/woodwork, equipment for commercial subjects, audio-visual equipment). Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

Table 5
Estimated Coefficients on Inadequate School Sport Facilities from Regression Models of Exercise Frequency using different Cut-Offs.

	Unconditional		Conditional on any regular exercise (≥1 day/month)	
Exercise ≥ 1 time/month	−0.027***	(0.009)	–	
Exercise ≥ 2–3 times/month	−0.026***	(0.009)	−0.000	(0.003)
Exercise ≥ 1 day/week	−0.030***	(0.009)	−0.008	(0.006)
Exercise ≥ 2–3 day/week	−0.013	(0.009)	0.006	(0.010)
Exercise ≥ 4–5 day/week	−0.006	(0.008)	0.003	(0.011)
Exercise = 7 day/week	−0.003	(0.007)	0.005	(0.009)

Notes: Each figures is the estimated coefficient on inadequate school sport facilities from a separate random-effects linear regression model. The dependent variable in each regression is binary and defined by the cut-off given in the left-hand column. Each regression includes the covariates included in Table 4 regressions. Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

Table 6
Coefficient estimates on inadequate school sport facilities from linear regression models of adulthood outcomes.

Dependent variable	Age Measured	N	Sample Mean	Coeff.	(Std. Error)
Biomedical survey					
Body mass index (kg/m^2)	44	5918	27.44	−0.015	(0.143)
Systolic blood pressure (mmHg)	44	5977	126.5	−0.644	(0.476)
HDL cholesterol (mmol/L)	44	5034	1.559	−0.004	(0.014)
Glycosylated hemoglobin (HbA1c)	44	6025	4.207	0.020	(0.073)
Lung function (FVC in liters)	44	5855	4.186	0.001	(0.023)
Self-assessed health and wellbeing					
Fair or poor general health (0/1)	33, 42, 50	20479	0.165	−0.000	(0.009)
Malaise score (0–9)	33, 42, 50	20427	1.314	−0.012	(0.035)
Life satisfaction (0–10)	33, 42, 50	20031	7.349	−0.020	(0.046)
Health lifestyle					
Drink alcohol daily (0/1)	33, 42, 50	20542	0.176	−0.003	(0.008)
Smoke cigarettes daily (0/1)	33, 42, 50	20507	0.260	−0.001	(0.009)
Socioeconomic status					
University degree (0/1)	33	7051	0.110	−0.002	(0.008)
Employed (0/1)	33, 42, 50	20563	0.834	0.003	(0.006)
Log real weekly wage (ln $)	33, 42, 50	13916	5.397	0.012	(0.017)
Living comfortably financially (0/1)	42, 50	13375	0.376	0.000	(0.011)

Notes: Coefficients are from linear random-effects regression models for all self-assessed wellbeing outcomes, employment and wages. All other coefficients from OLS regression models. All regression models include dummy variables for each local authority and covariates included in Table 4 regressions. Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

school's job to help develop skills in sports and games, and if they answered 'yes', they were subsequently asked how well the school did. We construct a binary indicator that equals 1 if the respondent believed their school did very well at developing skills in sports or games, and equals 0 if the school did quite well, not well or did not teach sport at all.

Table 7 shows that after controlling for all main covariates, students attending a school rated as having inadequate sports facilities were 2.8 percentage points less likely to be satisfied with playing fields and pitches for sport in their neighbourhood ($P = 0.017$). At age 23, respondents who attended such schools were 3.1 percentage points less likely to report that their school did "very well" at helping to develop skills in sports and games ($P = 0.025$). These two results provide evidence that the cohort members are in (partial) agreement with the principal's assessment of the school's sport facilities.

4. Conclusion

Despite recent global strategies to increase physical activity (World Health Organization, 2013), only 16% of girls and 21% of boys aged 5–15 in England are reaching the WHO Global Recommendations on Physical Activity for Health (2010) of being active for 60 min each day (HSCIC, 2012). Such failure in a period of increasing obesity rates has intensified interest in potential interventions that promote the take-up of regular physical activity in the general population. If sports skills and a habit for exercise is formed early in life, then a natural focus is on the role of schools in promoting physical activity. Our study builds on studies examining the contemporaneous relationship between school sports infrastructure and physical education programs on childhood physical activity and overweight (Kriemler et al., 2010; van Sluijs et al., 2007; Cawley et al., 2007; Metcalf et al., 2012; Sallis et al., 2001; Brink et al., 2010; Kahan and McKenzie, 2015; Datar and Sturm, 2004). We examine whether such school-level policies may have long-lasting effects into adulthood.

A key strength of our study is that we take selection and confounding issues seriously and our approach allows us to identify the causal impact of the adequacy of school sports facilities on physical activity, health, lifestyle choices and economic circumstances in adulthood. We find that attending a high school with adequate sports facilities at age 16 means individuals of both genders are more likely to exercise (at least once a month) during their 30s, 40s and 50s, but the size of the effect is small. We find no evidence that adequate sports facilities affect whether individuals do government-recommended levels of exercise that achieve health benefits. Our results also show that the extra exercise completed by adults who attended schools with adequate sports facilities does not affect obesity or key indicators of physical health, wellbeing or economic outcomes. At most, we might be able to infer that access to adequate high school sports facilities alone leads to a greater interest in exercise at the extensive margin, but not to a level that will make a material difference to health.

Our study is not without limitations. First, even though the attrition between age 11 and later adulthood in the NCDS is not large, a full analysis of its relationship to childhood circumstances does not exist. Second, the study is based on a British cohort born in 1958 and therefore may not be generalizable to the current generation of children. Third, we rely on subjective school principal assessments of the adequacy of their schools' sporting facilities. Though this measure is supported by our robustness analysis, we would ideally like to confirm

Table 7
Estimated coefficients of the contemporaneous effect of inadequate school sports facilities from linear regression models.

Dependent variable	Age Measured	N	Sample Mean	Coeff.	Std. Error
Satisfied with playing fields, pitches for sport	16	9208	0.438	−0.028**	(0.012)
School developed skills in sports very well	23	6488	0.353	−0.031**	(0.014)

Note: Each presented coefficient is of having inadequate school sport facilities from a separate OLS regression model with dependent variable as listed in column 1. Regression models include all variables included in Table 1, plus student-teacher ratio, and indicators for each local education authority, all-boys school, all-girls school, and inadequate school facilities in 6 areas (library, science laboratories, domestic science, metalwork/woodwork, equipment for commercial subjects, audio-visual equipment). Standard errors clustered at the LA level presented in parentheses. ** denotes statistical significance at the 0.05 level.

our findings with objective measures of facilities, such as the lack of specific sports fields or swimming pools, and the quantity of various types of sporting equipment. Unfortunately, such information is rare; indeed it is difficult to obtain any information on school sports facilities in longitudinal datasets that allow a rigorous analysis of its impacts decades into the future. Fourth, we have no measures of quality of teachers, and although we control for type of school and the student-teacher ratio, which may be associated with teacher quality, our findings for sports facilities could reflect the quality of physical education instruction."

It has been widely suggested that aside from increasing sports skills and habits, sports participation enhances the development of cognitive skills (Knaus et al., 2018) and other transferable skills that encourage success, such as discipline, confidence, persistence and team spirit (Gould and Carson, 2008). Studies have indicated that participation in high school sports is associated with economic position in adulthood, including educational attainment, wages and occupation (Stevenson, 2010; Barron et al., 2000; Ewing, 2007). Our research provides counter-evidence that suggests that after accounting for selection and confounding issues, raising physical activity participation alone may have little impact on later life outcomes. Our rich cohort data allow us to examine a wide range of important outcomes. In contrast to almost all the existing studies (Kaestner and Xu, 2010 are one exception), we examine behaviours and health over 20 years after individuals have left school. We therefore examine effects that last well after career and fertility choices have been made.

Our results suggest that spending resources to improve school sports facilities may have a small lasting impact in generating greater lifetime participation in physical activity, but that adequate school sports facilities alone cannot achieve long lasting health and socioeconomic benefits. Investments in other strategies are needed to combat low levels of physical activity and its associated health conditions over the life course.

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Appendix

Table A1
Summary Statistics for Variables from the 1969 and 1974 NCDS Surveys for the sample with complete information on adult physical activity.

Variable	Adequate Sport Facilities		Inadequate Sport Facilities		Diff
	Mean	(Std Dev)	Mean	(Std Dev)	*t*-stat
Study Collected Information (Age 11)					
Female	0.54	(0.50)	0.52	(0.50)	−1.54
Height in meters	1.45	(0.07)	1.45	(0.07)	0.32
Weight in kilograms	36.73	(7.34)	36.92	(7.15)	0.80
Bristol Social Adjustment Guide std. score	−0.06	(0.91)	−0.07	(0.89)	−0.45
Cognitive std. test score	0.14	(0.91)	0.16	(0.93)	0.82
Parent Reported Information (Age 11)					
Number of siblings	1.88	(1.53)	1.89	(1.56)	0.20
Often play non-school sports	0.45	(0.50)	0.46	(0.50)	0.45
Health-related school absence < 1 month	0.32	(0.46)	0.32	(0.47)	0.32
Health-related school absence > 1 month	0.05	(0.22)	0.05	(0.22)	0.13
Parent aspiration - child in school past min	0.72	(0.45)	0.74	(0.44)	1.90
Mother in school after min age	0.25	(0.43)	0.24	(0.43)	−0.35
Mother employed part-time	0.30	(0.46)	0.29	(0.45)	−0.73
Mother employed full-time	0.18	(0.38)	0.19	(0.39)	0.66
Father not in household	0.04	(0.19)	0.04	(0.20)	0.36
Father in school after min age	0.21	(0.41)	0.21	(0.41)	−0.29
Father unemployed in past year	0.05	(0.22)	0.05	(0.21)	−1.00
Father social class - professional	0.05	(0.22)	0.05	(0.21)	−0.68
Father social class – managerial/other prof	0.19	(0.39)	0.18	(0.39)	−0.19
Father social class - non-manual skilled	0.10	(0.31)	0.10	(0.31)	−0.03
Father social class - manual skilled	0.44	(0.50)	0.44	(0.50)	−0.19
Father social class - semi-skilled	0.17	(0.37)	0.17	(0.38)	0.35
Father social class – unskilled	0.05	(0.22)	0.06	(0.23)	0.86
Teacher Reported Information (Age 11)					
Poor physical coordination	0.14	(0.35)	0.14	(0.35)	0.26
Parent is very interested in child's education	0.42	(0.49)	0.42	(0.49)	0.17
Teacher Reported Information (Age 16)					
Grammar school	0.15	(0.35)	0.13	(0.34)	−1.43
Secondary modern school	0.21	(0.41)	0.25	(0.43)	3.18
Comprehensive school	0.64	(0.48)	0.61	(0.49)	−1.78

Notes: Sample size equals 15570. t-stat refers to the t-statistic for testing the null hypothesis that the difference in means between adequate and inadequate sports facilities groups equals zero.

Table A2
Coefficient Estimates on Inadequate School Sport Facilities from OLS Placebo Regression Models for the sample with complete information on adult physical activity

Variable	Coef.	(Std Error)	[p-value]
Female	−0.025	(0.016)	[0.110]
Height in meters	0.001	(0.002)	[0.543]
Weight in kilograms	0.124	(0.234)	[0.597]
Bristol Social Adjustment Guide std. score	−0.001	(0.026)	[0.980]
Cognitive std. test score	0.000	(0.031)	[0.987]
Number of siblings	−0.021	(0.043)	[0.633]
Often play non-school sports	0.004	(0.015)	[0.787]
Health-related school absence < 1 month	0.004	(0.017)	[0.812]
Health-related school absence > 1 month	−0.004	(0.007)	[0.584]
Parent aspiration - child in school past min	0.018	(0.013)	[0.174]
Mother in school after min age	0.003	(0.013)	[0.804]
Mother employed part-time	−0.011	(0.013)	[0.393]
Mother employed full-time	0.005	(0.011)	[0.683]
Father not in household	−0.001	(0.006)	[0.897]
Father in school after min age	−0.001	(0.013)	[0.957]
Father unemployed in past year	−0.008	(0.007)	[0.214]
Father social class - professional	−0.002	(0.007)	[0.734]
Father social class – managerial/other prof	0.002	(0.013)	[0.907]
Father social class - non-manual skilled	0.003	(0.010)	[0.788]
Father social class - manual skilled	−0.014	(0.014)	[0.323]
Father social class - semi-skilled	0.008	(0.012)	[0.539]
Father social class – unskilled	0.004	(0.007)	[0.536]
Poor physical coordination	0.008	(0.010)	[0.429]
Parent is very interested in child's education	−0.007	(0.0160)	[0.668]

Notes: Each presented coefficient is from a separate OLS regression model with dependent variable as listed in column 1. The covariate set includes inadequate school sport facilities and dummy variables for each local authority. Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively. Sample size equals 15570.

Table A3
Estimated Coefficients from Random-Effects Probit and Random-Effects Ordered Probit Regression Models of Exercise Frequency

	Probit Model of Any Exercise		Ordered Probit Model of Exercise Frequency	
	Coef.	Std. Error	Coef.	Std. Error
Variable of primary interest				
Inadequate school sport facilities	−0.106***	(0.038)	−0.059**	(0.028)
Selected variables for comparison				
Female	−0.115***	(0.039)	0.054*	(0.029)
Often play non-school sports	0.094***	(0.035)	0.051*	(0.026)
Poor physical coordination	−0.032	(0.052)	0.009	(0.039)
BSAG standardised score	−0.018	(0.021)	−0.004	(0.016)
Cognitive standardised test score	0.114***	(0.024)	0.026	(0.018)
Father social class - professional	0.096	(0.121)	0.012	(0.089)
Sample size	15570		15570	

Notes: Dependent variable in column 1 equals one if any regular exercise (≥1/month) and zero otherwise. Dependent variable in column 2 takes the values: 0 (no regular exercise), 1 (≤1 time a month), 2 (2–3 times a month), 3 (1 day/week), 4 (2–3 days/week), 5 (4–5 days/week), 6 (every day/most days). BSAG = Bristol Social Adjustment Guide. Regression models include all variables included in Table 1, plus student-teacher ratio, and indicators for all-boys school, all-girls school, and inadequate school facilities in 6 areas (library, science laboratories, domestic science, metalwork/woodwork, equipment for commercial subjects, audio-visual equipment). Standard errors clustered at the LA level presented in parentheses. *, ** and *** denote statistical significance at the 0.10, 0.05 and 0.01 levels, respectively.

Table A4
Tests of Differences between Genders in the Effects of Inadequate School Sport Facilities

Dependent variable	Male		Female		|t-statistic|
Any exercise	−0.026*	(0.014)	−0.028***	(0.011)	0.16
Exercise ≥ 4 days/week	0.015	(0.016)	−0.008	(0.015)	0.97
Body mass index	0.120	(0.153)	−0.130	(0.189)	1.18
Systolic blood pressure	0.068	(0.643)	−1.344***	(0.514)	1.90
HDL cholesterol	−0.018	(0.015)	0.007	(0.019)	1.16
Glycosylated hemoglobin	0.024	(0.032)	−0.015	(0.025)	1.03
Lung function	−0.032	(0.037)	0.020	(0.025)	1.19
Fair or poor general health	0.005	(0.011)	−0.000	(0.010)	0.38

(continued on next page)

Table A4 (*continued*)

Dependent variable	Male		Female		|t-statistic|
Malaise score	−0.032	(0.040)	0.014	(0.049)	0.78
Life satisfaction	0.057	(0.052)	−0.084	(0.059)	2.04
Drink alcohol daily	−0.022**	(0.011)	0.010	(0.010)	2.23
Smoke cigarettes daily	0.018	(0.012)	−0.016	(0.013)	1.96
University degree	−0.003	(0.011)	−0.001	(0.010)	0.20
Employed	−0.004	(0.007)	0.009	(0.010)	1.08
Log real weekly wage	−0.027	(0.017)	0.049**	(0.024)	2.94
Living comfortably financially	−0.006	(0.015)	0.006	(0.015)	0.63

Note: Coefficients reported for male*inadequate-sports-facilities and female*inadequate-sports-facilities. t-statistic from the test of the null hypothesis that the male and female effects are equal. Coefficients from linear random-effects regression models for exercise outcomes, self-assessed wellbeing outcomes, employment and wages. All other coefficients from OLS regression models. All regression models include dummy variables for each local education authority, variables included in Table S1, plus student-teacher ratio, and indicators for all-boys school, all-girls school, and inadequate school facilities in 6 areas (library, science laboratories, domestic science, metalwork/woodwork, equipment for commercial subjects, audio-visual equipment). Standard errors clustered at the LEA level presented in parentheses.

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