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Exploring activity levels in physical education lessons in the UK: a cross-sectional examination of activity types and fitness levels

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ABSTRACT

Objectives To establish pupil fitness levels, and the relationship to global norms and physical education (PE) enjoyment. To measure and describe physical activity (PA) levels during secondary school PE lessons, in the context of recommended levels, and how levels vary with activity and lesson type.

Methods A cross-sectional design; 10 697 pupils aged 12.5 (SD 0.30) years; pupils who completed a multistage fitness test and wore accelerometers to measure PA during PE lessons. Multilevel models estimated fitness and PE activity levels, accounting for school and class-level clustering.

Results Cardiorespiratory fitness was higher in boys than girls (ß=−0.48; 95% CI −0.56 to −0.39, p<0.001), within absolute terms 51% of boys and 54% of girls above the 50th percentile of global norms. On average, pupils spent 23.8% of PE lessons in moderate-to-vigorous PA (MVPA), and 7.1% in vigorous PA (VPA). Fitness-focused lessons recorded most VPA in co-educational (ß=1.09; 95% CI 0.43 to 1.74) and boys-only lessons (ß=0.32; 95% CI −0.21 to 0.85). In girls-only lessons, track athletics recorded most VPA (ß=0.13; 95% CI −0.50 to 0.75) and net/wall/racket games (ß=0.97; 95% CI 0.12 to 1.82) the most MVPA. For all lesson types, field athletics was least active (ß=−0.85; 95% CI −1.33 to −0.36). There was a relationship of enjoyment of PE to fitness (ß=1.03; 95% CI 0.83 to 1.23), and this relationship did not vary with sex (ß=−0.14 to 0.23; 95% CI −0.16 to 0.60).

Conclusions PE lessons were inactive compared with current guidelines. We propose that if we are to continue to develop a range of sporting skills in schools at the same time as increasing levels of fitness and PA, there is a need to introduce additional sessions of PE activity focused on increasing physical activity.

Trial registration number NCT03286725.

What are the new findings?

- Clear benchmarks against guidelines from a large-scale representative study for cardiorespiratory fitness levels of pupils in Year 7, and activity-specific levels of physical activity (PA) intensities in physical education (PE) lessons.
- PE lessons were inactive compared with current guidelines; choice of activity in combination with lesson type (sex composition) and enjoyment relate to PA levels.
- There is a clear hierarchy of PE activities, with some differences recorded for moderate-to-vigorous PA (MVPA) and girls-only lessons; however there are more similarities between groups, particularly enjoyment of PE, where regardless of sex, pupils that 'strongly agreed' to enjoying PE were fitter than their counterparts.

How might it impact on practice in the future?

- If increasing cardiorespiratory fitness and PA levels of pupils is an objective, then teachers must consider both how to maximise enjoyment of PE alongside introducing more MVPA sessions in school.
- Recommendations for teachers to deliver higher PA in PE, and reduce sedentary time. This might be through choice of activity, lesson type, or the inclusion of new elements to a lesson to both increase activity intensity and enjoyment.
- Certain types of PE activity are less active and it may be that, in order to continue to develop a range of sporting skills and achieve higher levels of PA in children for health and well-being, we may need to adopt a novel approach with the introduction of additional fitness-type sessions within schools alongside standard PE where sporting skills are built.

INTRODUCTION

Cardiorespiratory fitness (CRF) is related to better physical and psychological health[1] and higher academic achievement in school-children,[2–4] with higher childhood fitness being linked to better health, well-being and life-chances in adulthood.[5 6] Adolescent fitness levels have been falling globally,[7–10] raising concerns regarding the long-term impact. Alongside non-modifiable biological and genetic factors,[11] physical activity (PA)

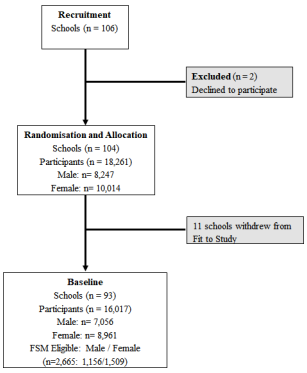

Figure 1 School recruitment and participant flow chart for the 'Fit to Study' project's baseline data. FSM, free school meal.

is a key modifiable determinant of fitness.[12] Indeed, moderate-to-vigorous PA (MVPA) levels in childhood are known to be critical for the healthy development of metabolic, cardiovascular and musculoskeletal systems. Activity levels decline throughout adolescence,[13] particularly in girls, and those who are more socioeconomically disadvantaged, or living in inner-city areas.[14–16] Worryingly just 43.2% of adolescents in the UK now meet the current government activity guidelines, which suggest accumulating at least 60 min MVPA per day across the week.[17–19]

Most young people in the UK have to attend school, and physical education (PE) lessons are compulsory until Year 11,[13] suggesting that school PE offers a suitable setting to promote adolescent PA and fitness.[20 21] During the past decade, focus on PE has shifted from fitness and competition[22 23] to learning experiences, skills development and fostering the benefits of regular PA.[24] The UK Association for Physical Education recommends pupils should be actively moving for 50%–80% of the available PE lesson time,[25] although no intensity level is specified. Previous studies suggest pupils spend an average of 40.5% of PE lesson time in MVPA.[26] Notably, time spent being sedentary or performing light activities in lesson time has been less clearly reported, but one Japanese study showed primary schoolchildren not moving for 27.3% of the time in PE.[27] Thus, provisional data suggest that a great deal of PE time might be spent standing or sitting and that lessons could be adapted to increase activity levels.

When considering factors affecting PA, a recent systematic review[28] identified modifiable variables that were consistently associated with levels of MVPA in PE including the class sex, the type of PE activities and content, lesson location (outdoors), beliefs and values of students, and enjoyment of exercise. The current levels of fitness and PA in PE in the UK are not well described; there are no recent large-scale surveys of PA in English PE lessons using accelerometry. A clear benchmark of performance against guidelines, from a large-scale representative study, is required to inform future policy. Our aim was to describe fitness, PA levels and patterns of PA in PE lessons alongside measuring factors known to affect activity levels. Our primary objectives were to describe: (1) the CRF levels of Year 7 pupils by sex in relation to global norms and enjoyment of PE, (2) the levels of sedentary PA (SPA), MVPA and vigorous PA (VPA) in PE lessons in the context of recommended levels, (3) the effect of activity type and lesson type (sex composition), in combination, on activity levels in PE.

METHODS

We used a subsample of baseline data from the 'Fit to Study' cluster-randomised controlled trial—10 697 pupils aged 12.5 (SD 0.30) years. Figure 1 presents a flow chart for school and participant recruitment for the collection of baseline data (16 017 pupils). Details of the trial, including recruitment, methodology and consent procedures, are reported in the study protocol.[29] Baseline data for each measure of interest are presented in online supplemental file 1. Primary analyses included participants who completed each measure of interest at baseline (online supplemental file 2).

Participants and setting

Participants were pupils aged 11–13 years from the UK state secondary schools. Baseline assessments were undertaken between June and September 2017, at the end of Year 7 and the start of Year 8. Schools provided participants' sex, birth date and pupil eligibility for free school meals (eFSMs), an indicator of socioeconomic deprivation. Participants completed questionnaires on school computers, or otherwise at home. Additional information on measures and data cleaning procedures are reported in online supplemental file 2.

Outcome measures

CRF was assessed by PE teachers during normal PE lessons, using a standardised multistage 20-metre shuttle run test.[30] Total number of laps completed was recorded: we compared pupils' performances with normative 50th percentile scores by sex aged 12 years.[31] We performed concurrent validity testing on the shuttle run test, through comparison of the field-based and lab-based (a cardiopulmonary exercise test) fitness measures in a subsample who participated in a brain imaging substudy (online supplemental file 3).

Pupil PA during PE lessons was measured with wrist-worn AX3 triaxial accelerometers designed by Open Lab, Newcastle University.[32] Through visits to a single lesson, we aimed to measure at least half of the year group in every school, which in some cases required multiple visits. All pupils in a lesson wore a monitor, excluding those who had opted out of the study. Pupils were not identified individually. A member of the research team noted the number of pupils per class, and the type of activity with reference to a General Certificate of Secondary Education (GCSE) classification of sports families.[33] Whether lessons were single sex or mixed sex, and whether they took place indoors or outdoors was also noted. To describe PA patterns, we calculated class average minutes

of SPA, light PA, moderate PA and VPA for the 'effective' lesson (timetabled lesson time minus changing time) and standardised this value to minutes per hour to account for different lesson lengths. The raw accelerometry data were processed into PA 'counts' using a 1 s epoch[34–38] and based on established 'cut-off points'.[39] Further detail is provided in online supplemental file 2.

PE enjoyment was measured with a single item, 'I enjoy PE' (1='strongly disagree' to 7='strongly agree') via an online questionnaire.[40–42]

Statistical analyses

Demographic data were analysed using descriptive statistics. Multilevel modelling was used to estimate the fitness levels of pupils, and the activity levels in PE, accounting for school and class-level clustering. Full details of model development and specification, data transformations and sensitivity analyses are reported in online supplemental file 4. All analysis was performed in R V.3.5.3,[43] using linear mixed-effects analysis. Pairwise comparisons for the fixed factors, where model estimates indicated significance, were examined as differences of least squares means adjusted according to Tukey.

Patient and public involvement

The 'Fit to Study' project (http://www.fit-to-study.org/) included an 18-month participatory and co-design development phase to establish and refine the measurement approaches. This included consultation with national and local sports associations, and PE teachers from eight local secondary schools, and guidance from a project Steering Advisory Group. Plans for recruitment were developed with the funders. No parties outside the research team were involved in implementation of the study, or were asked to advise on interpretation or writing up of results.

RESULTS

Demographic data

Demographic data are provided in online supplemental file 1. Mean age at the start of the school year was 12.5 (SD 0.30) years. The total number of lessons visited and pupils participating in these lessons is summarised (for activity group and lesson type) in table 1. A summary for all school-level and lesson-level variables is provided in online supplemental files 5 and 6. After data cleaning, 10 697 participants (girls=6078; 57%; eFSM=1647; 15.4%) from 74 schools completed the fitness test. Of these, 7485 (girls=4495; 60%; eFSM=1071; 14.3%) from 67 schools also completed the questionnaire. A total of 9483 participants (not individually identified) from 88 schools had their PA levels monitored during 249 PE lessons.

Fitness descriptives in comparison with global normal values

The mean absolute fitness levels and comparison with global norms are presented in table 2.

The results of the concurrent validity testing of in-school assessment compared with laboratory VO_2 max testing are presented in online supplemental file 3. Only one data point lied outside the 95% limits.

PE enjoyment

The aggregated results are plotted as a line graph of fitness to the 'PE enjoyment' measure by sex (figure 2). A multilevel model was used to investigate the effect of

Table 1 Number of lessons visited (A) and number of participating pupils (B) by activity group and by lesson type

		Lesson type			
Activity group	A B	Girls (n=60) (n=1961)	Boys (n=86) (n=2446)	Mixed (n=103) (n=5076)	Overall (n=249) (n=9483)
Invasion games	A B	13 (21.7%) 328 (16.7%)	19 (22.1%) 621 (25.4%)	5 (4.9%) 136 (2.7%)	37 (14.9%) 1085 (11.4%)
Net/wall/racket games	A B	3 (5.0%) 73 (3.7%)	8 (9.3%) 191 (7.8%)	5 (4.9%) 130 (2.6%)	16 (6.4%) 394 (4.2%)
Fielding/striking games	A B	17 (28.3%) 601 (30.6%)	37 (43.0%) 1058 (43.3%)	33 (32.0%) 1253 (24.7%)	87 (34.9%) 2912 (30.7%)
Athletics	A B	5 (8.3%) 110 (5.6%)	4 (4.7%) 105 (4.3%)	3 (2.9%) 114 (2.2%)	12 (4.8%) 329 (3.5%)
Fitness	A B	4 (6.7%) 88 (4.5%)	8 (9.3%) 243 (9.9%)	4 (3.9%) 170 (3.3%)	16 (6.4%) 501 (5.3%)
Adventure/games	A B	1 (1.7%) 16 (0.8%)	2 (2.3%) 55 (2.2%)	1 (1.0%) 41 (0.8%)	4 (1.6%) 112 (1.2%)
Various	A B	14 (23.3%) 661 (33.7%)	1 (1.2%) 20 (0.8%)	41 (39.8%) 2882 (56.8%)	56 (22.5%) 3563 (37.6%)
Athletics—field	A B	3 (5.0%) 84 (4.3%)	5 (5.8%) 93 (3.8%)	5 (4.9%) 135 (2.7%)	13 (5.2%) 312 (3.3%)
Athletics—track	A B	0 (0%) 0 (0%)	2 (2.3%) 60 (2.5%)	6 (5.8%) 215 (4.2%)	8 (3.2%) 275 (2.9%)

Table 2 Fitness (cumulative laps) for (A) sex, (B) eFSM, (C) sex by eFSM, compared with global norms (gn)

		Mean (SD)	Q_2 laps	Q_2 gn laps	n (%) above gn
A: sex p<0.001*	Boys (n=4619)	43.8 (23.5)	40	39	2365 (51)
	Girls (n=6078)	32.7 (16.7)	29	28	3300 (54)
	Total (n=10697)	37.5 (20.7)	33	–	5665 (53)
B: eFSM p<0.001	No (n=9050)	38.5 (20.9)	34		
	Yes (n=1647)	32.0 (18.4)	28		
		Mean (SD)	n (%) above gn		
C: sex by eFSM	Boys: No (n=3913)	44.9 (23.7)	2069 (53)		
	Yes (n=706)	37.5 (21.6)	296 (42)		
p=0.469	Girls: No (n=5137)	33.6 (16.9)	2887 (56)		
	Yes (n=941)	27.8 (14.2)	413 (44)		

Q_2=50th percentile.
*The p value is a simple approximation, based on the t-statistics and using the normal distribution function.
eFSM, eligibility for free school meal.

PE enjoyment on fitness according to sex. The results (online supplemental file 4) showed that fitness was positively related to PE enjoyment (ß=1.03; 95% CI 0.83 to 1.23). Moreover, the relationship was stronger among boys than girls (ß=−0.28; 95% CI −0.52 to −0.04).

Multilevel models of fitness levels

Online supplemental file 7 summarises associations between fitness and predictor variables. In fully adjusted models, 15.1% of the variance was explained by school.

The primary aim was to show how CRF varied between sex, accounting for differences between schools. The results (online supplemental file 7, Model 1 estimate) showed fitness varied significantly between boys and girls (ß=−0.48; p<0.001), and between eFSM pupils and their counterparts (ß=−0.22; p<0.001). There was no significant interaction effect between sex and FSM status in terms of their relationship with CRF.

Second, we explored how fitness varied between school location (based on postcode Index of Multiple Deprivation (IMD)[44] tertiles), and the interaction of school type (co-educational or single sex). The results (online supplemental file 7, Model 2 estimate) showed that pupils in schools located in areas of low deprivation recorded higher levels of fitness compared with pupils in schools located in areas of high deprivation (ß=0.40; p<0.013).

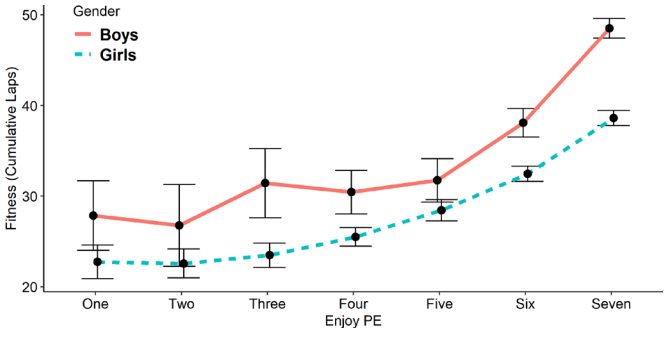

Figure 2 Grouped line plot of fitness (cumulative laps) by physical education (PE) enjoyment, by sex.

There was no significant main effect of school type, and there was no significant interaction effect between IMD tertile and school type in terms of their relationships with fitness. There was also no significant difference in girls' fitness between girls educated in co-educated schools compared with girls-only schools (online supplemental file 7, Model 3 estimate).

PE lesson PA descriptives

In summary, on average across schools, 23.7% of the time was spent in MVPA, 7.0% in VPA and 44.3% in SPA, respectively; table 3 and figure 3 present PA recorded for each type of activity. On average, the 'effective' or actual lesson time was 75.3% of the timetabled lesson (online supplemental file 5). The mean (SD) lesson-level PA during PE, expressed as a percentage of the lesson, for all PA domains is presented in online supplemental file 8 (for school location/type and lesson type) and in online supplemental file 9 (for activity group).

For MVPA and VPA, co-educational schools recorded higher levels of activity compared with single-sex schools (24.2% vs 21.6%, and 7.3% vs 5.6%, respectively), and schools located in areas of high deprivation recorded lower activity levels (22.7% vs 24.2%, and 6.5% vs 7.4%, respectively) than schools located in areas of low deprivation. Boys-only lessons were the most active (24.6% and 7.7%), followed by mixed lessons (23.8% and 6.9%) and then girls-only lessons (22.4% and 6.2%).

Figure 4 presents the relationship between lesson-average MVPA and VPA, by activity group, with no lesson achieving 30 min MVPA per hour of PE. The most active lessons by VPA were fitness and invasion games, with field athletics the least active. It was similar for MVPA, although the top-ranked single lesson for this intensity level was fielding/striking games. Violin plots of pupil average time (minutes/hour) split by PA intensity domains and activity group are presented in online supplemental file 9.

Table 3 Percentage of lesson time spent in physical activity (PA) domains, and the percentage of pupils achieving PA thresholds, by activity group

Activity group (ordered by VPA)	% of lesson			% of pupils meeting/hour		
	VPA	MVPA	SPA	>5 min VPA	>30 min MVPA	<20 min SPA
Fitness	10.2	27.9	42.1	55.9	0.4	22.0
Invasion games	9.2	28.4	37.0	48.4	2.1	40.6
Track athletics	7.9	22.1	47.0	40.4	0.4	10.6
Adventure games	6.7	19.1	51.3	37.5	0.0	16.1
Fielding/striking games	6.5	22.3	45.8	26.9	0.3	13.8
Net/wall/racket games	5.8	26.2	39.5	21.1	1.8	33.5
Field athletics	4.5	16.3	56.8	14.4	0.0	3.5

MPA, moderate PA; MVPA, moderate-to-vigorous PA; PA, physical activity; SPA, sedentary PA; VPA, vigorous PA.

Multilevel models of PA levels during PE

Our primary objective was to describe the effect of activity type and lesson type on PA levels during PE classes, and how levels varied with different combinations of these predictors. Online supplemental files 10-12 summarise associations between PA levels and predictor variables.

The results for school-level predictor variables (online supplemental file 10, Table 1 | Model 1 estimates) showed no significant effects of school type (ß=−0.18 to 0.05; p=0.421–0.911), school FSM status (ß=−0.02 to 0.02; p=0.916–0.938) or lesson type (ß=−0.21 to 0.25; p=0.246–0.975) on activity levels in PE. There was no significant interaction effect between school FSM and lesson type in terms of their effects on activity levels (ß=−0.15 to 0.18; p=0.445–0.998). Boys-only lessons were the most vigorously active (ß=0.23; p=0.338), with mixed lessons the least active (ß=−0.08; p=0.752). Girls-only lessons were the most sedentary (ß=0.06; p=0.826) and the least active in terms of MVPA (ß=0.04; p=0.877).

When considering the main effect of activity group, classes explained more variance than schools. School cluster effects explained 10.6%, 6.8% and 6.3% of the variance in VPA, MVPA and SPA, whereas class effects explained 22.1%, 20.8% and 21.9%, respectively. The results (online supplemental file 10, Table 2 | Model 2 estimates) showed fitness lessons and track athletics were characterised by the highest levels of activity (highest positive ß values), with fielding/striking games and field athletics showing the lowest activity levels, consistent with trends visible in figure 3. Post-hoc analysis directly comparing activity types (online supplemental file 12, Model 2—VPA, MVPA and SPA) reinforced these patterns.

When investigating the effect of 'lesson type', the results (online supplemental file 10, Table 3 | Model 3 estimates), showed boys-only classes were the most active (highest positive ß values), while mixed and girls-only classes exhibited similar activity levels (near to zero ß values). Mixed and girls-only classes were also the most sedentary. No significant main effect was observed,

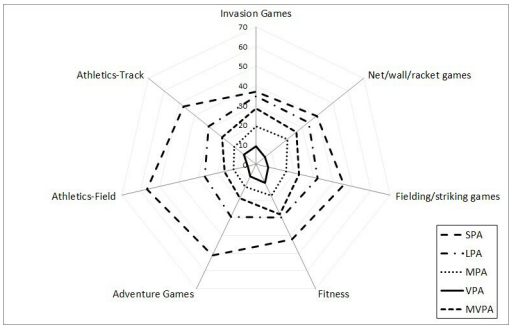

Figure 3 Average activity level (% of lesson) across physical activity (PA) domains, by activity group. LPA, light PA; MPA, moderate PA; MVPA, moderate-to-vigorous PA; SPA, sedentary PA; VPA, vigorous PA.

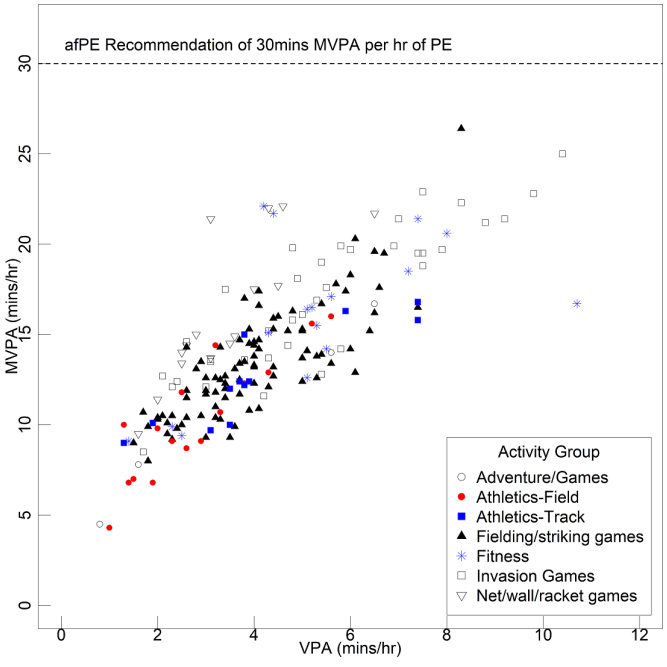

Figure 4 Grouped scatter of lesson average MVPA by lesson average VPA, by activity group. afPE, Association for Physical Education; PE, physical education; MVPA, moderate-to-vigorous physical activity; VPA, vigorous physical activity.

however, a significant interaction effect of 'activity group by lesson type' was observed for all the PA domains modelled (online supplemental file 10, Table 3 | Model 3 estimates).

For both boys' and mixed lessons, fitness-focused lessons recorded the highest levels of VPA (online supplemental file 11, Table 2 | Model 3—VPA). For girls-only lessons, fitness recorded the lowest VPA levels of all activity groups, with track athletics the highest. The lowest levels of activity in boys' and mixed lessons were recorded for field athletics. For girls' lessons, net/wall/racket games had the highest levels of MVPA (online supplemental file 11, Table 4 | Model 3–MVPA). For all lesson types, field athletics was the most sedentary (online supplemental file 11, Table 6 | Model 3–SPA); fitness being the least sedentary for boys' and mixed lessons, and net/wall/racket being the least sedentary for girls' lessons (online supplemental file 11, Table 6 | Model 3–SPA). Post-hoc analysis (online supplemental file 12, Model 3) reinforced these patterns.

DISCUSSION

We observed that the fitness levels of Year 7 schoolchildren in the UK were similar to current global norms (table 2). Girls were less fit than boys as were young people from lower socioeconomic backgrounds or from schools located in more deprived areas. We also noted that activity levels in PE lessons were low compared with guidelines,[25] and low compared with the most recent meta-analysis of global levels of PA in PE.[26] Less than 1% of pupils achieving the suggested level of activity, and an overall lesson average MVPA level of only 23.8% compared with the recommended 50%–80% of lesson time. Of note, the most commonly observed lesson activity—fielding/striking games—was one of the least active, along with field athletics. Some PE activities, particularly fitness, invasion games and track athletics, were more active—though still below guideline levels for MVPA. Once the type of activity was taken into account, there was no difference between single-sex and co-educational lessons in MVPA. Taken together our findings suggest the need for a novel approach to meet the need to develop a wide range of sporting skills and increase physical activity and fitness in school PE by possibly introducing separate fitness sessions.

Current fitness levels of young UK adolescents

In comparison with current global normative values,[31] for both boys and girls, we found average CRF was marginally higher with 51% of boys, and 54% of girls above the 50th percentile. Our findings should be considered alongside the known decline in fitness in recent decades, with annual declines ranging from 0.43%[7 31] to 1%[10 45] between 1998 and 2014, although now stabilised.[31] Our results also confirm lower fitness compared with global norms for lower socioeconomic status (SES) pupils, in both boys (42%) and girls (44%). By contrast a US study,[46] that observed a sample of 954 urban middle school pupils, found that SES was related to physical fitness only in girls. Finally, we observed that 15.1% of variance was explained by school effects. This might in part reflect the influence of school location, with pupils in schools located in areas of low deprivation recording higher levels of fitness compared with pupils in schools located in the highest deprived tertile.

Current levels of PA during secondary school PE lessons

Our findings show that pupils are not very active in PE classes, as not a single lesson achieved 30 min MVPA per hour of PE. The lesson average MVPA was only 23.8%, and sedentary time was 44.3%, and only 73 of 9483 pupils monitored achieved the 30 min MVPA threshold. Levels are well below the 40.5% identified in the meta-analysis by Hollis *et al*,[26] although this review covered nine countries including the UK, a mix of observational and objective data, and varied protocols and assumptions so is not fully representative of the UK position, unlike our study. An earlier review of British lessons reported this figure to be between 27% and 47%, and highlighted a large interindividual difference in MVPA levels across pupils.[47 48] The 'Fit to Study' pilot study (Delextrat, 2019) recorded an average figure of 30.7% MVPA when considering 'effective' PE time.[49]

It has been suggested that a pursuit of PA alone may result in teachers prioritising fitness-based activities, at the expense of enjoyment and developing physically literacy.[50] However, our observations during the summer curriculum was that fitness-based activities were not prioritised, and that fielding and striking games lessons, one of the least active lesson types, were most commonly observed. Some PE activities, particularly fitness, invasion games and track athletics, were the most active—though even for these more active lessons, only around 22%–28% of lesson time was spent in MVPA, and 8%–10% spent in VPA. Sedentary behaviour was less evident in invasion games and net/wall rackets games, with over 40% and 33% of pupils, respectively, exhibiting less than 20 min SPA per hour of PE in these activities.

We found no significant differences between boys, girls and mixed-sex lessons. This is in contrast to some past studies[51–54] that reported girls were more physically active in mixed-sex classes compared with girls-only classes, and that boys engage in more VPA and MVPA than girls[55–59] depending on the type of activity.[55 60–65] Our findings may be more robust as we were able to take account of school/class-level clustering. On the other hand, we did not aim to evenly sample mixed and single-sex lessons and so our sample is unbalanced in terms of lesson sex composition. Our results showed a significant interaction effect between activity type and sex of lessons for all intensity levels. For both boys' and mixed lessons, fitness recorded the highest levels of VPA and field athletics the lowest. For girls-only lessons, fitness recorded the lowest VPA levels, with track athletics the highest, and net/wall/racket games the highest levels in terms of MVPA.

We showed that pupils who 'strongly agreed' to enjoying PE were fitter than their counterparts, and that this relationship did not vary with sex (figure 2, online supplemental file 4). Further work would be required to confirm directionality, but looking at this result in isolation could indicate that PE should prioritise the joy of exercise and movement over high intensity. However, given the current low levels of intense activity we measured in PE, and the positive relationship between higher intensity and improved fitness, both aspects could be equally important and should be considered in future lesson planning.

Strengths and limitations

Our main strength was a large objectively measured sample which allowed for a hierarchical structure to the data analysis and better understanding of factors affecting PA in PE. The analysis was cross-sectional, and cannot determine cause and effect, and while effort was made to achieve a representative sample this may not have been achieved. Unfortunately, we were unable to explore the effect of individual pupil sex on PA levels during PE sessions, as pupils in PE lessons were not individually identified, and individual activity levels in PE could not be matched to other measures.

With our large sample size, all fully nested random structure models converged, with all fixed-effect terms of interest included. However, it should be noted that the dataset could have included a better representation (balance) of each subtype of independent variable in each class/school, and consequently the imbalance of observed number of PE activities might have introduced bias due to multiple comparisons and small power. However, this cannot be forced if the aim of the study is to examine current practices without intervening. A lack of a fully balanced dataset and the fact that we only recorded PA during one PE class per pupil should also be acknowledged as potential confounding factors.

We objectively measured PA and fitness which adds to previous understanding garnered via subjective means; adolescents often perceive themselves to be more physically active than they actually are,[66] which can provide misleading results. However, there is some indication in our sample that a higher number of eFSM boys and girls did not participate in the fitness test, raising the possibility that the sample is not fully representative. The positioning of accelerometers for measuring PA levels may affect activity recordings.[67] However, our methodology is in agreement with other large cohort studies, which derived similar parameters in the general population.[32] It is also possible that our choice of epoch times and cut-off points has influenced results,[60] and a researcher being present during testing in PE lessons might also have had an effect on teacher performance and pupil activity levels. Other factors that could influence PA levels were not recorded, for example, the state and size of school PE facilities and resources, including the number of PE staff, as well as the impact of weather conditions during testing that would have dictated location and choice of some activities.

Finally, we observed that pupils who were fitter were more likely to enjoy PE. While we were unable to explore enjoyment in relation to objective PA levels during PE (as we did not record pupil identity for accelerometry measures), it has previously been reported that pupils who report enjoying PE more engage in greater physical activity outside of school,[68] and are likely to be fitter as a consequence.

RECOMMENDATIONS

Considering that school for many young people is the main opportunity for being physically active, our results support the ideas expressed in the UK Government 2019 School Sport and Activity Action Plan,[69] that PE lessons cannot bear the whole burden of delivering PA and fitness. However, we suggest that if teachers are attempting to deliver more active PE, we recommend they take into consideration activity choice and the impact of sex composition of classes. We suggest that regardless of location, invasion games, track athletics and fitness lessons will provide an opportunity for higher levels of VPA, and that teachers may wish to include fitness infusions during less active lessons such as field athletics, or when teaching 'skills' is a focus of the lesson, as there is evidence that short bouts of VPA can improve adolescent fitness.[70 71]

If increasing CRF levels of pupils is also an objective, then teachers should consider enjoyment of PE alongside introducing more highly intense activities. The inter-relationship should be examined in interventional studies. It may be that additional fitness sessions need to be introduced in schools in order to address the health and well-being needs of young people.

Finally, and supporting past recommendations,[31 72] the monitoring of PA levels in PE and the fitness of all pupils, especially the least fit children in deprived areas, should be considered as part of any future activity action plan or exercise intervention in schools.

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REFERENCES

1 Sandercock G, Voss C, Cohen D, *et al*. Centile curves and normative values for the twenty metre shuttle-run test in English schoolchildren. *J Sports Sci* 2012;30:679–87.
2 Marques A, Santos DA, Hillman CH, *et al*. How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6-18 years. *Br J Sports Med* 2018;52:1039.
3 Santana CCA, Azevedo LB, Cattuzzo MT, *et al*. Physical fitness and academic performance in youth: a systematic review. *Scand J Med Sci Sports* 2017;27:579–603.
4 Chaddock-Heyman L, Erickson KI, Kienzler C, *et al*. The role of aerobic fitness in cortical thickness and mathematics achievement in preadolescent children. *PLoS One* 2015;10:e0134115.
5 Jose KA, Blizzard L, Dwyer T, *et al*. Childhood and adolescent predictors of leisure time physical activity during the transition from adolescence to adulthood: a population based cohort study. *Int J Behav Nutr Phys Act* 2011;8:54.
6 Aberg MAI, Pedersen NL, Torén K, *et al*. Cardiovascular fitness is associated with cognition in young adulthood. *Proc Natl Acad Sci U S A* 2009;106:20906–11.
7 Stratton G, Canoy D, Boddy LM, *et al*. Cardiorespiratory fitness and body mass index of 9-11-year-old English children: a serial cross-sectional study from 1998 to 2004. *Int J Obes* 2007;31:1172–8.
8 Tomkinson GR, Léger LA, Olds TS, *et al*. Secular trends in the performance of children and adolescents (1980-2000): an analysis of 55 studies of the 20m shuttle run test in 11 countries. *Sports Med* 2003;33:285–300.
9 Moraes Ferrari GLde, Bracco MM, Matsudo VKR, *et al*. Cardiorespiratory fitness and nutritional status of schoolchildren: 30-year evolution. *J Pediatr* 2013;89:366–73.
10 Sandercock GRH, Ogunleye A, Voss C. Six-Year changes in body mass index and cardiorespiratory fitness of English schoolchildren from an affluent area. *Int J Obes* 2015;39:1504–7.
11 Rankinen T, Roth SM, Bray MS, *et al*. Advances in exercise, fitness, and performance genomics. *Med Sci Sports Exerc* 2010;42:835–46.
12 Ruiz JR, Ortega FB, Martínez-Gómez D, *et al*. Objectively measured physical activity and sedentary time in European adolescents: the Helena study. *Am J Epidemiol* 2011;174:173–84.
13 Farooq MA, Parkinson KN, Adamson AJ, *et al*. Timing of the decline in physical activity in childhood and adolescence: Gateshead millennium cohort study. *Br J Sports Med* 2018;52:1002–6.
14 Reilly JJ. When does it all go wrong? Longitudinal studies of changes in moderate-to-vigorous-intensity physical activity across childhood and adolescence. *J Exerc Sci Fit* 2016;14:1–6.
15 Haapala HL, Hirvensalo MH, Kulmala J, *et al*. Changes in physical activity and sedentary time in the Finnish schools on the move program: a quasi-experimental study. *Scand J Med Sci Sports* 2017;27:1442–53.
16 Hankonen N, Heino MTJ, Araujo-Soares V, *et al*. 'Let's Move It' - a school-based multilevel intervention to increase physical activity and reduce sedentary behaviour among older adolescents in vocational secondary schools: a study protocol for a cluster-randomised trial. *BMC Public Health* 2016;16:451.
17 World Health Organisation. *Global recommendations on physical activity for health*. Geneva, Switzerland: World Health Organisation, 2011.
18 Department of Health and Social Care. *Uk chief medical officers' physical activity guidelines*. London: GOV.UK, 2019.
19 Sport England. *Active lives children and young people survey: academic year 2017/18*. London: Sport England, 2018.
20 Kriemler S, Meyer U, Martin E, *et al*. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of reviews and systematic update. *Br J Sports Med* 2011;45:923–30.
21 Department of Health and Social Care. CMO's annual report 2012: Our Children Deserve Better: CMO's Summary as a web page. GOV.UK, 2013. Available: https://tinyurl.com/ouf27uw/ [Accessed 7 April 2020].
22 Foster D, Roberts N. *Briefing Paper 6836 - Physical education, physical activity and sport in schools*. London: House of Commons Library, 2019.
23 OFSTED. *Beyond 2012: outstanding physical education for all - physical education in schools 2008-12*. London: GOV.UK, 2013.
24 Department for Education. National curriculum in England: PE programmes of study. *London::GOV.UK* 2013.
25 Harris J. *Health position paper*. UK: Association for Physical Education, 2015.
26 Hollis JL, Sutherland R, Williams AJ, *et al*. A systematic review and meta-analysis of moderate-to-vigorous physical activity levels in secondary school physical education lessons. *Int J Behav Nutr Phys Act* 2017;14:52.
27 Tanaka C, Tanaka M, Tanaka S. Objectively evaluated physical activity and sedentary time in primary school children by gender, grade and types of physical education lessons. *BMC Public Health* 2018;18:948.
28 Zhou Y, Wang L. Correlates of physical activity of students in secondary school physical education: a systematic review of literature. *Biomed Res Int* 2019;2019:1–12.
29 Wassenaar TM, Wheatley CM, Beale N, *et al*. Effects of a programme of vigorous physical activity during secondary school physical education on academic performance, fitness, cognition, mental health and the brain of adolescents (fit to study): study protocol for a cluster-randomised trial. *Trials* 2019;20:189.
30 Léger LA, Mercier D, Gadoury C, *et al*. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci* 1988;6:93–101.
31 Tomkinson GR, Lang JJ, Tremblay MS, *et al*. International normative 20 m shuttle run values from 1 142 026 children and youth representing 50 countries. *Br J Sports Med* 2017;51:1545–54.
32 Doherty A, Jackson D, Hammerla N, *et al*. Large scale population assessment of physical activity using wrist worn Accelerometers: the UK Biobank study. *PLoS One* 2017;12:e0169649.
33 S-Cool, the revision website. GCSE Classification of Sport - Sports Families. Available: https://www.s-cool.co.uk/gcse/pe/classification-of-sport/revise-it/sports-families/ [Accessed 24 Sept 2019].
34 Bailey RC, Olson J, Pepper SL, *et al*. The level and tempo of children's physical activities: an observational study. *Med Sci Sports Exerc* 1995;27:1033–41.
35 Rowlands A, Powell S, Humphries R. The effect of Accelerometer epoch on physical activity output measures. *J Exerc Sci Fit* 2006;4:52–8.
36 Stone MR, Rowlands AV, Eston RG. Relationships between accelerometer-assessed physical activity and health in children: impact of the activity-intensity classification method. *J Sports Sci Med* 2009;8:136–43.
37 Aibar A, Chanal J, Julien C. Physical education: the effect of epoch lengths on children's physical activity in a structured context. *PLoS One* 2015;10:e0121238.
38 de Almeida Mendes M, da Silva ICM, Ramires VV, *et al*. Calibration of raw accelerometer data to measure physical activity: a systematic review. *Gait Posture* 2018;61:98–110.

39 Phillips LRS, Parfitt G, Rowlands AV. Calibration of the GENEA accelerometer for assessment of physical activity intensity in children. *J Sci Med Sport* 2013;16:124–8.
40 Prochaska J, Sallis J, Slymen D. A longitudinal study of children's enjoyment of physical education. *Pediatr Exerc Sci* 2003;15:170–8.
41 Francis J, Eccles MP, Johnston M. *Constructing questionnaires based on the theory of planned behaviour: A manual for health services researchers*. Newcastle upon Tyne, UK: City Research Online, 2004.
42 de Leeuw JR. jsPsych: a JavaScript library for creating behavioral experiments in a web browser. *Behav Res Methods* 2015;47:1–12.
43 R Core Team. R: a language and environment for statistical computing. R foundation for statistical computing, 2019. Available: https://www.R-project.org/ [Accessed 20 September 2019].
44 Office for National Statistics. National statistics: English indices of deprivation 2015. Available: https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015/ [Accessed 26 Sept 2019].
45 Sandercock GRH, Cohen DD. Temporal trends in muscular fitness of English 10-year-olds 1998-2014: an allometric approach. *J Sci Med Sport* 2019;22:201–5.
46 Bohr AD, Brown DD, Laurson KR, *et al*. Relationship between socioeconomic status and physical fitness in junior high school students. *J Sch Health* 2013;83:542–7.
47 Fairclough S, Gareth S. Physical activity levels in middle and high school physical education: a review. *Pediatr Exerc Sci* 2005;17:217–36.
48 Fairclough S. Physical activity levels during key stage 3 physical education. *J Teach Phys Educ* 2003;34:40–5.
49 Delextrat A, Esser P, Beale N, *et al*. Effects of gender, activity type, class location and class composition on physical activity levels experienced during physical education classes in British secondary schools: a pilot cross-sectional study. *BMC Public Health* 2020;20:1590.
50 Hobbs M, Daly-Smith A, McKenna J, *et al*. Reconsidering current objectives for physical activity within physical education. *Br J Sports Med* 2018;52:1229–30.
51 Chow BC, McKenzie TL, Louie L. Physical activity and environmental influences during secondary school physical education. *J Teach Phys Educ* 2009;28:21–37.
52 Hannon J, Ratliffe T. Physical activity levels in Coeducational and Single-Gender high school physical education settings. *J Teach Phys Educ* 2005;24:149–64.
53 Dudley DA, Okely AD, Cotton WG, *et al*. Physical activity levels and movement skill instruction in secondary school physical education. *J Sci Med Sport* 2012;15:231–7.
54 McKenzie TL, Catellier DJ, Conway T, *et al*. Girls' activity levels and lesson contexts in middle school PE: TAAG baseline. *Med Sci Sports Exerc* 2006;38:1229–35.
55 Fairclough S, Stratton G. 'Physical education makes you fit and healthy'. Physical education's contribution to young people's physical activity levels. *Health Educ Res* 2005;20:14–23.
56 Ferreira FS, Mota J, Duarte JA. Patterns of physical activity in Portuguese adolescents. evaluation during physical education classes through Accelerometry. *Arch Exerc Health Dis* 2014;4:280–5.
57 Jago R, McMurray RG, Bassin S, *et al*. Modifying middle school physical education: piloting strategies to increase physical activity. *Pediatr Exerc Sci* 2009;21:171–85.
58 Scruggs PW, Mungen JD, Oh Y. Physical activity measurement device agreement: Pedometer Steps/Minute and physical activity time. *Meas Phys Educ Exerc Sci* 2010;14:151–63.
59 Scruggs PW, Mungen JD, Oh Y. Quantifying moderate to vigorous physical activity in high school physical education: a Pedometer Steps/Minute standard. *Meas Phys Educ Exerc Sci* 2010;14:104–15.
60 Fröberg A, Raustorp A, Pagels P, *et al*. Levels of physical activity during physical education lessons in Sweden. *Acta Paediatr* 2017;106:135–41.
61 Wang GY, Pereira B, Mota J. Indoor physical education measured by heart rate monitor. A case study in Portugal. *J Sports Med Phys Fitness* 2005;45:171–7.
62 Stratton G. Children's Heart Rates during British Physical Education Lessons. *J Teach Phys Educ* 1997;16:357–67.
63 Baquet G, Berthoin S, Gerbeaux M. Assessment of the maximal aerobic speed with the incremental running field tests in children. *Biol Sport* 1999;16:23–30.
64 Bronikowski M. Profiles of intensity loads in physical education classes in Poland. *Acta Gymnica* 2006;36:47–57.
65 Hodges-Kulinna P, Martin J, Lai Q. Student physical activity patterns: grade, gender, and activity influences. *J Teach Phys Educ* 2003;22:298–310.
66 Corder K, van Sluijs EMF, Goodyer I. Physical activity awareness of British adolescents. *Arch Pediatr Adolesc Med* 2011;165:603–9.
67 Mannini A, Intille SS, Rosenberger M, *et al*. Activity recognition using a single accelerometer placed at the wrist or ankle. *Med Sci Sports Exerc* 2013;45:2193–203.
68 Cox AE, Smith AL, Williams L. Change in physical education motivation and physical activity behavior during middle school. *J Adolesc Health* 2008;43:506–13.
69 Department for Education. School sport and activity action plan. *London::GOV.UK* 2019.
70 Costigan SA, Eather N, Plotnikoff RC, *et al*. High-Intensity interval training for cognitive and mental health in adolescents. *Med Sci Sports Exerc* 2016;48:1985–93.
71 Logan GRM, Harris N, Duncan S, *et al*. A review of adolescent high-intensity interval training. *Sports Med* 2014;44:1071–85.
72 Lang JJ, Tremblay MS, Léger L, *et al*. International variability in 20 m shuttle run performance in children and youth: who are the fittest from a 50-country comparison? A systematic literature review with pooling of aggregate results. *Br J Sports Med* 2018;52:1–13.

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SUPPLEMENTARY FILE 1: Fit-to-Study baseline demographic data

Table: Demographic Data for Schools/Pupils that participated in the 'Fit to Study' project and completed baseline assessments

		Full Baseline Dataset			Baseline Fitness Dataset			Baseline Questionnaire Dataset			Baseline PE Lesson Dataset
		Male	**Female**	**Total**	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**	
School Type (School Data)	Co-Ed	-	-	75	-	-	59	-	-	52	70 (206)
	Female	-	-	17	-	-	14	-	-	14	17 (42)
	Male	-	-	1	-	-	1	-	-	1	1 (1)
	Total (Classes)	-	-	93	-	-	74	-	-	67	88 (249)
School Type (Pupil Data)	Co-Ed	6993	6294	13287	4563	4167	8730	2955	2906	5861	8059
	Female	0	2667	2667	0	1911	1911	0	1589	1589	1408
	Male	63	0	63	56	0	56	35	0	35	16
	Total (%)	7056 (44)	8961 (56)	16017	4619 (43)	6078 (57)	10697	2990 (40)	4495 (60)	7485	9483
Free School Meals Eligible	No	5900	7452	13352	3913	5137	9050	2579	3835	6414	-
	Yes (%)	1156 (16.4)	1509 (16.8)	2665 (16.6)	706 (15.3)	941 (15.5)	1647 (15.4)	411 (13.7)	660 (14.7)	1071 (14.3)	-
Term Completed Test	Summer 2017	-	-	-	3795	5235	9030	-	-	-	-
	Autumn 2017	-	-	-	824	843	1667	-	-	-	-
PE Visits (No of lessons)	Summer 2017	-	-	-	-	-	-	-	-	-	100 (214)
	Autumn 2017	-	-	-	-	-	-	-	-	-	11 (35)
Questionnaire Completed	Term time	-	-	-	-	-	-	2,831	4,295	7,090	-
	Holidays	-	-	-	-	-	-	159	236	395	-
Age, Years (as at 1 Sept. 2017)	Mean (SD)	12.49 (0.29)	12.50 (0.30)	12.49 (0.29)	12.49 (0.29)	12.50 (0.30)	12.49 (0.30)	12.49 (0.29)	12.50 (0.29)	12.50 (0.29)	-
	Min-Max	11.76-13.88	11.60-14.66	11.60-14.66	12.00-13.88	12.00-14.66	12.00-14.66	12.00-13.73	12.00-13.96	12.00-13.96	-

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Table Notes

- PE lesson fitness test results were received from 74 schools, covering 10,697 / 12,534 pupils (85.3%).
- PE lesson physical activity data was collected in 88 schools, in June-July 2017 (100 visits) and September-October 2017 (11 visits). A total of 249 PE classes, and 9,483 pupils, were covered. This represented, on average, 60.5% of total pupils in the 88 schools. The aim was to capture at least 50% of the pupils in the year group, either through a single visit or multiple visits if necessary.
- Questionnaire data was received from 67 schools, covering 7,485 pupils (66.5% of total pupils in the 67 schools).
- The national average FSM % for 11 year old pupils in state funded secondary schools in 2018 was 14.2%[1]. The % for the fitness dataset is 15.4% compared to the whole study sample of 16.8%.

Fitness assessments were completed by 10,697 pupils (girls=57%; eFSM=15.4%) from 74 schools (59 co-educational, 15 single sex). The number of these pupils that also completed the online questionnaire was 7,485 (girls=60%; eFSM=14.3%) from 67 schools (52 co-educational, 15 single sex). Of these, 84.4% took the fitness test and 94.7% answered the questionnaire before the summer vacation. Mean age (SD) at the start of the school year was 12.5 (0.29) years. PA levels during PE were recorded in a total of 88 schools from 111 visits, covering 249 lessons and 9,483 pupils. Pupils were not identified individually, so PA levels could not be examined against fitness or questionnaire scores. 90.1% of visits (85.9% of lessons) were undertaken before the summer vacation.

REFERENCES

1. National Statistics: Schools, pupils and their characteristics: January 2019. Office for National Statistics. https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2019/ (accessed 24 Sept 2019).

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SUPPLEMENTARY FILE 2: Measures and data cleaning

Physical activity measurements were collected during PE lessons using the wrist-worn AX3 tri-axial accelerometer[1] designed by Open Lab, Newcastle University. The devices were worn on the non-dominant wrist and programmed to sample movement at a frequency of 100Hz. The dynamic range was set at +/- 8g. The raw accelerometry data was downloaded via the manufacturer's software (version AX-GUI-28), after which it was processed into physical activity 'counts' using a one second epoch[2-6] and based on established 'cut-points'[7], via a bespoke LabView programme (National Instruments, Ireland).

The classification of activities is an adaptation of the structure previously set out in the GCSE National Curriculum for Physical Education[8].

- Invasion Games (football, hockey, netball, basketball and rugby)
- Net/wall/racket games (tennis, badminton, table tennis, volleyball)
- Fielding/striking games (cricket, rounders, baseball and softball)
- Athletics (track, field)
- Fitness (circuits, fitness suite, gymnastics, trampolining, dance)
- Adventure (orienteering, other outdoor pursuits)
- Various (unknown or where there is a mix of activities within a lesson)

Data cleaning

Fitness

Baseline dataset (16,017 pupils) -> selected all pupils with a fitness test result (10,697 pupils). Given the large sample size, no outlier analysis was conducted. For fitness model 3, a girls-only dataset was used (6,078 pupils).

PE Enjoyment

Baseline dataset (16,017 pupils) -> selected all pupils with a fitness test result (10,697 pupils) -> selected all pupils with a questionnaire response, excluding outliers that were already tagged in the dataset (7,485 pupils).

Pupil PA during PE lessons

Baseline dataset (16,017 pupils) -> selected all pupils present in PE lessons visited, excluding those who had opted out of the study (9,693 pupils) -> excluded lessons where lesson type was unknown (9,483 pupils). For PE model 4, a location specific dataset (excluding lessons with a mix of location) was used (7,980 pupils).

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REFERENCES

1. Doherty A, Jackson D, Hammerla N, *et al*. Large Scale Population Assessment of Physical Activity Using Wrist Worn Accelerometers: The UK Biobank Study. *PLoS One* 2017;**12**:e0169649.

2. Bailey RC, Olson J, Pepper SL, *et al*. The level and tempo of children's physical activities: an observational study. *Med Sci Sports Exerc.* 1995;**27**:1033-41.

3. Rowlands A, Powell S, Humphries R, *et al*. The Effect of Accelerometer Epoch on Physical Activity Output Measures. *J Exerc Sci Fit.* 2006;**4**:52-58.

4. Stone M, Rowlands AV, Eston R. Relationships between accelerometer-assessed physical activity and health in children: impact of the activity-intensity classification method. *J Sports Sci Med.* 2009;**8**:136-43.

5. Aibar A, Julien C. Physical education: the effect of epoch lengths on children's physical activity in a structured context. *PLoS One* 2015;**10**:e0121238.

6. de Almeida Mendes M, da Silva ICM, Ramires VV, *et al*. Calibration of raw accelerometer data to measure physical activity: A systematic review. *Gait Posture* 2018;**61**:98-110.

7. Phillips LRS, Parfitt G, Rowlands AV. Calibration of the GENEA accelerometer for assessment of physical activity intensity in children. *J Sci Med Sport* 2013;**16:**124-8.

8. GCSE Classification of Sport - Sports Families. S-Cool, the revision website. https://www.s-cool.co.uk/gcse/pe/classification-of-sport/revise-it/sports-families/ (accessed 24 Sept 2019).

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SUPPLEMENTARY FILE 3: The Brain Imaging Sub-study

"The Effects of an In-school Physical Activity Intervention on Adolescents' Brain Structure and Function"

Physical activity has shown beneficial effects for cognitive and brain health, suggesting it might provide a highly scalable intervention to improve academic achievement. The sub-study was part of a large-scale randomised controlled trial called 'Fit to Study' (ClinicalTrials.gov ID: NCT03286725). The main 'Fit to Study' trial aimed to test the effect of a school-based physical activity intervention on academic performance (as well as cognition and physical measures) across Year8 pupils in 100 secondary schools. The 'Brain Imaging Sub-study' targeted a sub-sample of participants in the large-scale trial, in order to test pre- to post intervention changes in hippocampal volume, as well as cognitive performance, mental health, brain organisation and cardiorespiratory fitness.

Table: Demographic Data for Schools/Pupils that participated in the Brain imaging sub-study

		Sub-study Fitness Dataset		
		Male	**Female**	**Total**
School Type (Pupil data)	Co-Ed	30	29	59
	Female	0	1	1
	Male	0	0	0
	Total	30	30	*60
Free School Meals Eligible	No	29	30	59
	Yes	1	0	1
Age, Years (as at 1 Sept. 2017)	Mean (SD)	12.42 (0.28)	12.56 (0.45)	12.49 (0.38)
	Min-Max	12.05-12.95	12.01-14.52	12.01-14.52
Height (cm)	Mean (SD)	153.3 (5.6)	155.3 (7.0)	154.3 (6.4)
	Min-Max	142.0-164.0	140.0-166.0	140.0-166.0
Weight (kg)	Mean (SD)	46.1 (11.4)	46.6 (9.3)	46.4 (10.3)
	Min-Max	31.0-76.0	30.9-70.0	30.9-76.0
BMI (kgm-2)	Mean (SD)	19.65 (4.42)	19.09 (3.06)	19.38 (3.80)
	Min-Max	14.01-32.05	15.77-26.35	14.01-32.05
BMI z-score (entire sample)	Mean (SD)	,04 (1.17)	-,04 (.81)	,00 (1.00)
	Min-Max	-1.41-3.33	-,95-1.83	-1.41-3.33
MAP (mmHg)	Mean (SD)	82.8 (7.1)	84.2 (8.2)	83.5 (7.6)
	Min-Max	71.3-98.3	63.0-102.0	63.0-102.0

Notes

* 60 pupils from across 10 schools

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Table: VO2Max results from cardiopulmonary exercise tests (CPETs)

p = 0.018	**Male (n=30)**	**Female (n=30)**	**Overall (n=60)**
VO2Max (ml/min/kg)			
Mean (SD)	39.9 (9.41)	35.0 (6.09)	37.5 (8.25)

Reliability of fitness measure. Concurrent validity testing from CPET

To validate the shuttle run test, a sub-set of pupils (who were participating in a Brain Imaging Sub-study) undertook a cardiopulmonary exercise test to determine their maximal aerobic capacity. This involved a graded test[1, 2] on a cycle ergometer (Lode Excalibur Sport, Groningen, NL). The maximal oxygen uptake (VO2Max) per kilogram was the main dependent variable.

A Bland Altman plot of sub-study pupil fitness (VO2Max) and estimated VO2Max, calculated from the main study fitness data (shuttle run score) using the Leger conversion equation[3] was undertaken, to ascertain if the shuttle run test in schools is a good measure of recording fitness in this age group. Only one data point lied outside the 95% limits, indicating a reasonably accurate agreement between the measures, with a 9.7 (ml/kg/min) bias of overestimation of VO2Max from the shuttle run test.

Table: The results for Bland Altman Plot of the CPET test against the shuttle run test, with confidence intervals

		SE	**Lower**	**Upper**
Mean	9.7	0.901	7.832	11.487
SD	5.5			
Lower	-1.084	1.554	-4.236	2.068
Upper	20.403	1.554	17.251	23.555
n	37			
r	0.799		alpha	0.05

REFERENCES

1. Wassenaar TM, Wheatley CM, Beale N, *et al*. Effects of a programme of vigorous physical activity during secondary school physical education on academic performance, fitness, cognition, mental health and the brain of adolescents (Fit to Study): study protocol for a cluster-randomised trial. *Trials* 2019;**20**:189.

2. Godfrey S, Davies C. Estimates of arterial PCO2 and their effect on the calculated values of cardiac output and dead space on exercise. *Clin Sci.* 1970;**39**:529-37.

3. Leger L, Mercier D, Gadoury C, *et al*. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci.* 1988;**6**:93-101.

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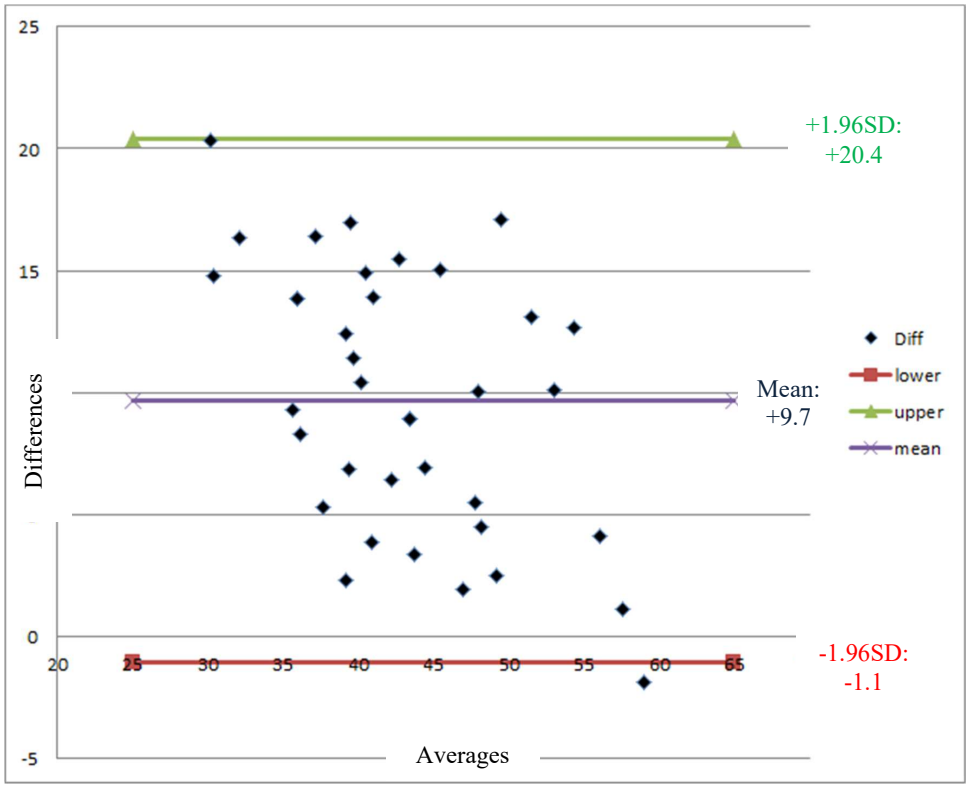

Figure: A Bland Altman Plot of the CPET (x axis) against the shuttle run test results

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SUPPLEMENTARY FILE 4: Multi-level model development

Details of model development and specifications, data transformations, and sensitivity analyses for A) Cardiorespiratory fitness (CRF), B) Physical activity (PA) in PE, and C) PE enjoyment.

Statistical analyses were performed in R[1], with lme4[2] using linear mixed effects (LME) analysis. A two-level structure was used for CRF, accounting for clustering at the school level (Level2), while a three-level structure was used for PA in PE classes, accounting for clustering at the school/class level (Level3/Level2). Schools and classes (nested within schools) were treated as having random effects. At the lowest level of the models (Level1), school-level and pupil-level variables, and interactions, were examined as fixed effects.

For all these analyses, data was transformed by the Yeo-Johnson method (VPA) and the orderNorm method (all other PA domains, fitness and PE enjoyment) using the bestNormalize function in R[3]. Pairwise comparisons for the fixed factors, where model estimates indicated significance, were examined as differences of Least Squares (LS) Means adjusted according to Tukey. For all these analyses, a P value inferior to 0.05 was considered statistically significant.

For PA in PE, models were developed for dependent variables SPA, VPA and MVPA, and 'effective' lessons only. Selecting 'effective' lesson data provided the best standardised measure as changing time varied from lesson to lesson, and also presented a 'best case' scenario in terms of PA levels in PE. The three PA domains were chosen because i) VPA more closely predicts CRF than lower intensity activity[4-7], and evidence suggests short bouts of VPA can deliver similar fitness benefits to longer moderate intensity efforts[8, 9], and there are currently no guidelines/recommendations for delivering VPA in PE, ii) MVPA has been, and remains, a focus for most PA research and health guidelines, and iii) reducing sedentary time during the school day is also a focus of research and PA interventions, and SPA has not previously been assessed in secondary school PE.

Development started with null models (intercept only) for the random effect term, and random intercept and fixed slope models were built up, adding group level predictors, and testing model fit improvement at each stage with reference to the Akaike Information Criterion (AIC).

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A) CRF

For CRF, we developed three separate models with fitness (cumulative 'bleep test' laps) as the outcome variable; the inclusion of predictor variables was determined by the research question being addressed. Model°1 was developed to determine how fitness varied i) between boys and girls, ii) with FSM status and iii) to determine the interaction effect of sex with FSM status. Model°2 was developed to explore how fitness varied between school location (based on the Index of Multiple Deprivation (IMD) Tertile[10] for postcode), and the interaction of school type (co-educational or single sex). Model°3 was developed to see if (for girls-only), fitness varied between school type. For all models, school location (based on Defra's Rural-Urban classification[11], school size (based on school year group pupil numbers), the term the fitness test was completed, and pupil age, were included as co-variates.

The main predictor variables used in the 'fitness' models were:

- Pupil sex (Male or Female)
- Pupil FSM status (Eligible for FSM: Yes or No)
- School type (Co-educational, Single Sex)
- School postcode IMD tertile (High, Medium, Low - based on the IMD Score)[10]
- The co-variates included in the 'fitness' models were:
- Term of test (Summer 2017 or Autumn 2017)
- Pupil age (as at 1 Sept 2017)
- School location (Urban Major Conurbation, Urban City and Town, Rural Town and Fringe)[11]
- School size (Small (<100pupils in year group), Medium (100-200 pupils), Large (200+ pupils)

The formulae for the three fitness models are presented below:

*Model 1 (Pupil Sex*Pupil FSM status- main effects and interaction)*
Model1<- **lmer(**NormFit$x.t ~ **Sex*FSM** + School.Sex.Type + Tertile + School.Location + SchoolSize + Age + Fitness.1.Term + **(1 + Sex|SchoolID)**, data=Fitness_T1a, REML=FALSE)

*Model 2 (School postcode IMD tertile*School Type- main effects and interaction)*
Model2 <- lmer(NormFit$x.t ~ **Tertile*School.Sex.Type** + Sex + FSM + School.Location + SchoolSize + Age + Fitness.1.Term + **(1 + Sex|SchoolID)**, data=Fitness_T1a, REML=FALSE)

Model 3 (School Type [Girls only dataset])
Model3 <- lmer(NormFit$x.t ~ **School.Sex.Type**+ FSM + Tertile + School.Location + SchoolSize + Age + Fitness.1.Term + **(1|SchoolID)**, data=Fitness_T1a_Girls, REML=FALSE)

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B) PA in PE

We developed four separate models with SPA, VPA, MVPA as the outcome variables; pupils were not identified individually. The inclusion of predictor variables was determined by the research question being addressed. Model°1 was developed to determine how the level of PA in PE lessons varied between school type, the interaction of school FSM status (the proportion of year group pupils eligible for FSM compared to the National average) and lesson type. Model°2 was developed to look at the main effect of activity group on PA levels in PE. Model°3 was developed to investigate the interaction effects of activity by lesson type by school type, however this was reduced to the best interaction according to AIC of activity by lesson type, as the three way interaction did not converge due to school type (single sex) being not represented in mixed classes. Model 4 was developed to explore the interaction of activity and PE Lesson location. The main predictor variables used in the 'PA in PE' models were:

- School type (Co-educational, Single Sex)
- SchoolFSM status (Above or Below National FSM average (all pupils))
- School postcode IMD tertile (High, Medium, Low - based on the IMD Score)[10]
- Lesson type (Boys-only, Girls-only, Mixed)
- Lesson location (Indoors, Outdoors, In/Out)
- Activity group (see Supplementary File 3)

The co-variates included in the 'PA in PE' models were:

- School location (Urban Major Conurbation, Urban City and Town, Rural Town and Fringe)[11]
- School size (Small (<100pupils in year group), Medium (100-200 pupils), Large (200+ pupils)
- Lesson length (<60mins, 60mins, >60mins)

The formulae for the four PE models are presented below:

*Model 1 (School Type + School FSM status*Lesson Type)*
Model1<- lmer(NormFit$x.t~ **SchoolFSM*LessonType + SchoolType** + school.location + Tertile + school.size + LessonLength + ActivityGroup + Location +**(1|SchoolID/LessonID)**, data=PE_Lesson_T1, REML=FALSE)

Model 2 (ActivityGroup)
Model2<- lmer(NormFit$x.t ~ **ActivityGroup**+ Location + LessonType + SchoolType + school.location + SchoolFSMNational + Tertile + school.size + LessonLength+ **(1|SchoolID/LessonID)**, data=PE_Lesson_T1, REML=F)

*Model 3 (ActivityGroup*LessonType)*
Model3<- lmer(NormFit$x.t ~ **ActivityGroup*LessonType**+ SchoolType + school.location + SchoolFSM + Tertile + school.size + LessonLength + Location + **(1|SchoolID/LessonID)**, data=PE_Lesson_T1, REML=F)

*Model 4 (ActivityGroup*Location of PE lesson)*
Model4<- lmer(NormFit$x.t ~ **ActivityGroup*Location**+ LessonType + SchoolType + school.location + SchoolFSMNational + Tertile + school.size + LessonLength+ **(1|SchoolID/LessonID)**, data=PE_Lesson_L3, REML=F)

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C) PE Enjoyment

A multi-level model was used to investigate the effect of PE enjoyment on fitness according to sex.

Table 1: The number of responses, and mean fitness, by PE enjoyment factor

				Fitness (cumulative laps)		
				Mean (SD)	Median	[Min, Max]
PE Enjoyment	**One**	Male	(n=71)	27.8 (16.1)	25.0	[2, 98]
		Female	(n=161)	22.7 (12.0)	20.0	[5, 66]
	Two	Male	(n=48)	26.8 (15.6)	23.5	[3, 73]
		Female	(n=132)	22.6 (9.19)	20.5	[7, 52]
	Three	Male	(n=68)	31.4 (15.8)	27.0	[8, 77]
		Female	(n=224)	23.5 (10.2)	23.0	[4, 67]
	Four	Male	(n=202)	30.4 (17.2)	26.5	[0, 125]
		Female	(n=506)	25.5 (11.5)	24.0	[3, 75]
	Five	Male	(n=189)	31.7 (16.7)	29.0	[7, 103]
		Female	(n=536)	28.4 (13.8)	25.0	[1, 109]
	Six	Male	(n=640)	38.1 (20.4)	35.0	[0, 120]
		Female	(n=1236)	32.5 (14.9)	30.0	[7, 98]
	Seven	Male	(n=1772)	48.5 (23.2)	46.0	[0, 137]
		Female	(n=1700)	38.6 (17.4)	36.0	[5, 99]
	Overall	Male	(n=2990)	42.8 (22.7)	39.0	[0, 137]
		Female	(n=4495)	32.4 (16.1)	29.0	[1, 109]

Table 2: Summary of fitness~PE enjoyment model estimates, CIs and p-values

Model 1 estimate [a]	**ß**	**95% CI**
(Intercept)	-2.65***	-3.57 – -1.73
Enjoy PE[b] [Two]	-0.18	-0.49 – 0.13
Enjoy PE [Three]	0.21	-0.07 – 0.49
Enjoy PE [Four]	0.22	-0.01 – 0.45
Enjoy PE [Five]	0.26*	0.03 – 0.49
Enjoy PE [Six]	0.56***	0.36 – 0.77
Enjoy PE [Seven]	1.03***	0.83 – 1.23
Sex[c] [Female]	-0.28*	-0.52 – -0.04
Enjoy PE [Two] * Sex [Female]	0.23	-0.14 – 0.60
Enjoy PE [Three] * Sex [Female]	-0.16	-0.49 – 0.17
Enjoy PE [Four] * Sex [Female]	-0.02	-0.29 – 0.25
Enjoy PE [Five] * Sex [Female]	0.10	-0.18 – 0.37
Enjoy PE [Six] * Sex [Female]	0.01	-0.24 – 0.26
Enjoy PE [Seven] * Sex [Female]	-0.14	-0.39 – 0.10

[a] Fully-adjusted model including age, eFSM, term of test, and school effects; fitness scores are orderNorm transformed
[b] Reference category: Enjoy PE [One]
[c] Reference category: Male
*** p<.001; ** p<.0125; * p <.05

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REFERENCES

1. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing. 2019.https://www.R-project.org/ (accessed 20 September 2019).

2. Bates D, Mächler M, Bolker B, *et al*. Fitting Linear Mixed-Effects Models Using lme4. *J Stat Softw.* 2015;**67:**1-48

3. Peterson RA, Cavanaugh JE. Ordered quantile normalization: a semiparametric transformation built for the cross-validation era. *J Appl Stat*. 2019;**47**:1-16.

4. Aires L, Silva P, Silva G, *et al*. Intensity of physical activity, cardiorespiratory fitness, and body mass index in youth. *J Phys Act Health* 2010;**7**:54-9.

5. Dencker M, Thorsson O, Karlsson MK, *et al*. Daily physical activity related to aerobic fitness and body fat in an urban sample of children. *Scand J Med Sci Sports* 2008;**18**:728-35.

6. Denton SJ, Trenell MI, Plötz T, *et al*. Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10-14 year old schoolchildren: the HAPPY study. *PLoS One* 2013;**8**:e61073.

7. Gutin B, Yin Z, Humphries MC, *et al*. Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. *Am J Clin Nutr.* 2005;**81**:746-50.

8. Costigan SA, Eather N, Plotnikoff RC, *et al*. High-Intensity Interval Training for Cognitive and Mental Health in Adolescents. *Med Sci Sports Exerc.* 2016;**48**:1985-93.

9. Logan GRM, Nigel H, Scott D, *et al*. A review of adolescent high-intensity interval training. *Sports Med.* 2014;**44**:1071-85.

10. National Statistics: English indices of deprivation 2015. Office for National Statistics. https://www.gov.uk/government/statistics/english-indices-of-deprivation-2015/ (accessed 26 Sept 2019).

11. The 2011 Rural-Urban Classification for Output Areas in England. Office for National Statistics.https://www.ons.gov.uk/methodology/geography/geographicalproducts/ruralurbanclassifications/2011ruralurbanclassification/ (accessed 3 Oct 2019).

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SUPPLEMENTARY FILE 5: Demographic data by school variables and lesson length – tables (PA in PE)

Table: (**School-level**) demographic data by school variables, and lesson length

	Lessons Visited (% by column)	School Type: Co-educational	Single Sex	Total
School Size	Small	8 (11.4)	4 (22.2)	12 (13.6)
	Medium	42 (60.0)	10 (55.6)	52 (59.1)
	Large	20 (28.6)	4 (22.2)	24 (27.3)
School FSM	Above Average	40 (51.7)	10 (55.6)	50 (56.8)
	Below Average	30 (42.9)	8 (44.4)	38 (43.2)
IMD Tertile	High	24 (34.3)	7 (38.9)	31 (35.2)
	Medium	17 (24.3)	6 (33.3)	23 (26.1)
	Low	29 (41.4)	5 (27.8)	34 (38.6)
Lesson Length	<60 mins	6 (8.6)	3 (16.7)	9 (10.2)
	60 mins	42 (60.0)	8 (44.4)	50 (56.8)
	>60 mins	22 (31.4)	7 (38.9)	29 (33.0)
	Total School	**70**	**18**	**88**

Table: (**Lesson-level**) demographic data by school variables, and lesson length

	Lessons Visited (% by column)	School Type: Co-educational	Single Sex	Total
Activity Group	Invasion games	31 (15.0)	6 (14.0)	37(14.9)
	Net/wall/racket games	14 (6.8)	2 (4.7)	16 (6.4)
	Fielding/striking games	76 (36.9)	11 (25.6)	87 (34.9)
	Athletics	7 (3.4)	5 (11.6)	12 (4.8)
	Fitness	14 (6.8)	2 (4.7)	16 (6.4)
	Adventure/Games	3 (1.5)	1 (2.3)	4 (1.6)
	Various	43 (20.9)	13 (30.2)	56 (22.5)
	Athletics-Field	10 (4.9)	3 (7.0)	13 (5.2)
	Athletics-Track	8 (3.9)	0	8 (3.2)
Lesson Location	Indoors	40 (19.4)	9 (20.9)	49 (19.7)
	Outdoors	149 (72.3)	28 (65.1)	177 (71.1)
	In/Out	17 (8.3)	6 (14.0)	23 (9.2)
Lesson Type	Girls	18 (8.7)	42 (97.7)	60 (24.1)
	Boys	85 (41.3)	1 (2.3)	86 (34.5)
	Mixed	103 (50.0)		103 (41.4)
Lesson Length	<60 mins	18 (8.7)	9 (20.9)	27 (10.8)
	60 mins	119 (57.8)	19 (44.2)	138 (55.4)
	>60 mins	69 (33.5)	15 (34.9)	84 (33.7)
IMD Tertile	High	69 (33.5)	13 (30.2)	82 (32.9)
	Medium	45 (21.8)	17 (39.5)	62 (24.9)
	Low	92 (44.7)	13 (30.2)	105 (42.2)
	Total Lessons	**206**	**43**	**249**

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Table: Length of lesson (timetabled versus 'effective' PE time)

Under 60mins (n=27)	60mins (n=138)	Above 60mins (n=84)	Overall (n=249)
Timetabled Lesson Length (minutes)	**Average of 'effective' PE time (minutes)**	**% of Lesson 'effective' time**	
45	32.8	72.9%	
50	33.6	67.2%	
55	44.0	80.0%	
60	43.4	72.4%	
65	50.5	77.7%	
75	58.0	77.3%	
80	50.4	63.0%	
90	82.2	91.3%	
100	74.9	74.9%	
105	89.7	85.4%	
110	97.1	88.2%	
120	92.9	77.4%	

The above tables show fielding/striking games were by far the most prevalent (34.9% of lessons) followed by invasion games (14.9%) and athletics (13.2%). 6.4% of lessons visited were 'fitness'. The majority of lessons (71.1%) were conducted outdoors. In co-educational schools, 50.0% of lessons visited were 'mixed' sex composition, compared to 8.7% for girls-only lessons. The balance of lesson visits to schools located across the postcode IMD tertile ratings were: high 35.2%, medium 26.1% and low 38.6%. 86.4% of schools contained more than 100 pupils in the year group, and 89.8% of timetabled lessons were 60 minutes and above.

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SUPPLEMENTARY FILE 6: Demographic data by school and lesson variables – tables (PA in PE)

Tables: (**Lesson-level**) demographic data by school and lesson variables

No. of Lessons	School Type		Tertile			Lesson Location			
ActivityGroup	Co-Ed (n=206)	Single Sex (n=43)	High (n=82)	Medium (n=62)	Low (n=105)	Indoors (n=49)	Outdoors (n=177)	In/Out (n=23)	Overall (n=249)
Invasion Games	31 (15.0%)	6 (14.0%)	13 (15.9%)	15 (24.2%)	9 (8.6%)	9 (18.4%)	28 (15.8%)	0 (0%)	37 (14.9%)
Net/wall/racket games	14 (6.8%)	2 (4.7%)	4 (4.9%)	1 (1.6%)	11 (10.5%)	6 (12.2%)	10 (5.6%)	0 (0%)	16 (6.4%)
Fielding/striking games	76 (36.9%)	11 (25.6%)	25 (30.5%)	25 (40.3%)	37 (35.2%)	9 (18.4%)	76 (42.9%)	2 (8.7%)	87 (34.9%)
Athletics	7 (3.4%)	5 (11.6%)	2 (2.4%)	5 (8.1%)	5 (4.8%)	0 (0%)	12 (6.8%)	0 (0%)	12 (4.8%)
Fitness	14 (6.8%)	2 (4.7%)	4 (4.9%)	0 (0%)	12 (11.4%)	15 (30.6%)	1 (0.6%)	0 (0%)	16 (6.4%)
Adventure/Games	3 (1.5%)	1 (2.3%)	1 (1.2%)	0 (0%)	3 (2.9%)	2 (4.1%)	2 (1.1%)	0 (0%)	4 (1.6%)
Various	43 (20.9%)	13 (30.2%)	19 (23.2%)	14 (22.6%)	23 (21.9%)	4 (8.2%)	31 (17.5%)	21 (91.3%)	56 (22.5%)
Athletics-Field	10 (4.9%)	3 (7.0%)	10 (12.2%)	1 (1.6%)	2 (1.9%)	4 (8.2%)	9 (5.1%)	0 (0%)	13 (5.2%)
Athletics-Track	8 (3.9%)	0 (0%)	4 (4.9%)	1 (1.6%)	3 (2.9%)	0 (0%)	8 (4.5%)	0 (0%)	8 (3.2%)

No. of Lessons	Lesson Type			
ActivityGroup	Girls (n=60)	Boys (n=86)	Mixed (n=103)	Overall (n=249)
Invasion Games	13 (21.7%)	19 (22.1%)	5 (4.9%)	37 (14.9%)
Net/wall/racket games	3 (5.0%)	8 (9.3%)	5 (4.9%)	16 (6.4%)
Fielding/striking games	17 (28.3%)	37 (43.0%)	33 (32.0%)	87 (34.9%)
Athletics	5 (8.3%)	4 (4.7%)	3 (2.9%)	12 (4.8%)
Fitness	4 (6.7%)	8 (9.3%)	4 (3.9%)	16 (6.4%)
Adventure/Games	1 (1.7%)	2 (2.3%)	1 (1.0%)	4 (1.6%)
Various	14 (23.3%)	1 (1.2%)	41 (39.8%)	56 (22.5%)
Athletics-Field	3 (5.0%)	5 (5.8%)	5 (4.9%)	13 (5.2%)
Athletics-Track	0 (0%)	2 (2.3%)	6 (5.8%)	8 (3.2%)

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Tables: (**Pupil-level**) demographic data by school and lesson variables

No. of Pupils	School Type		Tertile			Lesson Location			
ActivityGroup	**Co-Ed (n=8059)**	**Single Sex (n=1424)**	**High (n=2769)**	**Medium (n=2150)**	**Low (n=4564)**	**Indoors (n=1565)**	**Outdoors (n=6415)**	**In/Out (n=1503)**	**Overall (n=9483)**
Invasion Games	920 (11.4%)	165 (11.6%)	351 (12.7%)	400 (18.6%)	334 (7.3%)	322 (20.6%)	763 (11.9%)	0 (0%)	1085 (11.4%)
Net/wall/racket games	347 (4.3%)	47 (3.3%)	108 (3.9%)	27 (1.3%)	259 (5.7%)	145 (9.3%)	249 (3.9%)	0 (0%)	394 (4.2%)
Fielding/striking games	2539 (31.5%)	373 (26.2%)	738 (26.7%)	696 (32.4%)	1478 (32.4%)	348 (22.2%)	2453 (38.2%)	111 (7.4%)	2912 (30.7%)
Athletics	219 (2.7%)	110 (7.7%)	73 (2.6%)	110 (5.1%)	146 (3.2%)	0 (0%)	329 (5.1%)	0 (0%)	329 (3.5%)
Fitness	458 (5.7%)	43 (3.0%)	106 (3.8%)	0 (0%)	395 (8.7%)	468 (29.9%)	33 (0.5%)	0 (0%)	501 (5.3%)
Adventure/Games	96 (1.2%)	16 (1.1%)	16 (0.6%)	0 (0%)	96 (2.1%)	47 (3.0%)	65 (1.0%)	0 (0%)	112 (1.2%)
Various	2977 (36.9%)	586 (41.2%)	1037 (37.5%)	881 (41.0%)	1645 (36.0%)	160 (10.2%)	2011 (31.3%)	1392 (92.6%)	3563 (37.6%)
Athletics-Field	228 (2.8%)	84 (5.9%)	220 (7.9%)	20 (0.9%)	72 (1.6%)	75 (4.8%)	237 (3.7%)	0 (0%)	312 (3.3%)
Athletics-Track	275 (3.4%)	0 (0%)	120 (4.3%)	16 (0.7%)	139 (3.0%)	0 (0%)	275 (4.3%)	0 (0%)	275 (2.9%)

No. of Pupils	Lesson Type			
ActivityGroup	**Girls (n=1961)**	**Boys (n=2446)**	**Mixed (n=5076)**	**Overall (n=9483)**
Invasion Games	328 (16.7%)	621 (25.4%)	136 (2.7%)	1085 (11.4%)
Net/wall/racket games	73 (3.7%)	191 (7.8%)	130 (2.6%)	394 (4.2%)
Fielding/striking games	601 (30.6%)	1058 (43.3%)	1253 (24.7%)	2912 (30.7%)
Athletics	110 (5.6%)	105 (4.3%)	114 (2.2%)	329 (3.5%)
Fitness	88 (4.5%)	243 (9.9%)	170 (3.3%)	501 (5.3%)
Adventure/Games	16 (0.8%)	55 (2.2%)	41 (0.8%)	112 (1.2%)
Various	661 (33.7%)	20 (0.8%)	2882 (56.8%)	3563 (37.6%)
Athletics-Field	84 (4.3%)	93 (3.8%)	135 (2.7%)	312 (3.3%)
Athletics-Track	0 (0%)	60 (2.5%)	215 (4.2%)	275 (2.9%)

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SUPPLEMENTARY FILE 7: Fitness model estimates

Table: Summary of fitness model estimates, CIs and p-values

Model 1 estimate [a]	ß	95% CI
(Intercept)	-2.37***	-3.18 to -1.56
Female[b]	-0.48***	-0.56 to -0.39
eFSM[c]	-0.22***	-0.29 to -0.15
Female*eFSM	-0.01	-0.11 to 0.09

[a] Fully-adjusted model including age, term of test, and school effects; fitness scores are orderNorm transformed
[b] Reference category: male
[c] Reference category: not eligible for FSM
*** p<.001; ** p<.0125; * p <.05

Model 2 estimate [a]	ß	95% CI
(Intercept)	-2.34***	-3.16 to -1.52
Tertile-Low[b]	-0.40**	0.16 to 0.63
School Type (ST)[c]	-0.11	-0.48 to 0.26
Tertile-Medium*ST	0.27	-0.31 to 0.84
Tertile-Low*ST	-0.03	-0.55 to -0.49

[a] Fully-adjusted model including sex, FSM, age, term of test, and school effects; fitness scores are orderNorm transformed
[b] Reference category: High
[c] Reference category: Co-educational
*** p<.001; ** p<.0125; * p <.05

Model 3 estimate [a]	ß	95% CI
(Intercept)	-1.95***	-3.03 to -0.88
School Type[b]	-0.02	-0.30 to 0.26

[a] Fully-adjusted model including FSM, age, term of test, and school effects; fitness scores are orderNorm transformed
[b] Reference category: Co-educational
*** p<.001; ** p<.0125; * p <.05

Notes

*Fitness Model 1 (Pupil Sex*Pupil FSM status - main effects and interaction)* to determine how fitness varied i) between boys and girls, ii) with FSM status and iii) to determine the interaction effect of sex with FSM status on fitness.

*Fitness Model 2 (School postcode Index of Multiple Deprivation (IMD) Tertile*School Type - main effects and interaction) to* explore how fitness varied between school location (based on the IMD tertile), and the interaction of school type (co-educational or single sex).

Fitness Model 3 (School Type [Girls only]) was developed to see if, for girls-only, fitness varied between school type.

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SUPPLEMENTARY FILE 8: Pupil average time (%) for school/lesson variables - tables

Tables: (**Pupil-level**) pupil average time (%) in PE lessons split by PA domain, for school/lesson variables

	School Type		Tertile		
% of 1hr Lesson (SD)	**Co-Ed (n=8059)**	**Single Sex (n=1424)**	**High (n=2769)**	**Medium (n=2150)**	**Low (n=4564)**
PA Domains					
SPA	44.0 (13.3)	45.0 (13.0)	44.5 (14.3)	43.0 (12.2)	44.5 (13.1)
LPA	31.9 (7.77)	32.5 (7.13)	32.2 (7.82)	32.9 (7.23)	31.4 (7.76)
MPA	16.7 (6.46)	16.5 (6.54)	16.6 (6.72)	17.0 (6.07)	16.6 (6.49)
VPA	7.34 (4.55)	6.01 (3.72)	6.68 (4.56)	7.12 (4.09)	7.44 (4.54)
MVPA	24.1 (9.45)	22.5 (9.19)	23.3 (10.1)	24.1 (8.83)	24.1 (9.24)

	Lesson Type			
% of 1hr Lesson (SD)	**Girls (n=1961)**	**Boys (n=2446)**	**Mixed (n=5076)**	**Overall (n=9483)**
SPA	44.7 (12.7)	42.3 (13.2)	44.9 (13.4)	44.2 (13.3)
LPA	32.6 (7.09)	33.0 (7.71)	31.2 (7.81)	32.0 (7.68)
MPA	16.3 (6.36)	16.9 (6.32)	16.8 (6.57)	16.7 (6.47)
VPA	6.48 (3.97)	7.78 (4.50)	7.09 (4.58)	7.14 (4.46)
MVPA	22.7 (9.11)	24.7 (9.50)	23.9 (9.47)	23.8 (9.42)

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Tables: (**Lesson-level**) pupil average time (%) in PE lessons split by PA domain, for school/lesson variables

	School Type		Tertile		
% of 1hr Lesson (SD)	**Co-Ed (n=206)**	**Single Sex (n=43)**	**High (n=82)**	**Medium (n=62)**	**Low (n=105)**
PA Domains					
SPA	43.8 (8.96)	46.6 (8.46)	45.5 (10.3)	43.2 (8.34)	43.9 (8.02)
LPA	32.3 (4.56)	31.8 (3.74)	31.7 (4.65)	33.1 (4.20)	32.0 (4.34)
MPA	16.9 (4.25)	16.1 (4.41)	16.3 (4.47)	17.2 (4.11)	16.8 (4.22)
VPA	7.31 (3.05)	5.56 (2.11)	6.47 (2.94)	6.99 (2.87)	7.44 (3.05)
MVPA	24.2 (6.30)	21.6 (5.75)	22.7 (6.76)	24.2 (6.28)	24.2 (5.83)

	Lesson Type			
% of 1hr Lesson (SD)	**Girls (n=60)**	**Boys (n=86)**	**Mixed (n=103)**	**Overall (n=249)**
SPA	45.3 (8.61)	42.8 (9.31)	44.8 (8.70)	44.3 (8.93)
LPA	32.3 (3.63)	32.9 (4.78)	31.5 (4.47)	32.2 (4.43)
MPA	16.2 (4.37)	16.9 (4.47)	16.9 (4.07)	16.7 (4.28)
VPA	6.20 (2.61)	7.70 (3.19)	6.89 (2.91)	7.00 (2.98)
MVPA	22.4 (6.11)	24.6 (6.68)	23.8 (5.93)	23.7 (6.27)

SUPPLEMENTARY FILE 9: Pupil average time by activity group - tables and violin plots

Table. Pupil average time (mins/hr) of PA domains in PE lessons split by activity group

Time [mins/hr] (SD)	Invasion Games (n=1085)	Net/wall/racket games (n=394)	Fielding/striking games (n=2912)	Athletics (n=329)	Fitness (n=501)	Adventure/ Games (n=112)	Various (n=3563)	Athletics-Field (n=312)	Athletics-Track (n=275)	Overall (n=9483)
SPA	22.2 (7.64)	23.7 (8.30)	27.5 (7.15)	28.2 (5.74)	25.3 (6.85)	30.8 (12.2)	26.4 (8.00)	34.1 (8.72)	28.2 (6.75)	26.5 (7.97)
LPA	20.8 (4.62)	20.6 (4.42)	19.2 (4.01)	18.7 (4.08)	18.0 (4.83)	17.8 (6.88)	19.2 (4.72)	16.1 (5.17)	18.5 (4.77)	19.2 (4.61)
MPA	11.5 (3.79)	12.2 (4.67)	9.46 (3.50)	8.81 (2.62)	10.6 (4.29)	7.47 (3.66)	10.3 (3.89)	7.10 (3.31)	8.54 (3.15)	10.0 (3.88)
VPA	5.50 (3.29)	3.48 (2.23)	3.90 (2.16)	4.37 (2.11)	6.11 (3.77)	4.01 (3.06)	4.17 (2.49)	2.70 (1.91)	4.74 (3.29)	4.29 (2.68)
MVPA	17.0 (6.22)	15.7 (6.38)	13.4 (4.97)	13.2 (3.64)	16.7 (5.81)	11.5 (6.41)	14.4 (5.58)	9.80 (4.82)	13.3 (5.02)	14.3 (5.65)

Table. Pupil average % of PA domains in PE lessons split by activity group

% of Lesson (SD)	Invasion Games (n=1085)	Net/wall/racket games (n=394)	Fielding/striking games (n=2912)	Athletics (n=329)	Fitness (n=501)	Adventure/ Games (n=112)	Various (n=3563)	Athletics-Field (n=312)	Athletics-Track (n=275)	Overall (n=9483)
SPA	37.0 (12.7)	39.5 (13.8)	45.8 (11.9)	46.9 (9.56)	42.1 (11.4)	51.3 (20.4)	44.0 (13.3)	56.8 (14.5)	47.0 (11.3)	44.2 (13.3)
LPA	34.6 (7.69)	34.3 (7.37)	32.0 (6.68)	31.1 (6.80)	30.0 (8.05)	29.6 (11.5)	31.9 (7.87)	26.8 (8.62)	30.8 (7.96)	32.0 (7.68)
MPA	19.2 (6.31)	20.4 (7.79)	15.8 (5.83)	14.7 (4.37)	17.7 (7.15)	12.4 (6.10)	17.1 (6.48)	11.8 (5.52)	14.2 (5.25)	16.7 (6.47)
VPA	9.16 (5.49)	5.81 (3.72)	6.50 (3.60)	7.29 (3.51)	10.2 (6.29)	6.68 (5.10)	6.95 (4.15)	4.50 (3.19)	7.90 (5.48)	7.14 (4.46)
MVPA	28.4 (10.4)	26.2 (10.6)	22.3 (8.29)	22.0 (6.06)	27.9 (9.69)	19.1 (10.7)	24.0 (9.31)	16.3 (8.03)	22.1 (8.36)	23.8 (9.42)

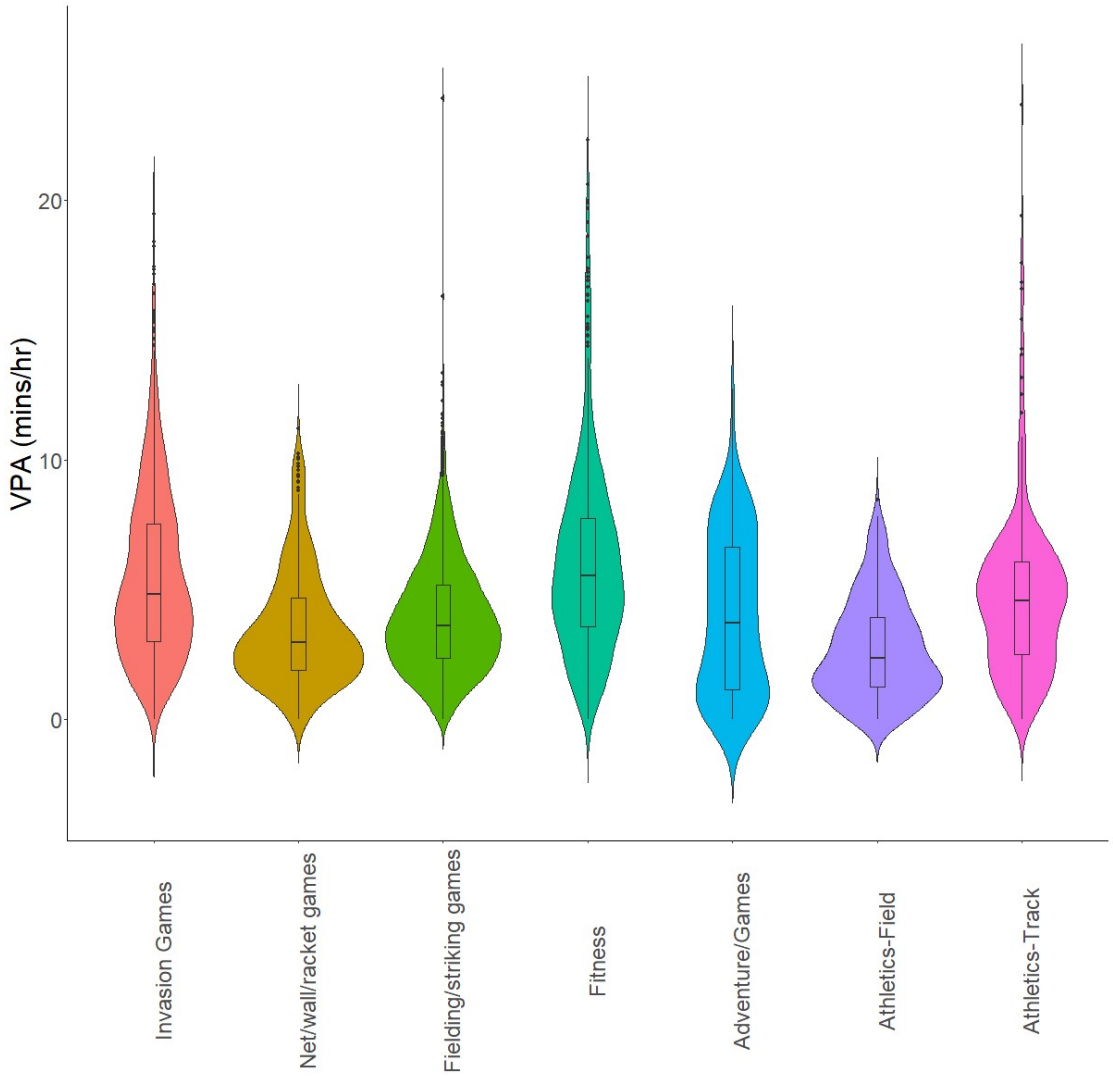

Figure: Violin plot of pupil average time (mins/hr) in PE lessons split by activity group for VPA

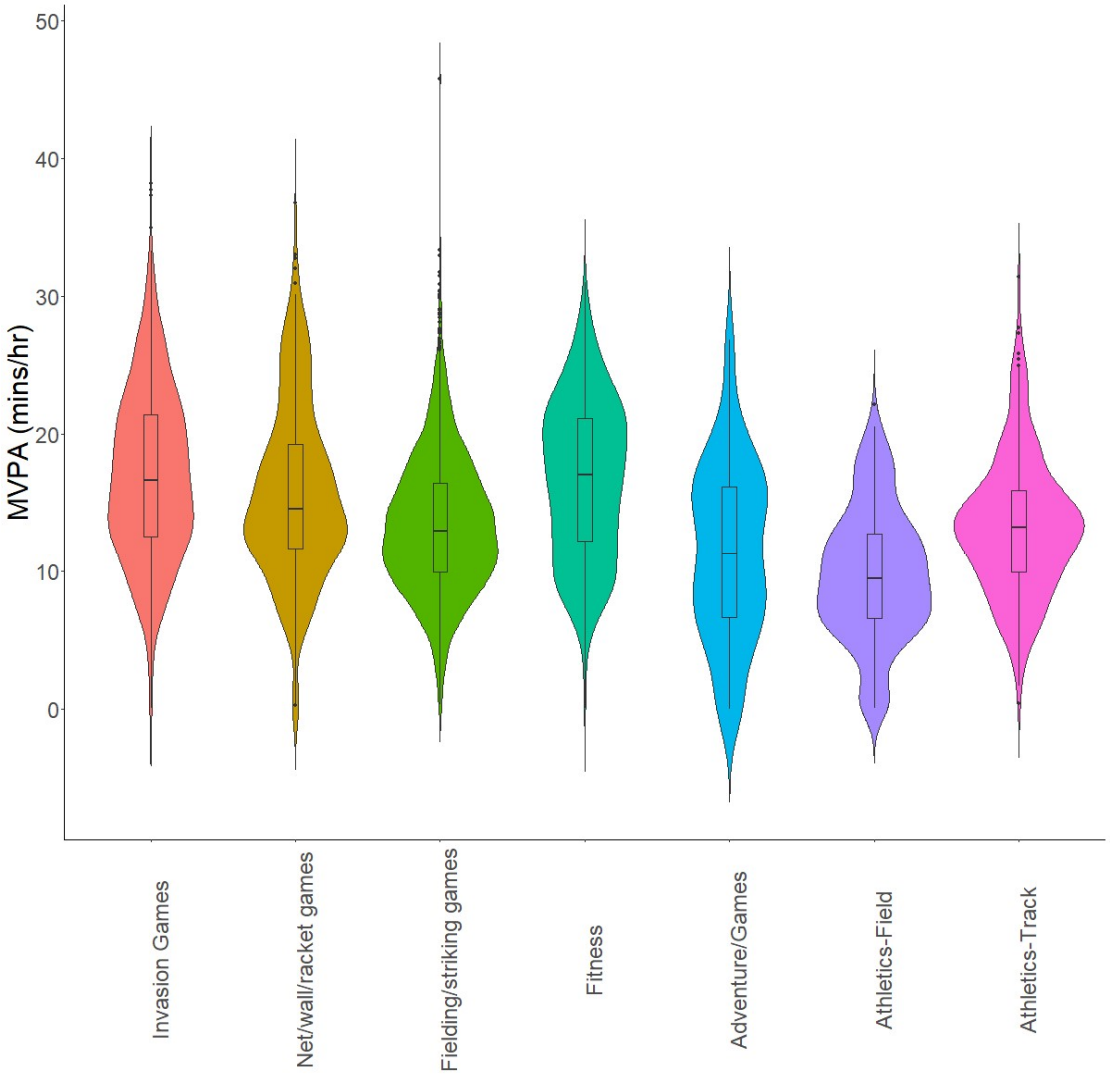

Figure: Violin plot of pupil average time (mins/hr) in PE lessons split by activity group for MVPA

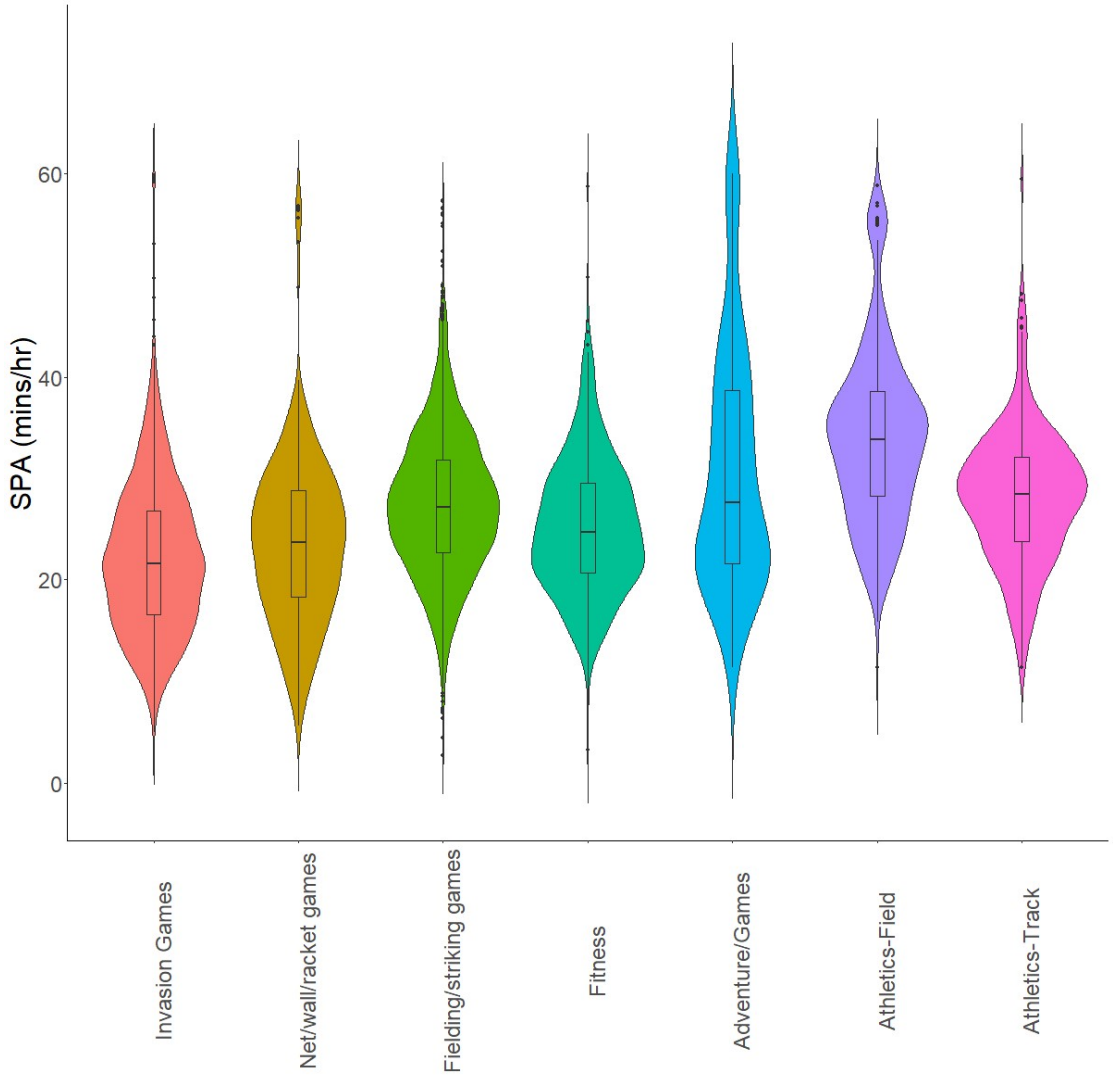

Figure: Violin plot of pupil average time (mins/hr) in PE lessons split by activity group for SPA

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SUPPLEMENTARY FILE 10: PA in PE model estimates

Tables: Summary of PA in PE model estimates, CIs and p-values

	VPA		MVPA		SPA	
Table 1 | Model 1 estimate [a]	**ß**	**95% CI**	**ß**	**95% CI**	**ß**	**95% CI**
(Intercept)	0.00	-0.61 to 0.62	0.04	-0.51 to 0.59	0.06	-0.47 to 0.59
School Type[b]	-0.18	-0.62 to 0.26	-0.02	-0.42 to 0.37	0.05	-0.33 to 0.43
School FSM[c]	-0.02	-0.42 to 0.39	0.02	-0.35 to 0.38	-0.02	-0.37 to 0.33
Lesson Type-Boys[d]	0.23	-0.24 to 0.71	0.25	-0.17 to 0.68	-0.21	-0.63 to 0.20
Lesson Type-Mixed[d]	-0.08	-0.54 to 0.39	0.10	-0.32 to 0.52	-0.01	-0.42 to 0.40
School FSM*Lesson Type-Boys	-0.15	-0.68 to 0.39	-0.15	-0.62 to 0.33	0.18	-0.28 to 0.64
School FSM*Lesson Type-Mixed	0.15	-0.37 to 0.67	0.04	-0.43 to 0.51	-0.00	-0.46 to 0.45

[a] Fully-adjusted model including lesson length, lesson location, activity and school effects; SPA/MVPA are orderNorm transformed; VPA are Yeo-Johnson transformed
[b] Reference category: Co-educational; [c] Reference category: Above average; [d] Reference category: Girls-only
*** p<.001; ** p<.0125; * p <.05

	VPA		MVPA		SPA	
Table 2 | Model 2 estimate [a]	**ß**	**95% CI**	**ß**	**95% CI**	**ß**	**95% CI**
(Intercept)	0.04	-0.56 to 0.64	0.08	-0.45 to 0.62	0.01	-0.51 to 0.53
Net/wall/racket games[b]	-0.38*	-0.68 to -0.07	-0.16	-0.46 to 0.13	0.10	-0.19 to 0.39
Fielding/striking games[b]	-0.49***	-0.74 to -0.24	-0.55***	-0.79 to -0.32	0.54***	0.31 to 0.77
Athletics	-0.09	-0.47 to 0.29	-0.45*	-0.81 to -0.08	0.58**	0.22 to 0.94
Fitness[b]	0.29	-0.06 to 0.63	0.22	-0.11 to 0.55	-0.18	-0.51 to 0.14
Adventure/Games[b]	-0.50	-1.06 to 0.06	-0.81**	-1.35 to -0.27	0.70**	0.17 to 1.24
Various	-0.40**	-0.71 to -0.09	-0.47**	-0.76 to -0.18	0.55***	0.26 to 0.83
Athletics-Field[b]	-0.81***	-1.23 to -0.39	-1.17***	-1.56 to -0.78	1.34***	0.95 to 1.72
Athletics-Track[b]	0.38*	0.01 to 0.74	0.02	-0.33 to 0.37	0.24	-0.10 to 0.58

[a] Fully-adjusted model including lesson length, lesson location, activity and school effects; SPA/MVPA are orderNorm transformed; VPA are Yeo-Johnson transformed.
[b] Reference category: Invasion games
*** p<.001; ** p<.0125; * p <.05
Significant differences observed for activity group; post-hoc analysis conducted – see Table 4.

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	VPA		MVPA		SPA	
Table 3 | Model 3 estimate [a]	**ß**	**95% CI**	**ß**	**95% CI**	**ß**	**95% CI**
(Intercept)	0.17	-0.40 to 0.74	0.19	-0.16 to 1.09	0.00	-0.54 to 0.54
Net/wall/racket games[b]	-0.10	-0.74 to 0.54	0.46	-1.04 to -0.22	-0.39	-1.02 to 0.25
Fielding/striking games[b]	-0.29	-0.72 to 0.13	-0.63**	-0.80 to 0.42	0.61**	0.19 to 1.03
Athletics[b]	0.15	-0.48 to 0.78	-0.19	-1.12 to -0.01	0.30	-0.32 to 0.92
Fitness[b]	-0.57*	-1.13 to -0.00	-0.57*	-1.77 to 0.30	0.10	-0.46 to 0.66
Adventure/Games[b]	-0.49	-1.55 to 0.56	-0.73	-0.74 to 0.14	0.46	-0.58 to 1.50
Various[b]	-0.14	-0.60 to 0.32	-0.30	-1.46 to -0.19	0.32	-0.13 to 0.77
Athletics-Field[b]	-0.30	-0.96 to 0.35	-0.82**	-0.44 to 0.53	1.07***	0.42 to 1.71
Athletics-Track[b]	0.34	-0.15 to 0.83	0.04	-0.29 to 0.62	0.13	-0.36 to 0.61
Lesson Type-Boys[c]	0.25	-0.24 to 0.73	0.16	-0.44 to 0.69	-0.20	-0.66 to 0.27
Lesson Type-Mixed[c]	0.05	-0.53 to 0.63	0.13	-0.52 to 0.24	0.03	-0.54 to 0.60
School Type[d]	-0.37	-0.78 to 0.04	-0.14	-1.52 to 0.02	0.14	-0.25 to 0.53
ActivityGroupNet/wall/racket games:LessonTypeBoys[e]	-0.48	-1.27 to 0.32	-0.75	-0.32 to 0.70	0.54	-0.24 to 1.32
ActivityGroupFielding/striking games:LessonTypeBoys[e]	-0.05	-0.58 to 0.49	0.19	-1.20 to 0.42	-0.06	-0.58 to 0.46
ActivityGroupAthletics:LessonTypeBoys[e]	-0.36	-1.20 to 0.48	-0.39	0.27 to 1.64	0.40	-0.43 to 1.22
ActivityGroupFitness:LessonTypeBoys[e]	0.70	-0.00 to 1.40	0.96**	-1.58 to 0.93	-0.46	-1.15 to 0.23
ActivityGroupAdventure/Games:LessonTypeBoys[e]	-0.41	-1.70 to 0.88	-0.33	-2.12 to 0.07	0.54	-0.73 to 1.82
ActivityGroupVarious:LessonTypeBoys[e]	-0.99	-2.12 to 0.14	-1.02	-1.53 to 0.34	1.28*	0.17 to 2.39
ActivityGroupAthletics-Field:LessonTypeBoys[e]	-1.03*	-2.02 to -0.05	-0.60	-1.40 to 0.34	0.59	-0.35 to 1.54
ActivityGroupAthletics-Track:LessonTypeBoys[e]	-0.68	-1.57 to 0.21	-0.53	-1.55 to 0.06	0.32	-0.56 to 1.19
ActivityGroupNet/wall/racket games:LessonTypeMixed[e]	-0.33	-1.14 to 0.49	-0.74	-0.57 to 0.64	0.53	-0.28 to 1.33
ActivityGroupFielding/striking games:LessonTypeMixed[e]	-0.36	-0.98 to 0.26	0.04	-1.18 to 0.64	-0.19	-0.79 to 0.42
ActivityGroupAthletics:LessonTypeMixed[e]	-0.10	-1.04 to 0.84	-0.27	0.26 to 1.87	0.32	-0.60 to 1.24
ActivityGroupFitness:LessonTypeMixed[e]	1.69***	0.86 to 2.51	1.06**	-1.18 to 1.72	-0.19	-1.00 to 0.63
ActivityGroupAdventure/Games:LessonTypeMixed[e]	0.49	-0.99 to 1.98	0.27	-0.81 to 0.41	-0.25	-1.71 to 1.22
ActivityGroupVarious:LessonTypeMixed[e]	-0.25	-0.88 to 0.38	-0.20	-1.40 to 0.42	0.19	-0.42 to 0.81
ActivityGroupAthletics-Field:LessonTypeMixed[e]	-0.64	-1.58 to 0.29	-0.49	-0.16 to 1.09	0.19	-0.73 to 1.11

[a] Fully-adjusted model including lesson length, lesson location, and school effects; SPA/MVPA are orderNorm transformed; VPA are Yeo-Johnson transformed.
[b] Reference category: Invasion games [c] Reference category: Girls-only [d] Reference category: Co-educational
[e] Reference category: ActivityGroupInvasion games:LessonTypeGirls
*** p<.001; ** p<.0125; * p <.05
Significant differences observed for ActivityGroup*LessonType; post-hoc analysis conducted

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SUPPLEMENTARY FILE 11: LSMeans tables

Tables: summary of the fixed effect interactions (LS Means) for Models 2, 3 and 4, for VPA, MVPA & SPA

Table 1 | Model 2 | Activity Group | VPA | lsmeans

Activity Group	lsmean	SE	df	lower.CL	upper.CL
Invasion games	0.1244	0.162	219	-0.1945	0.44336
Net/wall/racket games	-0.2481	0.169	311	-0.5807	0.08456
Fielding/striking games	-0.3645	0.135	169	-0.631	-0.09806
Athletics	0.0354	0.201	276	-0.3598	0.43056
Fitness	0.4115	0.203	273	0.0126	0.8103
Adventure/Games	-0.3718	0.3	264	-0.9616	0.21798
Various	-0.2662	0.137	163	-0.5374	0.00492
Athletics-Field	-0.679	0.225	225	-1.1214	-0.23652
Athletics-Track	0.5036	0.197	368	0.1169	0.89035

Table 2 | Model 3 | Activity Group*Lesson Type | VPA | lsmeans

Activity Group	LessonType	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Girls	0.0197	0.227	225.4	-0.427	0.4665
Net/wall/racket games	Girls	-0.0317	0.445	297	-0.907	0.8439
Fielding/striking games	Girls	-0.3135	0.197	205.8	-0.702	0.0747
Athletics	Girls	0.1261	0.316	280.3	-0.496	0.7484
Fitness	Girls	-0.5695	0.325	309.3	-1.21	0.0705
Adventure/Games	Girls	-0.5018	0.56	274.7	-1.604	0.6005
Various	Girls	-0.1548	0.214	226.5	-0.577	0.2673
Athletics-Field	Girls	-0.3095	0.342	303.2	-0.982	0.3635
Athletics-Track	Girls	nonEst	NA	NA	NA	NA
Invasion games	Boys	0.1838	0.223	193.2	-0.256	0.6239
Net/wall/racket games	Boys	-0.3942	0.27	292.4	-0.926	0.138
Fielding/striking games	Boys	-0.1589	0.19	152.7	-0.534	0.2156
Athletics	Boys	-0.0343	0.315	300.9	-0.654	0.5853
Fitness	Boys	0.3213	0.27	284.7	-0.211	0.8532
Adventure/Games	Boys	-0.7201	0.42	298.6	-1.547	0.1065
Various	Boys	-0.95	0.583	313.8	-2.097	0.1972
Athletics-Field	Boys	-1.1493	0.448	92.4	-2.039	-0.26
Athletics-Track	Boys	-0.1676	0.415	297.4	-0.984	0.6492
Invasion games	Mixed	-0.0955	0.274	316.9	-0.635	0.4439
Net/wall/racket games	Mixed	-0.4406	0.244	321.2	-0.921	0.0395
Fielding/striking games	Mixed	-0.6758	0.201	153.3	-1.073	-0.2785
Athletics	Mixed	0.0257	0.339	280.2	-0.642	0.6937
Fitness	Mixed	1.0863	0.334	299.8	0.43	1.7428
Adventure/Games	Mixed	-0.0203	0.556	269.6	-1.115	1.0744
Various	Mixed	-0.4141	0.174	138.6	-0.757	-0.0708
Athletics-Field	Mixed	-0.9618	0.335	238.3	-1.623	-0.3009
Athletics-Track	Mixed	0.3065	0.242	289.2	-0.169	0.7819

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Table 3 | Model 2 | Activity Group | MVPA | lsmeans

Activity Group	lsmean	SE	df	lower.CL	upper.CL
Invasion games	0.341	0.149	216	0.047069	0.6356
Net/wall/racket games	0.174	0.159	316	-0.138372	0.4863
Fielding/striking games	-0.21	0.123	170	-0.452468	0.0334
Athletics	-0.102	0.189	278	-0.472863	0.2697
Fitness	0.566	0.19	275	0.192397	0.9391
Adventure/Games	-0.462	0.286	268	-1.024355	0.1006
Various	-0.125	0.125	165	-0.37155	0.1221
Athletics-Field	-0.823	0.208	214	-1.231889	-0.4137
Athletics-Track	0.367	0.186	386	0.000293	0.733

Table 4 | Model 3 | Activity Group*Lesson Type | MVPA | lsmeans

Activity Group	LessonType	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Girls	0.2617	0.214	225	-0.1602	0.6835
Net/wall/racket games	Girls	0.9681	0.431	303	0.1193	1.8169
Fielding/striking games	Girls	-0.3982	0.185	207	-0.7634	-0.0329
Athletics	Girls	0.0418	0.302	280	-0.5526	0.6363
Fitness	Girls	-0.3185	0.313	312	-0.9337	0.2968
Adventure/Games	Girls	-0.5064	0.549	284	-1.5879	0.5752
Various	Girls	-0.0656	0.202	230	-0.4644	0.3332
Athletics-Field	Girls	-0.5817	0.33	305	-1.2312	0.0677
Athletics-Track	Girls	nonEst	NA	NA	NA	NA
Invasion games	Boys	0.3364	0.21	191	-0.0771	0.75
Net/wall/racket games	Boys	0.0554	0.258	292	-0.4531	0.5639
Fielding/striking games	Boys	-0.106	0.177	153	-0.4551	0.2432
Athletics	Boys	-0.2419	0.304	302	-0.84	0.3562
Fitness	Boys	0.7339	0.258	286	0.2262	1.2417
Adventure/Games	Boys	-0.7335	0.406	300	-1.5321	0.0651
Various	Boys	-0.9797	0.564	317	-2.0902	0.1309
Athletics-Field	Boys	-1.0823	0.41	91	-1.8963	-0.2682
Athletics-Track	Boys	-0.1661	0.401	298	-0.9556	0.6234
Invasion games	Mixed	0.2098	0.263	315	-0.3069	0.7264
Net/wall/racket games	Mixed	0.027	0.234	334	-0.4332	0.4873
Fielding/striking games	Mixed	-0.3039	0.188	152	-0.6746	0.0668
Athletics	Mixed	-0.1711	0.328	281	-0.8174	0.4752
Fitness	Mixed	0.7814	0.32	300	0.1508	1.4119
Adventure/Games	Mixed	-0.1641	0.539	272	-1.2259	0.8977
Various	Mixed	-0.2078	0.161	140	-0.5268	0.1111
Athletics-Field	Mixed	-1.0156	0.318	233	-1.6422	-0.389
Athletics-Track	Mixed	0.3189	0.23	306	-0.1344	0.7722

Table 5 | Model 2 | Activity Group | SPA | lsmeans

Activity Group	lsmean	SE	df	lower.CL	upper.CL
Invasion games	-0.387	0.146	212	-0.6741	-0.09922
Net/wall/racket games	-0.296	0.155	314	-0.6014	0.00885
Fielding/striking games	0.147	0.12	168	-0.0897	0.38343
Athletics	0.191	0.185	277	-0.1745	0.55577
Fitness	-0.572	0.186	273	-0.9383	-0.20529
Adventure/Games	0.309	0.282	268	-0.2463	0.86408
Various	0.149	0.122	163	-0.0915	0.38954
Athletics-Field	0.942	0.203	208	0.5423	1.34233
Athletics-Track	-0.153	0.182	382	-0.5113	0.20537

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Table 6 | Model 3 | Activity Group*Lesson Type | SPA | lsmeans

Activity Group	LessonType	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Girls	-0.37379	0.215	221.1	-0.7979	0.0503
Net/wall/racket games	Girls	-1.09657	0.435	301.4	-1.9517	-0.2414
Fielding/striking games	Girls	0.28178	0.186	203.8	-0.0854	0.6489
Athletics	Girls	-0.02647	0.304	275.8	-0.6243	0.5714
Fitness	Girls	-0.24808	0.315	308.1	-0.8672	0.371
Adventure/Games	Girls	0.1416	0.553	279.7	-0.9467	1.2299
Various	Girls	-0.01638	0.204	227.7	-0.4176	0.3848
Athletics-Field	Girls	0.72495	0.332	301.8	0.0708	1.3791
Athletics-Track	Girls	nonEst	NA	NA	NA	NA
Invasion games	Boys	-0.44331	0.211	188.2	-0.859	-0.0276
Net/wall/racket games	Boys	-0.29381	0.26	288	-0.8053	0.2177
Fielding/striking games	Boys	0.11637	0.177	150.1	-0.2342	0.467
Athletics	Boys	0.2544	0.306	299.9	-0.3481	0.8569
Fitness	Boys	-0.80308	0.26	282.9	-1.314	-0.2921
Adventure/Games	Boys	0.56927	0.409	297.7	-0.2353	1.3739
Various	Boys	1.15076	0.568	312.8	0.0331	2.2684
Athletics-Field	Boys	1.21921	0.41	89.2	0.4037	2.0347
Athletics-Track	Boys	0.01577	0.404	295.8	-0.7797	0.8113
Invasion games	Mixed	-0.12472	0.263	312.1	-0.6423	0.3929
Net/wall/racket games	Mixed	-0.04981	0.233	327.2	-0.5088	0.4092
Fielding/striking games	Mixed	0.22717	0.188	149.8	-0.1448	0.5992
Athletics	Mixed	0.41556	0.331	279.6	-0.2363	1.0674
Fitness	Mixed	-0.2882	0.323	297.3	-0.9233	0.3469
Adventure/Games	Mixed	-0.00435	0.544	271.7	-1.0759	1.0672
Various	Mixed	0.30931	0.162	138.6	-0.011	0.6296
Athletics-Field	Mixed	1.0559	0.32	229.5	0.4257	1.6861
Athletics-Track	Mixed	-0.05507	0.23	298.3	-0.5086	0.3985

Table 7 | Model 3 | Activity Group*Lesson Type | VPA (Girls only) | lsmeans

Activity Group	LessonType	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Girls	0.313	0.413	104.6	-0.506	1.132
Athletics	Girls	0.2666	0.512	121.6	-0.746	1.28
Net/wall/racket games	Girls	0.104	0.495	121.1	-0.877	1.085
Athletics-Field	Girls	-0.0773	0.482	119.9	-1.032	0.878
Various	Girls	-0.0993	0.43	116.5	-0.952	0.753
Fielding/striking games	Girls	-0.1084	0.405	106.8	-0.911	0.694
Fitness	Girls	-0.3847	0.5	122.1	-1.373	0.604
Adventure/Games	Girls	-0.4194	0.669	105.7	-1.746	0.907
Fitness	Girls-Mixed	0.9499	0.987	82.3	-1.014	2.914
Adventure/Games	Girls-Mixed	0.5377	0.756	112.5	-0.959	2.035
Athletics	Girls-Mixed	0.4552	0.753	111.7	-1.037	1.947
Fielding/striking games	Girls-Mixed	-0.2247	0.508	120.8	-1.23	0.781
Various	Girls-Mixed	-0.4897	0.685	87.8	-1.851	0.871
Net/wall/racket games	Girls-Mixed	-0.4505	0.548	125.2	-1.536	0.635
Invasion games	Girls-Mixed	-0.5778	1.033	108.2	-2.625	1.47
Athletics-Field	Girls-Mixed	nonEst	NA	NA	NA	NA

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SUPPLEMENTARY FILE 12: Post-hoc LSMeans tables

Tables: Post-hoc LS Means, Contrasts and significances for Model 2 & 3, and SPA, VPA and MVPA

Model 2: Activity Group Main Effect				VPA Yes	SPA Yes	MVPA Yes
	Invasion Games (+)		Fielding/striking games (-)	0.492**	-0.538***	0.554***
	Invasion Games (+)		Athletics-Field (-)	0.808*	-1.339***	1.168***
	Invasion Games (+)		Various (-)		-0.548*	
	Net/wall/racket games(+)		Fielding/striking games (-)		-0.442*	
	Net/wall/racket games (+)		Athletics-Field (-)		-1.241***	1.003***
	Net/wall/racket games (-)		Athletics-Track (+)	-0.754**		
	Net/wall/racket games (-)		Fitness (+)	-0.663*		
	Fielding/striking games (+)		Athletics-Field (-)		-0.800**	
	Fielding/striking games (-)		Athletics-Track (+)	-0.868***		-0.574***
	Fielding/striking games (-)		Fitness (+)	-0.777***	0.720***	-0.778***
	Athletics (-)		Fitness (+)		0.764*	
	Athletics-Field (-)		Athletics-Track (+)	-1.185***	1.098***	-1.188***
	Fitness (+)		Athletics-Field (-)	1.094**	-1.520***	1.391***
	Fitness (+)		Adventure/Games (-)			1.031*
	Fitness (+)		Various (-)	0.684*	-0.730**	0.695*
	Various (+)		Athletics-Field (-)		-0.790**	0.697*
	Various (-)		Athletics-Track (+)	-0.775**		
Model 3: Activity Group*Lesson Type Interaction Effect				**Yes**	**Yes**	**Yes**
Mixed	Net/wall/racket games (-)	Mixed	Fitness (+)	-1.542**		
Mixed	Fielding/striking games (-)	Mixed	Athletics-Track (+)	-0.992***		-0.636**
Mixed	Fielding/striking games (-)	Mixed	Fitness (+)	-1.769***		
Mixed	Athletics-Field (-)	Mixed	Athletics-Track (+)	-1.286*		-1.353**
Mixed	Fitness (+)	Mixed	Athletics-Field (-)	2.063***		1.805**
Mixed	Fitness (+)	Mixed	Various (-)	1.510***		
Boys	Invasion Games (+)	Boys	Athletics-Field (-)		-1.660*	
Boys	Fitness (+)	Boys	Athletics-Field (-)		-2.016**	1.810*
Boys	Invasion Games (+)	Mixed	Fielding/striking games (-)	0.853**		
Boys	Fitness (+)	Mixed	Fielding/striking games (-)	0.984*	-1.007*	1.022**
Boys	Invasion Games (+)	Mixed	Athletics-Field (-)		-1.491**	1.348*
Boys	Fitness (+)	Mixed	Athletics-Field (-)		-1.846***	1.739***
Boys	Net/wall/racket games (-)	Mixed	Fitness (+)	-1.494*		
Boys	Fielding/striking games (-)	Mixed	Fitness (+)	-1.256*		
Boys	Athletics-Field (-)	Mixed	Fitness (+)	-2.252**		-1.876*
Boys	Invasion Games (+)	Mixed	Various (-)		-0.743*	
Boys	Fitness (+)	Mixed	Various (-)		-1.099**	
Girls	Net/wall/racket games (+)	Girls	Fielding/striking games (-)			
Girls	Net/wall/racket games (+)	Girls	Athletics-Field (-)			
Girls	Fitness (-)	Girls	Athletics-Field (+)			
Girls	Net/wall/racket games (+)	Mixed	Athletics-Field (-)			
Girls	Fitness (-)	Mixed	Fitness (+)	-1.732*		
Girls	Fielding/striking games (-)	Boys	Fitness (+)			
Girls	Athletics-Field (-)	Boys	Fitness (+)		1.622*	

Notes

- The direction of the effect is indicated by a (+) for 'more active', and a (-) for 'less active'.
- *** p<.001; ** p<.0125; * p <.05. Values that are inferior to 0.0125 are highlighted in red.

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SUPPLEMENTARY FILE 13: Lesson Location

When considering factors affecting PA, a recent systematic review[1] identified modifiable variables that were consistently associated with levels of MVPA in PE including the class sex, the type of PE activities and content, **lesson location (outdoors)**, beliefs and values of students, and enjoyment of exercise.

RESULTS

Table: Pupil average time (%) in PE lessons split by PA domain, for lesson location, at the A) Lesson-level and B) Pupil-level

	A) Lesson-level				B) Pupil-level			
% of 1hr Lesson (SD)	**Indoors (n=49)**	**Outdoors (n=177)**	**In/Out (n=23)**	**Overall (n=249)**	**Indoors (n=1565)**	**Outdoors (n=6415)**	**In/Out (n=1503)**	**Overall (n=9483)**
PA Domain								
SPA	44.5 (14.3)	43.0 (12.2)	44.5 (13.1)	44.3 (8.93)	47.6 (15.6)	43.7 (12.8)	42.6 (12.2)	44.2 (13.3)
LPA	32.2 (7.82)	32.9 (7.23)	31.4 (7.76)	32.2 (4.43)	28.9 (8.53)	32.5 (7.35)	33.2 (7.33)	32.0 (7.68)
MPA	16.6 (6.72)	17.0 (6.07)	16.6 (6.49)	16.7 (4.28)	16.3 (7.64)	16.6 (6.23)	17.4 (6.07)	16.7 (6.47)
VPA	6.68 (4.56)	7.12 (4.09)	7.44 (4.54)	7.00 (2.98)	7.20 (5.26)	7.21 (4.33)	6.79 (4.06)	7.14 (4.46)
MVPA	23.3 (10.1)	24.1 (8.83)	24.1 (9.24)	23.7 (6.27)	23.5 (10.9)	23.8 (9.13)	24.2 (8.93)	23.8 (9.42)

For MVPA and VPA, similar PA levels were recorded for lesson locations (23.9% v 23.6%, and 7.0% vs 7.1% for indoor vs outdoor lessons respectively).

Multi-level Models of Physical Activity Levels during PE

The following tables summarise associations between PA levels and predictor variables. The interaction of **'activity group by lesson location'** was examined. As summarized (Table 1 | Model estimates - SPA), outdoor lessons were less sedentary than indoor lessons. For MVPA, no significant differences were observed for the interaction (Table 1 | Model estimates - MVPA). Post-hoc analysis (Table 4 - VPA) showed that showed outdoor track athletics and invasion games were more vigorously active than indoor fielding/striking games and outdoor field athletics. For SPA (Table 4 - SPA), regardless of location, fielding/striking games and field athletics were more sedentary than outdoor invasion games, and net/wall/racket games and track athletics respectively. Outdoor field athletics was more sedentary than indoor fitness, and outdoor fielding/striking games.

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Table 1: Summary of PA in PE model estimates, CIs and p-values

	VPA		MVPA		SPA	
Model estimate [a]	**ß**	**95% CI**	**ß**	**95% CI**	**ß**	**95% CI**
(Intercept)	0.18	-0.48 to 0.84	0.20	-0.41 to 0.81	0.04	-0.54 to 0.62
Net/wall/racket games[b]	-0.43	-0.93 to 0.07	-0.11	-0.60 to 0.38	-0.16	-0.65 to 0.32
Fielding/striking games[b]	-0.86***	-1.32 to -0.40	-0.80***	-1.24 to -0.36	0.39	-0.05 to 0.82
Athletics	-0.06	-0.44 to 0.32	-0.45*	-0.81 to -0.08	0.63***	0.27 to 0.99
Fitness[b]	0.24	-0.19 to 0.66	0.18	-0.23 to 0.59	-0.31	-0.72 to 0.09
Adventure/Games[b]	-1.05**	-1.87 to -0.24	-1.21**	-2.00 to -0.42	0.94*	0.16 to 1.72
Various	-0.58	-1.28 to 0.12	-0.75*	-1.42 to -0.09	0.76*	0.11 to 1.42
Athletics-Field[b]	-0.18	-0.83 to 0.47	-0.76*	-1.38 to -0.14	0.78*	0.17 to 1.39
Athletics-Track[b]	0.17	-0.21 to 0.55	-0.12	-0.49 to 0.25	0.28	-0.08 to 0.64
Location-Outdoors[c]	0.35	-0.03 to 0.72	0.33	-0.03 to 0.70	-0.71***	-1.07 to -0.35
ActivityGroupNet/wall/racket games:LocationOutdoors	-0.00	-0.60 to 0.60	-0.19	-0.77 to 0.40	0.43	-0.15 – 1.00
ActivityGroupFielding/striking games:LocationOutdoors	0.47	-0.01 to 0.95	0.30	-0.17 to 0.77	0.19	-0.28 – 0.65
ActivityGroupFitness:LocationOutdoors	-0.41	-1.55 to 0.73	-0.26	-1.35 to 0.84	0.32	-0.75 – 1.39
ActivityGroupAdventure/Games:LocationOutdoors	0.94	-0.16 to 2.04	0.70	-0.36 to 1.76	-0.50	-1.55 – 0.54
ActivityGroupVarious:LocationOutdoors	0.18	-0.55 to 0.92	0.27	-0.43 to 0.98	-0.16	-0.85 – 0.52
ActivityGroupAthletics-Field:LocationOutdoors	-0.91*	-1.63 to -0.20	-0.58	-1.28 to 0.11	0.77*	0.08 – 1.45

[a] Fully-adjusted model including lesson length, lesson type, and school effects; SPA/MVPA are orderNorm transformed; VPA are Yeo-Johnson transformed.
[b] Reference category: Invasion games; [c] Reference category: Indoors
[d] Reference category: ActivityGroupInvasion games:LocationIndoors
*** p<.001; ** p<.0125; * p <.05
Significant differences observed for ActivityGroup*LessonType for VPA and SPA; post-hoc analysis conducted.

Notes

*Model (ActivityGroup*Location of PE lesson)* This model was developed to explore the interaction of activity and PE Lesson location.

Exploring activity levels in physical education lessons in the UK: A cross-sectional examination of activity types and fitness levels

Tables: summary of the fixed effect interactions (LS Means) for Model 4, for VPA, MVPA & SPA

Table 2 | Model | Activity Group*Lesson Location | VPA | lsmeans

Activity Group	Location	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Indoors	-0.1064	0.221	257	-0.5413	0.3285
Net/wall/racket games	Indoors	-0.5327	0.218	403	-0.962	-0.1035
Fielding/striking games	Indoors	-0.9593	0.188	294	-1.3296	-0.5891
Athletics	Indoors	nonEst	NA	NA	NA	NA
Fitness	Indoors	0.1325	0.192	243	-0.2452	0.5101
Adventure/Games	Indoors	-1.1535	0.409	253	-1.9585	-0.3485
Various	Indoors	-0.679	0.327	248	-1.3224	-0.0355
Athletics-Field	Indoors	-0.2813	0.31	269	-0.8922	0.3296
Athletics-Track	Indoors	nonEst	NA	NA	NA	NA
Invasion games	Outdoors	0.2442	0.165	206	-0.0814	0.5699
Net/wall/racket games	Outdoors	-0.1902	0.201	320	-0.5848	0.2044
Fielding/striking games	Outdoors	-0.1414	0.136	145	-0.4108	0.128
Athletics	Outdoors	0.1887	0.196	258	-0.1976	0.5749
Fitness	Outdoors	0.0785	0.582	242	-1.0686	1.2257
Adventure/Games	Outdoors	0.1355	0.397	222	-0.6467	0.9178
Various	Outdoors	-0.1457	0.168	165	-0.4776	0.1861
Athletics-Field	Outdoors	-0.8465	0.247	225	-1.3323	-0.3606
Athletics-Track	Outdoors	0.4176	0.196	333	0.0313	0.8039

Model 4 | Activity Group*Lesson Location | MVPA
The interaction effect was not significant.

Table 3 | Model | Activity Group*Lesson Location | SPA | lsmeans

Activity Group	Location	lsmean	SE	df	lower.CL	upper.CL
Invasion games	Indoors	0.14284	0.206	257	-0.262	0.548
Net/wall/racket games	Indoors	-0.02937	0.204	398	-0.431	0.372
Fielding/striking games	Indoors	0.52101	0.173	301	0.181	0.8613
Athletics	Indoors	nonEst	NA	NA	NA	NA
Fitness	Indoors	-0.17726	0.175	245	-0.523	0.1681
Adventure/Games	Indoors	1.07449	0.388	261	0.311	1.838
Various	Indoors	0.89613	0.3	239	0.305	1.4877
Athletics-Field	Indoors	0.91557	0.292	275	0.341	1.4898
Athletics-Track	Indoors	nonEst	NA	NA	NA	NA
Invasion games	Outdoors	-0.56981	0.149	202	-0.863	-0.2766
Net/wall/racket games	Outdoors	-0.31401	0.187	321	-0.682	0.0535
Fielding/striking games	Outdoors	0.00343	0.12	142	-0.234	0.2407
Athletics	Outdoors	0.05543	0.181	259	-0.301	0.4121
Fitness	Outdoors	-0.56815	0.549	248	-1.649	0.5131
Adventure/Games	Outdoors	-0.13935	0.378	230	-0.885	0.6059
Various	Outdoors	0.02164	0.15	164	-0.274	0.3169
Athletics-Field	Outdoors	0.97543	0.224	210	0.534	1.4168
Athletics-Track	Outdoors	-0.28991	0.182	345	-0.647	0.0675

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Table 4: Post-hoc LS Means, Contrasts and significances, and SPA, VPA and MVPA

Model: Activity Group*Location Interaction Effect				VPA Yes	SPA Yes	MVPA No
Indoor	Invasion Games (-)	Outdoor	Invasion Games (+)		0.707*	
Indoor	Invasion Games (-)	Outdoor	Net/wall/racket games (+)			
Indoor	Net/wall/racket games (+)	Outdoor	Athletics-Field (-)		-1.005*	
Indoor	Net/wall/racket games (-)	Outdoor	Athletics-Track (+)	-0.949**		
Indoor	Fielding/striking games (-)	Outdoor	Invasion Games (+)	-1.208***	1.094***	
Indoor	Fielding/striking games (-)	Outdoor	Net/wall/racket games (+)		0.832*	
Indoor	Fielding/striking games (-)	Outdoor	Fielding/striking games (+)	-0.820***		
Indoor	Fielding/striking games (-)	Outdoor	Athletics (+)	-1.150***		
Indoor	Fielding/striking games (-)	Outdoor	Athletics-Track (+)	-1.377***	0.811***	
Indoor	Fielding/striking games (-)	Outdoor	Various (+)	-0.811*		
Indoor	Athletics-Field (-)	Outdoor	Invasion Games (+)		1.488***	
Indoor	Athletics-Field (-)	Outdoor	Net/wall/racket games (+)		1.226*	
Indoor	Athletics-Field (-)	Outdoor	Fielding/striking games (+)			
Indoor	Athletics-Field (-)	Outdoor	Athletics-Track (+)		1.205*	
Indoor	Fitness (+)	Outdoor	Athletics-Field (-)		-1.156**	
Indoor	Adventure/Games (-)	Outdoor	Invasion Games (+)		1.645**	
Indoor	Adventure/Games (-)	Outdoor	Athletics-Track (+)	-1.570*		
Indoor	Various (-)	Outdoor	Invasion Games (+)		1.470**	
Indoor	Various (-)	Outdoor	Net/wall/racket games (+)			
Indoor	Various (-)	Outdoor	Fielding/striking games (+)			
Indoor	Various (-)	Outdoor	Athletics-Track (+)			
Indoor	Various (-)	Outdoor	Various (+)			
Outdoor	Invasion Games (+)	Outdoor	Fielding/striking games (-)		-0.572**	
Outdoor	Invasion Games (+)	Outdoor	Athletics-Field (-)	1.094**	-1.548***	
Outdoor	Net/wall/racket games (+)	Outdoor	Athletics-Field (-)		-1.286***	
Outdoor	Fielding/striking games (+)	Outdoor	Athletics-Field (-)		-0.974**	
Outdoor	Athletics (+)	Outdoor	Athletics-Field (-)	1.037*		
Outdoor	Athletics-Field (-)	Outdoor	Athletics-Track (+)	-1.263***	1.265***	
Outdoor	Various (+)	Outdoor	Athletics-Field (-)		-0.948*	

Notes

- The direction of the effect is indicated by a (+) for 'more active', and a (-) for 'less active'.
- *** p<.001; ** p<.0125; * p <.05. Values that are inferior to 0.0125 are highlighted in red.

DISCUSSION

In general, we found outdoor lessons to be more vigorously active, and significantly less sedentary, than indoor lessons, apart from outdoor field athletics which was more sedentary than indoor fitness and indoor net/wall/racket games. Previous studies suggest that lesson location influences the intensity of PE lessons[2, 3] with a greater proportion of MVPA and VPA in outdoors compared to indoor classes, and less time spent doing SPA.

REFERENCES

1. Zhou Y, Wang L. Correlates of Physical Activity of Students in Secondary School Physical Education: A Systematic Review of Literature. *Biomed Res Int.* 2019;**2019**:1-12.

2. Chow BC, McKenzie TL, Louie, L. Physical Activity and Environmental Influences during Secondary School Physical Education. *J Teach Phys Educ.*2009;**28**:21-37.

3. McKenzie T, Catellier D, Conway T, *et a*l. Girls' activity levels and lesson contexts in middle school PE: TAAG baseline. *Med Sci Sports Exerc.*2006;**38**:1229-35.