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; 1069 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 (β=−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 (β=1.09; 95% CI 0.43 to 1.74) and boys-only lessons (β=0.32; 95% CI −0.21 to 0.85). In girls-only lessons, track athletics recorded most VPA (β=0.13; 95% CI −0.59 to 0.75) and net/wall/racket games (β=0.97; 95% CI 0.12 to 1.82) the most MVPA. For all lesson types, field athletics was least active (β=−0.85; 95% CI −1.33 to −0.36). There was a relationship of enjoyment of PE to fitness (β=1.03; 95% CI 0.83 to 1.23), and this relationship did not vary with sex (β=−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.

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INTRODUCTION

Cardiorespiratory fitness (CRF) is related to better physical and psychological health and higher academic achievement in schoolchildren, with higher childhood fitness being linked to better health, well-being and life-chances in adulthood. Adolescent fitness levels have been falling globally, raising concerns regarding the long-term impact. Alongside non-modifiable biological and genetic factors, physical activity (PA)
Activity levels decline throughout adolescence, particularly in girls, and those who are more socioeconomically disadvantaged, or living in inner-city areas. 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.

Most young people in the UK have to attend school, and physical education (PE) lessons are compulsory until Year 11, suggesting that school PE offers a suitable setting to promote adolescent PA and fitness. During the past decade, focus on PE has shifted from fitness and competition to learning experiences, skills development and fostering the benefits of regular PA. The UK Association for Physical Education recommends pupils should be actively moving for 50%–80% of the available PE lesson time, although no intensity level is specified. Previous studies suggest pupils spend an average of 40.5% of PE lesson time in MVPA. 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. Thus, provisional data suggest that a great deal of PE time might be spent sitting or sitting and that lessons could be adapted to increase activity levels.

When considering factors affecting PA, a recent systematic review 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 (indoors), 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 (16017 pupils). Details of the trial, including recruitment, methodology and consent procedures, are reported in the study protocol. 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. Total number of laps completed was recorded: we compared pupils’ performances with normative 50th percentile scores by sex aged 12 years. 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.

Pupil PA during PE lessons was measured with wrist-worn AX3 triaxial accelerometers designed by Open Lab, Newcastle University. 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. 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 (timetable 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 and based on established ‘cut-off points’. 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.

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, 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, 1097 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 descriptors 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\textsubscript{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 |
|--------------|---------------------------------------------------------------|
| Activity group | Lesson type              | Girls (n=60) | Boys (n=86) | Mixed (n=103) | Overall (n=249) |
|               | A       | B |   | A       | B |   | A       | B |   | A       | B |   | A       | B |   | A       | B |   |
| Invasion games | A       | 13 (21.7%) | 328 (16.7%) | 19 (22.1%) | 621 (25.4%) | 5 (4.9%) | 136 (2.7%) | 37 (14.9%) | 1085 (41.4%) | B       | 12 (21.7%) | 215 (4.2%) | 37 (14.9%) | 73 (2.5%) | 38 (2.1%) | 73 (2.5%) | 34 (1.9%) |
| Net/wall/racket games | A       | 3 (6.0%) | 60 (11.7%) | 8 (9.3%) | 191 (21.8%) | 5 (4.9%) | 130 (2.6%) | 16 (6.4%) | 394 (4.2%) | B       | 6 (1.2%) | 13 (2.6%) | 5 (4.9%) | 130 (2.6%) | 16 (6.4%) | 394 (4.2%) | 16 (6.4%) |
| Fielding/striking games | A       | 17 (28.3%) | 601 (30.6%) | 37 (43.0%) | 1058 (43.3%) | 33 (32.0%) | 1253 (24.7%) | 87 (34.9%) | 2912 (30.7%) | B       | 32 (5.6%) | 93 (3.8%) | 243 (9.9%) | 170 (3.7%) | 110 (4.2%) | 17 (3.7%) | 501 (5.3%) |
| Athletics       | A       | 5 (8.3%) | 110 (5.6%) | 4 (4.7%) | 105 (4.3%) | 3 (2.9%) | 114 (2.2%) | 329 (3.5%) | 16 (4.8%) | B       | 5 (8.3%) | 105 (4.3%) | 4 (4.7%) | 105 (4.3%) | 3 (2.9%) | 114 (2.2%) | 329 (3.5%) | 16 (4.8%) |
| Fitness         | A       | 4 (6.7%) | 88 (4.5%) | 8 (9.3%) | 243 (9.9%) | 4 (3.9%) | 170 (3.3%) | 501 (5.3%) | 16 (6.4%) | B       | 4 (6.7%) | 88 (4.5%) | 8 (9.3%) | 243 (9.9%) | 4 (3.9%) | 170 (3.3%) | 501 (5.3%) | 16 (6.4%) |
| Adventure/games | A       | 1 (1.7%) | 16 (0.8%) | 2 (2.3%) | 55 (2.2%) | 1 (1.0%) | 41 (0.8%) | 112 (1.2%) | 4 (1.6%) | B       | 1 (1.7%) | 16 (0.8%) | 2 (2.3%) | 55 (2.2%) | 1 (1.0%) | 41 (0.8%) | 112 (1.2%) | 4 (1.6%) |
| Various         | A       | 14 (23.3%) | 661 (33.7%) | 1 (1.2%) | 20 (0.8%) | 41 (39.8%) | 2882 (58.6%) | 56 (22.5%) | 3563 (37.6%) | B       | 75 (13.6%) | 304 (15.6%) | 2 (0.4%) | 1 (0.2%) | 41 (39.8%) | 2882 (58.6%) | 56 (22.5%) | 3563 (37.6%) |
| Athletics—field | A       | 3 (5.0%) | 84 (4.3%) | 5 (5.8%) | 93 (3.8%) | 135 (2.7%) | 312 (3.3%) | 13 (5.2%) | 312 (3.3%) | B       | 3 (5.0%) | 84 (4.3%) | 5 (5.8%) | 93 (3.8%) | 135 (2.7%) | 312 (3.3%) | 13 (5.2%) | 312 (3.3%) |
| Athletics—track | A       | 0 (0%) | 0 (0%) | 2 (2.3%) | 60 (2.5%) | 6 (5.8%) | 215 (4.2%) | 8 (3.2%) | 275 (2.9%) | B       | 0 (0%) | 0 (0%) | 2 (2.3%) | 60 (2.5%) | 6 (5.8%) | 215 (4.2%) | 8 (3.2%) | 275 (2.9%) |
PE enjoyment on fitness according to sex. The results (online supplemental file 4) showed that fitness was positively related to PE enjoyment ($\beta$=1.03; 95% CI 0.83 to 1.23). Moreover, the relationship was stronger among boys than girls ($\beta$=−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 ($\beta$=−0.48; p<0.001), and between eFSM pupils and their counterparts ($\beta$=−0.22; p<0.001). There was no significant interaction effect between sex and FSM status in terms of their relationship 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-educated 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 low deprivation recorded lower activity levels (22.7% vs 24.2%, and 6.5% vs 7.4%, respectively) than schools located in areas of high 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 2** Fitness (cumulative laps) for (A) sex, (B) eFSM, (C) sex by eFSM, compared with global norms (gn)

|                          | Mean (SD) | Q₂ laps | Q₂ 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      |            |                |
| C: sex by eFSM           |           |         |            |                |
| Boys: No (n=3913)        | 44.9 (23.7)| 2069    | 37.5 (21.6)| 296 (42)       |
| Yes (n=706)              | 37.5 (21.6)| 296     |            |                |
| Girls: No (n=5137)       | 33.6 (16.9)| 2887    | 27.8 (14.2)| 413 (44)       |
| Yes (n=941)              | 27.8 (14.2)| 413     |            |                |

Q₂=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.
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 ($\beta=-0.18$ to 0.05; $p=0.421$–0.911), school FSM status ($\beta=-0.02$ to 0.02; $p=0.916$–0.938) or lesson type ($\beta=-0.21$ 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 ($\beta=-0.15$ to 0.18; $p=0.445$–0.998). Boys-only lessons were the most vigorously active ($\beta=0.23$; $p=0.338$), with mixed lessons the least active ($\beta=-0.08$; $p=0.752$). Girls-only lessons were the most sedentary ($\beta=0.06$; $p=0.826$) and the least active in terms of MVPA ($\beta=0.04$; $p=0.877$).

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 $\beta$ 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 $\beta$ values), while mixed and girls-only classes exhibited similar activity levels (near to zero $\beta$ values). Mixed and girls-only classes were also the most sedentary. No significant main effect was observed.

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        | >5min VPA | >30min MVPA | <20min 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.
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, and low compared with the most recent meta-analysis of global levels of PA in PE. 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, 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% to 1% between 1998 and 2014, although now stabilised. 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, 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, 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 inter-individual difference in MVPA levels across pupils. The ‘Fit to Study’ pilot study (Delextrat, 2019) recorded an average figure of 30.7% MVPA when considering ‘effective’ PE time.

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. 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 53% 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 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 depending on the type of activity. 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 even 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.39 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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Contributors

NB—interpretation of findings, writing, data analysis, data collection/processing and implementation. EE—interpretation of findings, writing, data analysis, data collection/processing and contribution to implementation. AD—interpretation of findings and contribution to writing. PE—data processing, programming and actigraphy analysis. OB—contribution to writing and data collection/processing. EC—data collection/processing and contribution to implementation. TW—advice on data analysis and contribution to implementation. CW—contribution to implementation and experimental design. HU-B—advice on implementation and experimental design. HD—interpretation of findings, advice on implementation and experimental design.

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Data availability statement
Deidentified participant data are available from the corresponding author upon reasonable request.

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REFERENCES
1 Sandrock 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, Cattuzio MT, et al. Physical fitness and academic performance in youth: a systematic review. Scand J Med Sci Sports 2017;27:597–603.
4 Chaddock-Heyman L, Erickson KL, Kiebzak Z, et al. The role of aerobic fitness in cortical thickness and mathematics achievement in preadolescent children. PLoS One 2015;10:e0131415.
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, Törén 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, Boddye 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 Sandrock 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, Martinez-Gomez 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, Kulfmala 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-Saeres 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/ou27twl [Accessed 7 July 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;14:92.
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, Gadouy C, et al. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1986;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 representng 50 countries. Br J Sports Med 2017;51:1545–54.
32 Dolherty J, 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/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 Albar 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:e012138.
38 de Souza 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;28:9–37.
52 Hannon J, Ratcliffe 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 Accelerometer. 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, Berthon 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-Kulmina 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;43:508–13.
69 Department for Education. School sport and activity action plan. London::GOV.UK 2019.
70 Costigan SA, Eather N, Plotnikof S, et al. Relationship between socioeconomic status and physical fitness in junior high school students. J Sci Med Sport 2016;19:221–6.
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.
### 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

| School Type | School Data | Male | Female | Total | Male | Female | Total | Male | Female | Total |
|-------------|-------------|------|--------|-------|------|--------|-------|------|--------|-------|
| Co-Ed       |            | -    | -      | 75    | -    | -      | 59    |      |        | 17    |
| (School Data)|            |      |        |       |      |        |       |      |        |       |
| Female      |            | -    | -      | 17    | -    | -      | 14    |      |        | 14    |
| Male        |            | -    | -      | 1     | -    | -      | 1     |      |        | 1     |
| Total (Classes) |            | -    | -      | 93    | -    | -      | 74    |      |        | 67    |
| Co-Ed       | (Pupil Data)| 6993 | 6294   | 13287 | 4563 | 4167   | 8730  | 2955 | 2906   | 5861  |
| Female      |            | 0    | 2667   | 2667  | 0    | 1911   | 1911  | 0    | 1589   | 1589  |
| Male        |            | 63   | 0      | 63    | 56   | 0      | 56    | 35   | 0      | 35    |
| Total (%)   |            | 7056 | 8961   | 16017 | 4619 | 6078   | 10697 | 2990 | 4495   | 7483  |
| Free School | No          | 5900 | 7452   | 13352 | 3913 | 5137   | 9050  | 2579 | 3835   | 6414  |
| Meals Eligible | Yes (%)   | 1156 | 1509   | 2665  | 15 (1) | 10697 | 15 (1) | 10697 |
| Term Completed | Summer 2017 | -    | -      | -     | 3795 | 5235   | 9030  |      |        |       |
| Test        | Autumn 2017 | -    | -      | -     | 824  | 843    | 1667  |      |        |       |
| PE Visits (No of lessons) | Summer 2017 | -    | -      | -     | -    | -      | -     |      |        |       |
|             | Autumn 2017 | -    | -      | -     | -    | -      | -     |      |        |       |
| Questionnaire Completed | Term time | -    | -      | -     | -    | -      | -     | 2,831| 4,295  | 7,090 |
| Holidays    | Min-Max     | -    | -      | -     | -    | -      | -     | 159  | 236    | 395   |
| Age, Years (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) | 12.50 (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 | Total |
|-----------------------------|---------------------------|-------|
|                             | Male          | Female |      |
| 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 | -1.95-1.83 | -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)

|                     | Male (n=30) | Female (n=30) | Overall (n=60) |
|---------------------|-------------|---------------|----------------|
| p = 0.018           |             |               |                |
| 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 (<100 pupils 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)
- School FSM 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 (<100 pupils 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

| PE Enjoyment | Male (n) | Female (n) | Fitness (cumulative laps) | Mean (SD) | Median | [Min, Max] |
|--------------|---------|------------|---------------------------|-----------|--------|------------|
| One          | 71      | 161        |                           | 27.8 (16.1) | 25.0   | [2, 98]    |
|              | Male    | 48         |                           | 26.8 (15.6) | 23.5   | [3, 73]    |
|              | Female  | 132        |                           | 22.6 (9.19) | 20.5   | [7, 52]    |
| Three        | 224     | 132        |                           | 31.4 (15.8) | 27.0   | [8, 77]    |
|              | Male    | 202        |                           | 35.4 (17.2) | 26.5   | [0, 125]   |
|              | Female  | 506        |                           | 25.5 (11.5) | 24.0   | [3, 75]    |
| Four         | 189     | 536        |                           | 31.7 (16.7) | 29.0   | [7, 103]   |
|              | Male    | 1236       |                           | 38.1 (20.4) | 35.0   | [0, 120]   |
|              | Female  | 1772       |                           | 48.5 (23.2) | 46.0   | [0, 137]   |
| Six          | 640     | 1700       |                           | 38.6 (17.4) | 36.0   | [5, 99]    |
| Seven        | 2990    | 4495       |                           | 42.8 (22.7) | 39.0   | [0, 137]   |
| Overall      |         |            |                           | 32.4 (16.1) | 29.0   | [1, 109]   |

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

| Model 1 estimate | β        | 95% CI        |
|------------------|----------|---------------|
| (Intercept)      | -2.65*** | -3.57 – -1.73 |
| Enjoy PE [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 [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).
Supplemental material
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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**                |                    |                |            |       |
| 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)

| Timetabled Lesson Length (minutes) | Average of 'effective' PE time (minutes) | % of Lesson 'effective' time |
|-----------------------------------|----------------------------------------|----------------------------|
| Under 60mins (n=27)               | 60mins (n=138)                          | Above 60mins (n=84)         |
| 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 |
|----------------|-------------|---------|-----------------|
|                | 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 | 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=4564) | 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 | Overall (n=9483) |
|---------------|-------------|-----------------|
| ActivityGroup | Girls (n=1961) | Boys (n=2446) | Mixed (n=5076) |
| 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* | β     | 95% CI            | Model 2 estimate* | β     | 95% CI            | Model 3 estimate* | β     | 95% CI            |
|-------------------|-------|-------------------|-------------------|-------|-------------------|-------------------|-------|-------------------|
| (Intercept)       | -2.37 *** | -3.18 to -1.56   | (Intercept)       | -2.34 *** | -3.16 to -1.52   |                  |       |                   |
| Female            | -0.48 *** | -0.56 to -0.39   | Tertile-Low       | -0.40 ** | 0.16 to 0.63     |                  |       |                   |
| eFSM              | -0.22 *** | -0.29 to -0.15   | School Type (ST)  | -0.11   | -0.48 to 0.26    |                  |       |                   |
| Female*eFSM       | -0.01   | -0.11 to 0.09     | Tertile-Medium*ST | 0.27   | -0.31 to 0.84    |                  |       |                   |
|                   |         |                   | Tertile-Low*ST    | -0.03   | -0.55 to -0.49    |                  |       |                   |

*Fully-adjusted model including age, term of test, and school effects; fitness scores are orderNorm transformed

| 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

| PA Domains | School Type | Tertile | % of 1hr Lesson (SD) |
|------------|-------------|---------|-----------------------|
|            | Co-Ed (n=8059) | Single Sex (n=1424) | High (n=2769) | Medium (n=2150) | Low (n=4564) |
| 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

| PA Domains | Co-Ed (n=206) | Single Sex (n=43) | High (n=82) | Medium (n=62) | Low (n=105) |
|------------|---------------|-------------------|-------------|--------------|-------------|
| 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 | Girls (n=60) | Boys (n=86) | Mixed (n=103) | Overall (n=249) |
|-------------|--------------|-------------|---------------|-----------------|
| SPA         | 45.3 (8.61)  | 42.2 (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         | 16.8 (4.73)  | 16.9 (4.47) | 16.9 (4.07)   | 16.7 (4.28)     |
| VPA         | 7.50 (2.68)  | 7.70 (3.91)  | 6.90 (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/Various 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/Various 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

### Table 1 | Model 1 estimate

| Activity | VPA          | 95% CI       | MVPA         | 95% CI       | SPA          | 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 | -0.18        | -0.62 to 0.26| -0.02        | -0.42 to 0.37| 0.05         | -0.33 to 0.43|
| School FSM | -0.02        | -0.42 to 0.39| 0.02         | -0.35 to 0.38| -0.02        | -0.37 to 0.33|
| Lesson Type-Boys | 0.23         | -0.24 to 0.71| 0.25         | -0.17 to 0.68| -0.21        | -0.63 to 0.20|
| Lesson Type-Mixed | -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|

| **Notes**: | a | Fully-adjusted model including lesson length, lesson location, activity and school effects; SPA/MVPA are orderNorm transformed; VPA are Yeo-Johnson transformed. |
| a | b | Reference category: Co-educational; |
| c | d | Reference category: Above average; |
| d | e | Reference category: Girls-only |

### Table 2 | Model 2 estimate

| Activity | VPA          | 95% CI       | MVPA         | 95% CI       | SPA          | 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 | -0.38*        | -0.68 to -0.07| -0.16        | -0.46 to 0.13| 0.10         | -0.19 to 0.39|
| Fielding/striking games | -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 | 0.29         | -0.06 to 0.63| 0.22         | -0.11 to 0.55| -0.18        | -0.51 to 0.14|
| Adventure/Games | -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 | -0.81***      | -1.23 to -0.39| -1.17***     | -1.56 to -0.78| 1.34***     | 0.95 to 1.72|
| Athletics-Track | 0.38*        | 0.01 to 0.74| 0.02         | -0.33 to 0.37| 0.24         | -0.10 to 0.58|

| **Notes**: | * | 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 < 0.01; ** | p < 0.025; * p < 0.05 |

Significant differences observed for activity group; post-hoc analysis conducted – see Table 4.
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| Table 3 | Model 3 estimate a | VPA | 95% CI | MVPA | 95% CI | SPA | 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 0.60 |
| 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 | -0.09 | -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 f | -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 f | -0.36 | -0.98 to 0.26 | 0.04 | -1.18 to 0.64 | -0.19 | -0.79 to 0.42 |
| ActivityGroupAthletics:LessonTypeMixed f | -0.10 | -1.04 to 0.84 | -0.27 | 0.26 to 1.87 | 0.32 | -0.60 to 1.24 |
| ActivityGroupFitness:LessonTypeMixed f | 1.69*** | 0.86 to 2.51 | 1.06** | -1.18 to 1.72 | -0.19 | -1.00 to 0.63 |
| ActivityGroupAdventure/Games:LessonTypeMixed f | 0.49 | -0.09 to 1.98 | 0.27 | -0.81 to 0.41 | -0.25 | -1.71 to 1.22 |
| ActivityGroupVarious:LessonTypeMixed f | -0.25 | -0.88 to 0.38 | -0.20 | -1.40 to 0.42 | 0.19 | -0.42 to 0.81 |
| ActivityGroupAthletics-Field:LessonTypeMixed f | -0.64 | -1.58 to 0.29 | -0.49 | -0.16 to 1.09 | 0.19 | -0.73 to 1.11 |

a Full-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 <0.01; ***p <0.001; *p <0.05

Significant differences observed for ActivityGroup*LessonType; post-hoc analysis conducted

Beale N, et al. BMJ Open Sp Ex Med 2021; 7:e000924. doi: 10.1136/bmjsem-2020-000924
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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 | -0.3056 | 0.197 | 368 | 0.1169 | 0.89035 |
| 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      | -0.5817| 0.33  | 305    | -1.2312  | 0.0677   |
| 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 | Lesson Type | 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 | -0.2921    | 1.3739     |
| 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 | -0.506     | 1.132      |
| Net/wall/racket games | Mixed       | -0.49811 | 0.233 | 327.2 | -0.5088    | 0.4092     |
| Fielding/striking games | Mixed       | 0.22717  | 0.188 | 149.8 | -0.1448    | 0.5992     |
| Athletics       | Mixed       | 0.41536  | 0.331 | 297.6 | -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 | Lesson Type | 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 | SPA | MVPA |
|------------------------------------|-----|-----|------|
| Invasion Games (+) | Fielding/striking games (-) | 0.492** | -0.538*** | 0.354*** |
| Invasion Games (+) | Athletics-Field (-) | 0.808* | -1.339*** | 1.168*** |
| Invasion Games (+) | Various (-) | -0.548* | -0.442* | -0.800** |
| Net/wall/racket games (+) | Fielding/striking games (-) | -0.754** | -1.241*** | 1.003*** |
| Net/wall/racket games (+) | Athletics-Field (-) | -0.663* | 0.764* | -1.353** |
| Fielding/striking games (+) | Athletics-Track (+) | -0.868*** | -0.574*** | -1.188*** |
| Fielding/striking games (+) | Fitness (+) | -0.777*** | 0.720*** | -0.778*** |
| Athletics (-) | Fitness (+) | 1.094* | -1.520*** | 1.391*** |
| Athletics-Field (-) | Athletics-Track (+) | -1.185*** | 1.098*** | -1.188*** |
| Fitness (+) | Athletics-Field (-) | 0.548* | -0.442* | -0.800** |
| Fitness (+) | Athletics-Field (-) | 0.754* | -0.548* | -0.800** |
| Fitness (+) | Fitness (+) | 0.674* | -0.730** | -0.778*** |
| Various (+) | Athletics-Field (-) | 0.684* | -0.730** | 0.695* |
| Various (+) | Athletics-Track (+) | -0.775** | -0.778*** | 1.391*** |

| Model 3: Activity Group*Lesson Type Interaction Effect | VPA | SPA | MVPA |
|------------------------------------------------------|-----|-----|------|
| Mixed Net/wall/racket games (-) Mixed Fitness (+) | -1.542** | -0.636** | -1.353** |
| Mixed Fielding/striking games (-) Mixed Athletics-Field (-) | -0.992*** | -1.286* | -1.353** |
| Mixed Fielding/striking games (-) Mixed Fitness (+) | -1.769*** | -1.286* | -1.353** |
| Mixed Athletics-Field (-) Mixed Athletics-Track (+) | -1.286* | -1.353** | -1.353** |
| Mixed Fitness (+) Mixed Athletics-Field (-) | 1.094* | -1.520*** | 1.391*** |
| Mixed Fitness (+) Mixed Athletics-Track (+) | 0.548* | -0.442* | -0.800** |
| Mixed Fitness (+) Mixed Fitness (+) | 1.094* | -1.520*** | 1.391*** |
| Boys Invasion Games (+) Boys Athletics-Field (-) | -1.660* | -2.016** | 1.810* |
| Boys Fitness (+) Boys Athletics-Field (-) | -2.016** | -2.016** | 1.810* |
| Boys Invasion Games (+) Mixed Fielding/striking games (-) | 0.853** | -1.007* | -1.022** |
| Boys Fitness (+) Mixed Fielding/striking games (-) | 0.984* | -1.007* | -1.022** |
| Boys Invasion Games (+) Mixed Athletics-Field (-) | -1.941*** | -1.491*** | 1.348* |
| Boys Fitness (+) Mixed Athletics-Field (-) | -1.846*** | -1.384*** | 1.739*** |
| Boys Net/wall/racket games (-) Mixed Fitness (+) | -1.494* | -1.494* | -1.494* |
| Boys Fielding/striking games (-) Mixed Fitness (+) | -1.256* | -1.256* | -1.256* |
| Boys Athletics-Field (-) Mixed Fitness (+) | -2.252** | -2.252** | -2.252** |
| Boys Invasion Games (+) Mixed Various (-) | -0.743* | -0.743* | -0.743* |
| Boys Fitness (+) Mixed Various (-) | -1.099** | -1.099** | -1.099** |
| Girls Net/wall/racket games (+) Girls Fielding/striking games (-) | -1.372* | -1.372* | -1.372* |
| Girls Net/wall/racket games (+) Girls Athletics-Field (-) | -1.372* | -1.372* | -1.372* |
| Girls Fitness (-) Girls Athletics-Field (-) | -1.372* | -1.372* | -1.372* |
| Girls Net/wall/racket games (+) Mixed Athletics-Field (-) | -1.372* | -1.372* | -1.372* |
| Girls Fitness (-) Mixed Athletics-Field (-) | -1.372* | -1.372* | -1.372* |
| Girls Fielding/striking games (-) Boys Fitness (+) | 1.622* | 1.622* | 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

| PA Domain | A) Lesson-level | B) Pupil-level |
|-----------|----------------|----------------|
|           | 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) |
| 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**

| Model estimate a | VPA | MVPA | SPA |
|------------------|-----|------|-----|
| (Intercept)      | 0.18 | 0.20 | 0.04 |
|                  | -0.48 to 0.84 | -0.41 to 0.81 | -0.54 to 0.62 |
| Net/wall/racket games b | -0.43 | -0.11 | -0.16 |
|                  | -0.93 to 0.07 | -0.60 to 0.38 | -0.65 to 0.32 |
| Fielding/striking games b | -0.86*** | -0.80*** | 0.39 |
|                  | -1.32 to -0.40 | -1.24 to -0.36 | -0.05 to 0.82 |
| Athletics        | -0.06 | -0.12 | 0.28 |
|                  | -0.44 to 0.32 | -0.81 to -0.08 | -0.08 to 0.64 |
| Fitness b        | 0.24 | 0.18 | 0.28 |
|                  | -0.19 to 0.66 | -0.23 to 0.59 | -0.72 to 0.09 |
| Adventure/Games b | -1.05** | 0.30 | 0.17 |
|                  | -1.87 to -0.24 | -1.38 to -0.14 | 0.17 to 1.39 |
| Various          | -0.58 | -0.12 | 0.28 |
|                  | -1.28 to 0.12 | -0.49 to 0.25 | -0.08 to 0.64 |
| Athletics-Field b | -0.18 | -0.12 | 0.28 |
|                  | -0.83 to 0.47 | -0.49 to 0.25 | -0.08 to 0.64 |
| Location-Outdoors c | 0.35 | 0.33 | 0.74 |
|                  | -0.03 to 0.72 | -0.03 to 0.70 | -0.10 to 1.35 |
| ActivityGroupNet/wall/racket games:LocationOutdoors | -0.00 | -0.19 | 0.43 |
|                  | -0.60 to 0.60 | -0.77 to 0.40 | -0.15 to 1.00 |
| ActivityGroupFielding/striking games:LocationOutdoors | 0.47 | 0.30 | 0.19 |
|                  | -0.01 to 0.95 | -0.17 to 0.77 | -0.28 to 0.65 |
| ActivityGroupFitness:LocationOutdoors | -0.41 | -0.26 | 0.32 |
|                  | -1.55 to 0.73 | -1.35 to 0.84 | -0.75 to 1.39 |
| ActivityGroupAdventure/Games:LocationOutdoors | 0.94 | 0.70 | -0.50 |
|                  | -0.16 to 2.04 | -0.36 to 1.76 | -1.55 to 0.54 |
| ActivityGroupVarious:LocationOutdoors | 0.18 | 0.27 | -0.16 |
|                  | -0.55 to 0.92 | -0.43 to 0.98 | -0.85 to 0.52 |
| ActivityGroupAthletics-Field:LocationOutdoors | -0.91* | -0.58 | 0.77* |
|                  | -1.63 to -0.20 | -1.28 to 0.11 | 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

**Notes**

**Model (ActivityGroup * Location of PE lesson)** This model was developed to explore the interaction of activity and PE Lesson location.
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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 | NA |
| Fitness Indoors 0.1325 | 0.218 | 403 | -0.962 | -0.1035 |
| Adventure/Games Indoors -1.1535 | 0.409 | 253 | -1.9585 | -0.3485 |
| Various Indoors -0.9593 | 0.188 | 294 | -1.3296 | -0.5891 |
| Athletics Indoors nonEst | NA | NA | NA | NA |
| Fitness Indoors 0.1325 | 0.218 | 403 | -0.962 | -0.1035 |
| Adventure/Games Indoors -1.1535 | 0.409 | 253 | -1.9585 | -0.3485 |
| Various Indoors -0.9593 | 0.188 | 294 | -1.3296 | -0.5891 |
| Athletics Indoors nonEst | NA | NA | NA | NA |

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 | NA |
| Fitness Indoors 0.0785 | 0.582 | 242 | -1.0686 | 1.2257 |
| Adventure/Games Indoors 0.1355 | 0.397 | 222 | -0.6467 | 0.9178 |
| Various Indoors -0.1457 | 0.168 | 165 | -0.4776 | 0.1861 |
| Athletics Indoors nonEst | NA | NA | NA | NA | NA |
| Fitness Indoors 0.0785 | 0.582 | 242 | -1.0686 | 1.2257 |
| Adventure/Games Indoors 0.1355 | 0.397 | 222 | -0.6467 | 0.9178 |
| Various Indoors -0.1457 | 0.168 | 165 | -0.4776 | 0.1861 |
| Athletics Indoors nonEst | NA | NA | NA | NA | NA |

Model 4 | Activity Group*Lesson Location | SPA | lsmeans
The interaction effect was not significant.
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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  | SPA  | MVPA |
|-----------------------------------------------|------|------|------|
| Indoor Invasion Games (-) : Outdoor Invasion Games (+) |      |      | 0.707* |
| Indoor Invasion Games (-) : Outdoor Net/wall/racket games (+) |      |      | -1.005* |
| Indoor Net/wall/racket games (+) : Outdoor Athletics-Field (-) | -0.949** |      |      |
| Indoor Fielding/striking games (-) : Outdoor Invasion Games (+) | -1.208*** | 1.094*** |      |
| 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 (+) |      | 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 (-) | 1.094** | -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 al. Girls' activity levels and lesson contexts in middle school PE: TAAG baseline. Med Sci Sports Exerc. 2006;38:1229-35.