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1 **Introducing physically active lessons in UK secondary schools: feasibility study and**
2 **pilot cluster-randomised controlled trial**

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15 **Keywords:** Active lessons, movement integration, physical activity, sedentary time, school health

16 **Word count:** 5,717

17 Abstract

18 **Objectives:** Assess feasibility, acceptability and costs of delivering a physically active lessons (PAL)
19 training programme to secondary school teachers and explore preliminary effectiveness for reducing
20 pupils' sedentary time.

21 **Design and setting:** Secondary schools in East England; one school participated in a pre-post feasibility
22 study, two in a pilot cluster-randomised controlled trial. In the pilot trial, blinding to group assignment
23 was not possible.

24 **Participants:** Across studies, 321 randomly selected students (51% male; mean age: 12.9 years), 78
25 teachers (35% male) and two assistant head-teachers enrolled; 296(92%) students, 69(88%) teachers
26 and two assistant head teachers completed the studies.

27 **Intervention:** PAL training was delivered to teachers over two after-school sessions. Teachers were
28 made aware of how to integrate movement into lessons; strategies included students collecting data
29 from the environment for class activities, and completing activities posted on classroom walls, instead
30 of sitting at desks.

31 **Primary and secondary outcomes:** Quantitative and qualitative data were collected to assess feasibility
32 and acceptability of PAL training and delivery. Outcomes were assessed at baseline and ~8 weeks post-
33 training; measures included accelerometer-assessed activity, self-reported well-being, and
34 observations of time-on-task. Process evaluation was conducted at follow-up.

35 **Results:** In the feasibility study, teachers reported good acceptability of PAL training and mixed
36 experiences of delivering PAL. In the pilot study, teachers' acceptability of training was lower and
37 teachers identified aspects of the training in need of review, including the outdoor PAL training and
38 learning challenge of PAL strategies. In both studies, students and assistant head-teachers reported
39 good acceptability of the intervention. Preliminary effectiveness for reducing students' sedentary time
40 was not demonstrated in either study.

Conclusions: No evidence of preliminary effectiveness on the primary outcome and mixed reports of teachers' acceptability of PAL training suggest the need to review the training. The results do not support continuation of research with the current intervention.

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Article Summary

Strength and limitations of this study

- We completed thorough feasibility and pilot testing work to inform the decision of whether to progress with the current intervention and its evaluation.
- We collected quantitative and qualitative data which provided valuable information on contextual influences and allowed us to address research questions more comprehensively.
- We were unable to collect all planned follow-up measures from teachers and students in feasibility study, including teacher follow-up questionnaires and class observations of time-on-task.
- We did not carry out longer-term follow-up measures of teacher acceptability and physically active lesson delivery (i.e., beyond ~8 weeks post-training); longer follow-up would have provided an indication of the sustainability of the intervention.

58 INTRODUCTION

59 Globally, most adolescents (~80%) do not achieve government-recommended physical activity
60 guidelines[1] and engage in high levels of sedentary behaviour[2]. As such, interventions are needed to
61 support youth in achieving a healthy activity profile. Secondary/high schools present an opportunity for
62 the implementation of activity interventions, as during school hours activity is lower and sedentary time
63 is higher than during other segments of an adolescent's week[3, 4].

64 The Creating Active School Environments (CASE) project is a three-year research programme funded by
65 the UK Department of Health Policy Research Programme. CASE aims to identify environmental
66 strategies to help adolescents move more and sit less during school hours. Initial phases of CASE
67 involved a systematic literature review[5] and secondary data analysis[6] to identify promising
68 secondary school-based activity interventions. Morton and colleagues (2017) subsequently completed
69 a Delphi study, involving stakeholders in the prioritisation of interventions. Physically active lessons
70 (PAL) were perceived to be the most feasible, acceptable and cost-effective intervention for secondary
71 school settings[7]; these results informed the final, feasibility and pilot-testing phase of CASE.

72 PAL are a pedagogical approach whereby activity supports the delivery of academic material[8]. During
73 PAL, movement is integrated into teaching and as such, PAL are distinct from 'brain/movement breaks',
74 when activity is separate from learning. Evidence from primary schools indicates that PAL can improve
75 physical activity, academic achievement and lesson enjoyment[9-12]. To our knowledge, only two
76 studies have trialled the use of PAL among adolescents[13, 14]. Helgeson (2013) reported no influence
77 of the 'Energizers' PAL programme on reading comprehension scores among junior high school
78 students and did not explore activity levels as a primary outcome[13]. Cothran and colleagues (2010)
79 reported on primary and secondary/high school teachers' experiences of a one-year movement
80 integration intervention. Compared to primary school teachers, secondary teachers faced different
81 challenges when attempting to integrate activity into lessons, in particular standardised testing
82 pressures and students not staying with one teacher all day (as typically is the case in primary

schools)[14]. Cothran and colleagues did not measure student activity behaviours as an intervention outcome[14]. The positive effects of PAL reported for primary students suggest there is value in exploring if secondary students can experience similar benefits. Given the organisational and environmental differences between primary and secondary schools, it is important to conduct high quality feasibility and pilot testing of secondary school PAL interventions.

A PAL training programme for secondary school teachers was tested in a feasibility study and a cluster-randomised controlled pilot study. The studies aimed to explore the feasibility, acceptability, costs, and preliminary effectiveness of a PAL training programme for secondary teachers. Acceptability of study processes was also examined, in anticipation of conducting a subsequent full trial. The feasibility study tested the intervention among maths and English teachers at one school, the pilot study tested the intervention among all-subject teachers and as part of a controlled trial. This paper presents the feasibility study and pilot study followed by an overall discussion and conclusion (ISRCTN38409550).

1. FEASIBILITY STUDY

Ethical approval for both studies was granted by the University of Cambridge's School of the Humanities and Social Sciences. The aim of the feasibility study was to assess (i) the feasibility, acceptability, costs, and preliminary effectiveness (for reducing sedentary time and improving wellbeing and time-on-task among students) of a PAL training programme for secondary school teachers, and (ii) the feasibility and acceptability of study procedures.

Feasibility Study - Methods

Recruitment

Potential schools were identified from previous local research and approached with study information (n=2). One mixed-sex, non fee-paying secondary school participated. The head teacher provided written consent for the intervention to be delivered to the teachers, elected for the intervention to be

trialled with maths and English teachers, and chose years 7 and 9 to participate in study evaluation measures. The school were told they would be able to keep the PAL training resources.

Parents of all Year 7 and 9 students (11-14 years) received study information and students were invited to participate in evaluation measures. Parents were given two weeks to opt out (passive parental consent) via email, freephone, or freepost. From the students who had not been opted out, 120 (sixty Year-7 and sixty Year-9 students; 50% male) were randomly selected for evaluation measures (using class lists and random number generating software). The study's feasibility focus meant that a formal power calculation was not necessary to inform sample size; a sample of 60 participants per year is consistent with samples of similar studies[15]. Students provided written assent for evaluation measures.

Maths and English teachers (n=15) received study information two weeks before the PAL training. The senior leadership team requested that all maths and English teachers attend the training. Teachers could choose to participate in the evaluation measures, those agreeing provided written consent. Over five school days students received approximately five maths lessons and four English lessons.

Intervention

The PAL training was developed by a team with teacher training qualifications and experience in indoor (two trainers) and outdoor active learning (one trainer). The training was delivered at the intervention school between March and April, during pre-scheduled after-school teacher-training time. Table 1 outlines the training programme and example active lessons are published as supplementary material. The focus was on supporting teachers to adopt active pedagogical approaches (teaching strategies that incorporate activity), rather than providing new, PAL plans. The training was underpinned by aspects of social cognitive theory and aimed to enhance teachers' self-efficacy in relation to PAL[16]. As such it drew from two prominent behaviour change techniques: barrier identification and modelling/demonstrating behaviour[17]. With the former, teachers were encouraged to identify barriers that might impact their ability to implement PAL and plan ways to overcome these. With the

latter, the trainers demonstrated a plethora of PAL teaching strategies that teachers could employ in their lessons. Figure 1 outlines the preliminary logic model of how the teacher-focused intervention could lead to changes in students' activity. Prior to the training, the research team visited the participating school and ascertained the availability of indoor and outdoor spaces and equipment that could be used for PAL. Syllabi for maths and English were requested to allow trainers to prepare relevant examples for the training.

Measurements

Table 1 outlines the timeline of study measures. Feasibility and acceptability were assessed using questionnaires and focus groups. Three focus groups (with five teachers, eight Year-7 and four Year-9 students) and an interview with the assistant head teacher were completed using a semi-structured interview.

i. Evaluation of Intervention and Study

Feasibility/acceptability of the intervention: Questionnaire items and focus group questions asked about teachers' perceptions of the utility, value and relevance of the training (adapted from[18, 19]). Questionnaires asked if teachers would recommend the training to other teachers and provided free-text boxes for teachers to suggest improvements. Training session attendance rates were recorded.

Feasibility/acceptability of PAL delivery: Questionnaire items and focus group questions asked teachers about classroom management during PAL, enjoyment of teaching PAL, time needed to prepare and deliver PAL, and barriers to PAL delivery (items from[20]).

Acceptability of PAL participation: Questionnaire items and focus group questions asked students about their experience of PAL participation, enjoyment of PAL, their preference for active vs. desk-based lessons, and the best and worst things about PAL.

Costs: Teachers and students reported resources purchased to deliver/participate in PAL. The research team recorded time and costs associated with the training team's development and delivery of the intervention.

Study processes: The research team made field notes on study processes that proved to be challenging or ineffective, for example, students struggling to understand a questionnaire item.

ii. Intervention Outcomes

Student anthropometry: Anthropometric measures were completed by trained staff using standard procedures. Height was measured using a stadiometer (Leicester height measure, Chasmors, Leicester, UK) to the nearest 0.1 cm, and weight was measured to the nearest 0.1 kg (Tanita, type TBF-300A, Tokyo, Japan). The measurement stations were set up so that results were not visible to anyone except the measurement staff. Height, weight, sex, birthdate and measurement date were used to calculate participants' body mass index (BMI; kg/m²) and BMI percentile.

Activity intensity: Axivity AX3 triaxial wrist-worn accelerometers (non-dominant wrist) were used to measure activity behaviours. These devices have been used among a larger sample of Year-9 participants in the GoActive study[21] and the UK Biobank Cohort Study[22]. Wrist-worn monitors are validated for the assessment of energy expenditure in pediatric populations[23] with higher participant compliance when compared to waist-worn accelerometers[24]. Participants were given verbal and written instructions on monitor wear, including that the monitor was waterproof and could be worn continuously for the next seven days (Monday to Monday).

The first day of monitor wear was dropped[25]; included participants provided valid data for ≥80% of school hours for ≥two school days, at baseline and follow-up[26-28]. Acceleration was recorded at 100Hz with a dynamic range of ±8g. Data from the monitors was downloaded in continuous waveform. Euclidean Norm Minus One (ENMO) represents acceleration magnitude at each measurement, accounting for the influence of gravity. ENMO thresholds were used to classify activity intensities: time

spent at 0-30 ENMO was classified as sedentary activity (equivalent to 1-1.5 METs); 30-210 ENMO as light-intensity activity (1.5-4 METs); 210-500 ENMO as moderate-intensity activity (4-7 METs), and above 500 ENMO as vigorous-intensity activity[29, 30].

Mental Health and Wellbeing: Students completed questionnaire measures of positive and negative affect[31], academic efficacy, disruptive behaviour[32], enjoyment of school classes[33] and health related quality of life[34-39] at baseline and follow-up. All questionnaires are validated for use with adolescents and were analysed according to published instructions[31, 32, 39].

Time-on-task: Students' time-on-task was assessed during three lessons by one member of the research team using a momentary time-sampling procedure (which incurs less bias than other sampling procedures[40, 41]). At the start of each observed class, the teacher asked all students participating in the study to raise their hands. From the students that raised their hands, the researcher identified two boys and two girls (when possible) to observe. The researcher chose students sitting in different areas of the classroom. Each student was observed once per minute, in a consistent order, for the duration of the lesson. Students' behaviour was coded as: (i) on-task, (ii) off-task-passive, (iii) off-task-motor, or (iv) off-task-noise[42]. The mean percentage of intervals recorded as 'on task' for observed students and classes was calculated and used as the outcome measure.

Prior to classroom observations, a validation activity was completed where two researchers discussed definitions and concurrently coded student behaviour using four online videos. Observers' codes matched for 95% of observation intervals.

Descriptive Statistics

Descriptive statistics of the sample, primary and secondary outcomes, and quantitative measures of feasibility and acceptability are summarised. Focus group transcripts were reviewed; recurring comments and themes relevant to the research questions were identified.

202 **Feasibility Study - Results**

203 Recruitment and sample characteristics

204 Student and teacher recruitment and characteristics are summarised in supplementary tables 1 and 2.
205 Of 120 students invited to participate in the evaluation measures, 99 were recruited, with 91 (92%)
206 providing data at baseline and follow-up. Students had a mean age of 13.0 (± 1.1) years, 52% were male
207 and 27% were classified as overweight/obese. Teachers were predominantly female (67%) and below
208 the age of 45 (83%).

209 Feasibility and Acceptability

210 Training session one was attended by 14 (out of 15) teachers (7 maths, 7 English), training session two
211 was attended by 12 teachers (7 maths, 5 English), 11 teachers attended both sessions. Teacher
212 feedback demonstrated acceptability of the training, with 100% recommending the training to other
213 teachers (supplementary table 3). Individual and collective efficacy for delivering PAL improved from
214 2.7 to 3.2, and 2.4 to 3 (out of 4), respectively. At follow-up, \geq eight teachers had attempted to deliver
215 PAL. Teacher's goals for PAL delivery averaged 2.1 (SD=1.0) lessons per week, with an average targeted
216 reduction in sitting time of 15.8 (SD=8.0) minutes. Some teachers reported positive experiences of
217 delivering PAL, while others reported challenges (Text box 1).

218 Teacher-reported barriers included disruptive behaviour, lethargy and off-topic chatting, challenges re-
219 focusing students after an active portion of class, and limited classroom space. Teachers identified
220 facilitators of PAL delivery as theirs and the students' enjoyment of PAL, good weather allowing them
221 to go outside, more classroom space and a more diligent group of students. Teachers reported ≤ 15
222 extra minutes were required to plan PAL, and a few extra minutes were needed to prepare students
223 for PAL participation.

224 Of the students who recalled participating in an active lesson (47%), most preferred PAL to desk-based
225 lessons (70%; 19% indicated 'no preference') and 93% wanted teachers to continue delivering them.

226 Students reported enjoying going outside and moving around (30%), that PAL were less boring/more
227 fun than desk-based lessons (26%) and that they could concentrate better (14%). Negative comments
228 about PAL included lethargy (12%), more disruptive behaviour (9%), and less work achieved (12%; text
229 box 1).

230 The assistant head teacher felt the training was well-received and high-quality professional
231 development. The school's reasons for participating in the project included the potential for improving
232 students' mental health and the motivation to be innovative in the classroom. The assistant head
233 teacher commented that teaching staff had enjoyed taking students outside for lessons and the project
234 had involved a low level of commitment from the school.

235 Costs

236 Training delivery costed £910, comprised of £410 staff costs and £500 for training equipment.
237 Participants reported purchasing sticky tape (teacher, ~£2) and shoes and tights (student, ~£30).

238 Study Processes

239 The majority of study procedures were completed successfully. Challenges encountered included that
240 students struggled to complete a blank timetable indicating when their Maths and English lessons were,
241 and despite efforts, we were unable to schedule follow-up classroom observations. Teacher baseline
242 questionnaire return was low and the follow-up focus group was conducted in a 15-minute timeslot
243 due to late changes.

244 Preliminary effectiveness

245 Table 2 summarises baseline and follow-up data for all student measures. Sedentary time increased by
246 8.7 minutes and time spent in light-intensity activity decreased by 8.1 minutes. Minimal changes were
247 observed in the mental health and wellbeing scores between baseline and follow-up.

248 Feasibility Study - Reflections

The findings suggest it is feasible and acceptable to deliver a PAL training program to secondary school maths and English teachers. Importantly, the senior leadership representative was supportive of the training[43]. Secondary school teachers had mixed reports of delivering PAL, the identified barriers and facilitators were consistent with those previously reported[43]. It was noted that teacher acceptability of PAL delivery should be explored further in the next phase of intervention evaluation. The positive student response to PAL indicates acceptability and is consistent with results from PAL interventions in primary schools[44].

We were successful in recruiting and consenting participants, and the majority of evaluation measures were completed without problems. The retention of >90% of participants from baseline to follow-up suggests evaluation measures were acceptable. Suggested changes included scheduling all research activities at the start of the project and acquiring student timetables from the school's administration team.

Limitations of this feasibility study include the small sample size and the lack of control group, making it not possible to draw conclusions about the contribution of the intervention to the observed changes. The change in sedentary activity levels is inconsistent with previous research reporting that younger children's sedentary time on weekdays decreases between spring and summer[45]. Increased negative feelings and lower wellbeing among students between March and June is consistent with typical changes observed in students' wellbeing over a school term[46, 47].

2. PILOT STUDY

Following successful implementation of the intervention in the feasibility study, we sought to extend our previous work and explore the potential value of conducting a full-scale randomised controlled trial. The aims of the pilot cluster-randomised controlled trial were (i) to assess the feasibility, acceptability, preliminary effectiveness and costs of delivering a PAL intervention at a whole-school level (to all subject teachers) and (ii) to test the acceptability of school-level randomisation.

274

275 **Pilot Study - Methods**

276 Recruitment and Randomisation

277 *Schools:* We aimed to recruit three schools - two intervention (to test whole-school delivery of the
278 intervention in different settings) and one control (to test the acceptability of school-level
279 randomisation). In June-July 2017, 26 non fee-paying, mixed gender, secondary schools in the East of
280 England were emailed study information and invited to participate (the school that took part in the
281 feasibility study was not invited to participate in the pilot study). The first three schools to agree were
282 recruited; one school withdrew prior to student recruitment (and randomisation). We were unable to
283 replace the school within an appropriate timeframe. After baseline measures, individuals separate from
284 the research team performed a coin-toss to assign intervention and control schools. The nature of the
285 intervention and goals of the evaluation measures meant it was not possible to blind participants. Due
286 to differences in follow-up measures between control and intervention schools, it was not possible to
287 blind measurement staff at follow-up.

288 *Students:* Recruitment proceeded as outlined for the feasibility study. Schools were asked to choose
289 one younger year (7 or 8) and one older year (9 or 10) group to participate in evaluation measures. This
290 would allow assessment of differential responses to the intervention by age. The intervention school
291 selected Years 7 and 9 and the control school selected Years 8 and 9. Following feasibility study
292 procedures, we randomly selected 130 students (50% male, 50% from each year) from each school for
293 evaluation measures (based on feasibility study retention rates), with the aim of obtaining full data on
294 100 participants.

295 *Teachers:* A teacher information and recruitment meeting was scheduled at both schools, during which
296 a researcher introduced the study and distributed consent forms. Teachers were advised by their senior

297 leadership team that they would be required to attend the PAL training if allocated as the intervention
298 school; all teachers were free to decide on participation in evaluation measures.

299 Intervention

300 Extending the feasibility study, the intervention was delivered to all subject teachers. Training all subject
301 teachers is consistent with the whole-school approach recommended for activity promotion and
302 obesity prevention among youth[48, 49]. Given the acceptability of the training demonstrated in the
303 feasibility study, the structure and goals of the training for the pilot study were similar. Minimal changes
304 were made to the indoor training component, which focused on generic active learning strategies,
305 applicable to any subject (e.g., different workstations around the classroom). In the feasibility study,
306 the outdoor training component provided multiple subject- and topic-specific lesson ideas; the
307 inclusion of all subject teachers meant fewer subject-specific examples could be actively worked
308 through during the pilot study training. One additional outdoor lessons trainer was involved to train the
309 larger group of teachers.

310 Measurements

311 Table 1 outlines the timeline of study measures; all data were collected at schools, during school hours.
312 To increase teacher baseline questionnaire return, questionnaires were distributed during the pre-
313 training teacher information meeting, and completed following consent. Data collection followed the
314 same procedures as described for the feasibility study, except for the assessment of PAL dose and time
315 on task.

316 *PAL Dose:* A teacher timetable was created using school-provided student timetables, detailing their
317 Year 7 and 9 lessons. During the student accelerometer assessment at follow-up, teachers were given
318 their personalised timetable and asked 'please circle which of the listed Year 7 and/or 9 classes were
319 (or will be) delivered as an active lesson.' Teachers responses were used to calculate PAL dose. *Time on*
320 *task:* Four lessons were observed at baseline and follow-up, at both schools. At baseline (prior to

321 delivery of PAL training) the research team observed typical desk-based lessons. At follow-up, the
322 research team asked to observe physically active lessons.

323 Patient and Public Involvement

324 In an earlier phase of CASE, opinions of key stakeholders regarding (i) suitable PA interventions for
325 secondary schools and (ii) salient outcomes, were explored in a Delphi study ([7]). The decision to trial
326 a PAL intervention and inclusion of mental health and time-on-task measures were informed by the
327 Delphi study. While stakeholders were not involved in study design, conduct or recruitment, they
328 reviewed questionnaires and provided feedback on qualitative findings. Student participants received
329 a personal PA report and participating schools will be provided with a summary of the findings. Assistant
330 head teachers commented on the time commitment of the intervention and teacher participants
331 reported on time spent implementing intervention components.

332 Descriptive statistics

333 Descriptive statistics and focus group analysis proceeded as outlined for the feasibility study.

334 Pilot Study - Results

335 Figure 2 shows the flow of participants, with further information on student and teacher recruitment
336 and sample characteristics in supplementary tables 1 and 2. Of the assenting students (n=222) 92%
337 provided data at two time points. Half of the students were male and 24% were classified as
338 overweight/obese. The majority of teachers were female and >50% of staff reported delivering at least
339 one PAL a week at baseline. At the intervention school, 30 and 33 teachers attended training session
340 one and two, respectively (29 teachers attended both).

341 Feasibility and Acceptability

342 Average scores regarding teachers' acceptability of the training fell below 4 (the 'neutral' value)
343 indicating negative feelings towards the training (supplementary table 3). Teachers reported training
344 activities to be more suited for primary schools and not sufficiently challenging for secondary students.

345 One teacher commented: *“they were more bonus activities, like extra treat things... you couldn’t get*
346 *much learning done through them”* (Science teacher, female). Teachers felt it was assumed they
347 weren’t delivering PALs prior to the training and this created resistance towards the training effort.
348 Teachers reported that the PAL ideas were not novel and repetitive, the focus on outdoor learning was
349 distracting, and the value of outdoor activities wasn’t clear.

350 More than half of teachers reported delivering at least one PAL a week at baseline. PAL delivery
351 decreased for four teachers (11%), was maintained by six teachers (17%), and increased for 13 teachers
352 (36%) (excluding P.E. and drama teachers). At follow-up, teachers indicated they were likely to continue
353 teaching PAL, although they reported concerns about students not learning as much during PAL. Some
354 teachers felt older students could be more lethargic and resistant: *“the younger ones love getting up*
355 *and interacting with each other. I think the older ones do, it just takes... more effort to get them going”*
356 (History teacher, female).

357 The majority of teachers reported ≤ 15 minutes for planning, ≤ 5 minutes for classroom preparation, and
358 ≤ 5 minutes for student preparation. The time needed to deliver an outdoor activity – in particular the
359 transition between indoors and outdoors - was identified as a barrier to implementation. The assistant
360 head teacher also commented about the pitch of the training and poor use of learning time due to
361 transitioning. They felt the indoor component of the training had been more informative and
362 appropriate, and commented staff had used active learning strategies indoors, but not outdoors.
363 Finally, they commented that PAL implementation had declined with time.

364 Of the students who recalled participating in a PAL (58%), >90% wanted teachers to continue teaching
365 PAL, with no evidence of differences in intervention acceptability by sex or weight status. Students
366 commented that PAL were fun and helped learning, and they liked moving more: *“I really enjoyed it. It*
367 *gave me more of an understanding... because when you’re just copying off the board some writing I*
368 *don’t always understand it, then when you’re moving about it’s a lot more clearer”* (Year-7, female).

369 Students however also commented that during PAL some students messed around more and didn't
370 focus on work, and work was easier to do when sitting down.

371 Student PAL dose

372 In one week, 62/175 lessons (35%) to Year 7 and 9 students were active (31 lessons each). Each teacher
373 delivered an average of 2.2 PALs (range = 0-9). Year-7 students received an average of 6.9 PAL (range:
374 5-10; 28% of one week's lessons) and Year-9 students 6.9 (range: 2-13; 28%). This represents the
375 contribution across all subjects.

376 Costs

377 The cost of delivering the training was £901, comprised of £451 staff time and £450 equipment. Session
378 one was delivered by three trainers, while session two was delivered by four trainers. Four teachers
379 purchased resources to support PAL delivery, including science equipment, textiles equipment, post-it
380 notes and whiteboard pens, and printed resources. Four students reported purchasing resources to
381 support PAL participation – three purchased sports shoes (~£30 per pair) and one a mouth guard (~£7).

382 Preliminary Effectiveness

383 Table 3 presents activity intensity during PAL at follow-up and the equivalent lesson at baseline
384 (excluding P.E. and drama lessons). There was no evidence of changes in sedentary activity or time
385 spent in light, moderate and vigorous activity intensities. Table 4 summarises baseline and follow-up
386 values for all outcome measures for intervention and control participants. There was no evidence of
387 preliminary effectiveness on sedentary time or light activity, or on indicators of mental health and
388 wellbeing (including academic efficacy, positive & negative affect, and disruptive behaviour).

389 **Pilot Study - Reflections**

390 Extending the work conducted in the feasibility study, this pilot study demonstrates the feasibility of
391 whole-school intervention delivery. However, teachers expressed numerous concerns about the PAL
392 training, including the insufficiently challenging content, lack of understanding of the value/purpose of

the outdoor component, and potential loss of valuable learning time. These examples are consistent with previous research reporting that time and standardised testing pressures are barriers to PAL implementation, particularly for secondary school teachers[14]. The feedback suggests a need to review the content of the training, particularly the outdoor component.

Teachers comments indicated acceptability of delivering PAL and there was a measurable increase in PAL delivery. Feedback suggests teachers' acceptability may reflect prior knowledge and experience of PAL. In addition, students reported enjoying PAL. Support for the intervention by multiple stakeholders is an important facilitator of successful implementation[43]; as such, the feedback received here is encouraging.

Some students reported purchasing sports shoes and mouthguards for PAL; none of the strategies introduced in the PAL training involved students changing clothing/shoes or using mouthguards. It is conceivable that when completing the follow-up questionnaire some students considered P.E. lessons in their appraisal of PAL and reported shoes and mouthguards purchased for this.

We successfully tested study procedures and intervention delivery at a whole-school level, with adequate recruitment and retention rates and continued control school involvement indicating acceptability of randomisation. Efforts made to improve data collection processes from the feasibility study, e.g., of student timetables and teacher questionnaires, were successful.

The assessment of PAL dose showed that students received an average of 6-7 x 60-minute PAL a week, which has the potential to make a valuable contribution to reducing sedentary time among adolescents. Despite a measured increase in PAL delivery, there was no evidence of reduced sedentary time, suggesting a need to review the PAL strategies that were shared with teachers, with a focus on the amount of activity introduced. It is also possible that teachers over-reported PAL delivery out of concern for being judged by the researchers and/or their senior leadership team.

417 OVERALL DISCUSSION

418 In this project, we aimed to assess the feasibility, acceptability, preliminary effectiveness and costs of a
419 teacher-training programme for integrating activity into secondary school lessons. We also sought to
420 understand the feasibility and acceptability of study procedures, including repeated accelerometer
421 wear and school-level randomisation. The intervention was delivered in two schools and quantitative
422 and qualitative data were successfully collected from multiple stakeholders, enabling us to address all
423 research questions. The majority of PAL evaluations have been carried out in primary schools[9] and as
424 such, this study makes a valuable contribution to the literature.

425 Feasibility/acceptability of PAL training

426 Consistent with previous research, it was feasible to deliver PAL training to secondary school teachers
427 over two, 2-hour, after-school sessions[50]. Schools scheduled the PAL training during pre-scheduled
428 after-school teacher-training slots, as such, the intervention did not require teachers to attend any
429 more after-school training than they typically would within a school term. In both studies, a small
430 number of teachers were unable to attend both training sessions which may have influenced
431 intervention outcomes. It is realistic that at any school receiving the intervention, a proportion of staff
432 would be unable to attend both training sessions. As such the external validity of the findings is
433 supported.

434 While acceptability of the training was demonstrated in the feasibility study and is reported
435 elsewhere[18, 44, 50], feedback from teachers in the pilot study was less positive. Delivery to teachers
436 of two subjects in the feasibility study meant a smaller training group and a smaller trainer:staff ratio
437 than in the pilot study. This allowed more subject-specific discussion and more time to address
438 teachers' personal questions. Teacher feedback suggests that training acceptability is related to
439 teachers' experience delivering PAL. In the pilot study, teachers delivering PAL more regularly rated the
440 intervention more poorly than less experienced teachers. A PAL intervention targeting teachers not
441 regularly delivering PAL may be more acceptable. The positive responses to the training in the feasibility

study (involving teachers reporting low levels of PAL delivery) support this suggestion. Teacher's concerns regarding the lack of learning associated with PAL strategies must be an important consideration in the design of future PAL interventions. Student learning is the core focus of schools and implementation of PAL is likely to be contingent on teachers perceiving that PAL supports this goal.

Feasibility/acceptability of delivering/participating in PAL

In the feasibility study, teachers had mixed reviews of delivering PAL, whereas in the pilot study, teachers reported acceptability of delivering PAL. Pilot study teachers were more likely to report regular PAL delivery at baseline than feasibility teachers and to have had previous exposure to PAL during their initial teacher training and/or career. A longer trial period and increased support may have allowed teachers in the feasibility study to become more confident and accrue more positive PAL experiences. Overall, the data suggest that PAL delivery can be acceptable to secondary school teachers.

While teachers were the direct intervention recipients and their acceptability is crucial for successful implementation, it is important to consider acceptability for other stakeholders, who also influence implementation. Across both studies students responded positively to PAL, and senior leadership representatives reported satisfaction with the intervention (in the pilot study, satisfaction with the indoor component). Both senior leadership representatives commented that reasons for study participation included the potential positive influence on students' mental health. This observation is consistent with previous findings[7] and indicates potentially effective strategies for promotion of the intervention to schools.

Preliminary Effectiveness

Despite a measured increase in PAL delivery, no changes in activity were observed. The findings are consistent with a systematic review and meta-analysis of secondary school classroom-based physical activity interventions, which reported no significant influence on activity behaviours[51]. Although, other PAL feasibility and pilot studies have reported more encouraging changes[42, 51-53]. In the feasibility

study, early implementation efforts of Maths and English teachers may not have been sufficient to translate to changes in activity. It's possible that more or longer training sessions could increase teacher's confidence and competency for delivering PAL, however, initial discussions with the feasibility study school suggested that a 2-hour after-school training session would be acceptable while a 3-hour session would be too long. Across both studies, teachers were advised that any non-seated activity was considered an 'active lesson' - as such, the intervention may be too dilute for measurable impact using wrist-worn accelerometers; **classroom observations of PAL (beyond assessing time on task) may have aided our interpretation of the findings.** Overall, the results suggest the need to review the amount of activity the PAL strategies introduce.

Students received an encouraging dose of PAL (6-7 x 60-minute lessons per week). This dose is consistent with previous studies, for example, 10-30 minutes of activity, daily[42, 53-56] and 3 x 60-minute PAL per week[57]. It is worth noting that teachers in the current pilot study chose how many PAL they delivered, rather than being prescribed a weekly target; as such the dose indicates what is naturally achievable by secondary school teachers. A weekly dose of 6-7 PAL has the potential to substantially reduce adolescents' sedentary time during school hours, providing sufficient activity is introduced as part of the PAL.

Costs

Training delivery costs (independent of travel and planning time) was estimated around £900 (\$1,187) in both studies. Strategies to reduce costs could include reducing the number of staff delivering the sessions or hiring staff with a mixture of training levels, rather than the highly experienced staff in the current studies. Approximately 25% of the cost was spent on equipment, primarily for outdoor-based subject-specific examples; reviewing the equipment purchases may identify cost saving opportunities. Research reports that small grants (~\$2,000) to schools can lead to increased implementation of practices to promote activity[58]. Senior leadership teams commented on how thinly English schools

budgets are stretched; it was suggested that school funds set aside for (for example) mental health services might represent an avenue of funding for the programme for some schools.

Strengths and Limitations

High quality formative work for interventions is necessary to ensure appropriate allocation of research efforts and funding, and the publication of feasibility and pilot research is important to support other researchers and interventionists[59]. Limitations of this work include that samples were predominantly white; consequently, we are unable to explore differential responses to PAL by ethnicity. Moreover, parental opt out consent procedures limited the ability to obtain information on participants' socioeconomic position. The issue of lack of diversity among samples in PAL studies has been previously raised[60]; future research should seek to explore feasibility, acceptability and effectiveness among different racial/ethnic and socio-economic groups. Estimated training delivery costs are based on wage rates, national insurance and superannuation costs but don't include overhead costs such as costs of employing individuals and providing building space. As such, training delivery costs may be underestimated. In addition, we did not carry out longer-term follow-up assessments so we do not know if teachers continued to deliver PAL beyond eight weeks after the training. Finally, we do not believe that lack of blinding of measurement staff has impacted the conclusions drawn from these studies, but acknowledge that a potential fully-powered trial would benefit from efforts to blind measurement staff.

CONCLUSION

We successfully demonstrated the feasibility and acceptability of introducing and evaluating a PAL teacher-training programme in secondary schools. Across feasibility and pilot studies, teachers' acceptability of the intervention and of delivering PAL was demonstrated, although aspects of the training programme, particularly the outdoor component, require review. The intervention was acceptable to students and senior leadership representatives, and the dose of PAL received by students was sufficient to have the potential to make a substantial contribution to reducing adolescents'

515 sedentary time during school hours. However, we did not observe preliminary effectiveness on
516 students' activity behaviours or wellbeing indicators. Taken together, the findings do not support
517 continuation with the current PAL training programme, though its acceptability does highlight the need
518 for further research into how the identified barriers might be overcome.

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Data sharing

The datasets are not available for download. The study’s participant information sheets and ethics applications stipulated that the data would not be shared outside of the research team. The data are held at the MRC Epidemiology Unit at the University of Cambridge.

Competing interests

The authors declare that they have no competing interests.

Author contributions

All authors (Catherine Gammon, Katie Morton, Andrew Atkin, Kirsten Corder, Andy Daly-Smith, Thomas Quarmby, Marc Suhrcke, David Turner and Esther van Sluijs) contributed to the conceptualisation and design of the work, and reviewed and approved the final manuscript. Catherine Gammon, David Turner, and Esther van Sluijs contributed to the acquisition, analysis and interpretation of data. Catherine Gammon drafted the manuscript.

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Figure legends:

Figure 1. Logic model of how a PAL intervention may result in changes in student's sedentary activity (SED).

Figure 2. CONSORT flow chart of pilot study participant recruitment (schools and students).

Table 1. Outline of the PAL training programme and timeline of evaluation measures.

	Week 0 Baseline Measures	Week 1	Week 4	Week 12 Follow-Up Measures
Feasibility Study	Students: <ul style="list-style-type: none"> • Anthropometry • Questionnaire (15 minutes) • Accelerometry • Time-on-Task Teachers: <ul style="list-style-type: none"> • Questionnaire 	Training session 1 (2 hours) 30 minutes: Introduction to active learning 40 minutes: Split group in half: <ul style="list-style-type: none"> • Half stay in classroom and review classroom-based PAL strategies • Half go outside and review outdoor PAL strategies 40 minutes: Groups switch 10 minutes: Final comments	Training session 2 (2 hours) 30 minutes: Sharing PAL experiences 30 minutes: Outdoor PAL examples 15 minutes: Indoor PAL examples 15 minutes: Discussion of intervention expectations 10 minutes: Post-training questionnaire	Students: <ul style="list-style-type: none"> • Questionnaire (15 minutes) • Accelerometry • Time-on-Task • Focus groups Teachers: <ul style="list-style-type: none"> • Questionnaire • Focus group Senior Leadership Team: <ul style="list-style-type: none"> • Interview
Pilot Study: Intervention School	<i>Same as for feasibility study baseline measures</i>	<i>Same as for feasibility study training session 1</i>	Training session 2 (2 hours) 45 minutes: Split group in half: <ul style="list-style-type: none"> • Half review indoor PAL strategies • Half review outdoor PAL strategies 45 minutes: Groups switch 10 minutes: Whole-group outdoor activity. 10 minutes: Post-training questionnaire	<i>Same as for feasibility study follow-up measures</i>
Pilot Study: Control School	<i>Same as for feasibility study baseline measures</i>	No training session	No training session	Students: <ul style="list-style-type: none"> • Questionnaire • Accelerometry • Time-on-Task

Table 2. Baseline and follow-up values for primary and secondary outcomes; mean (SD).

	N	Baseline	Follow-Up	Mean Difference (95% C.I.)
Sedentary activity (minutes)	76	237.4 (26.4)	246.1 (27.6)	8.7 (3.8,13.7)
Light activity (minutes)	76	139.8 (21.8)	131.7 (22.6)	-8.1 (-12.4,-3.8)
Moderate activity (minutes)	76	10.8 (6.0)	10.3 (5.8)	-0.6 (-1.4,0.3)
Vigorous activity (minutes)	76	2.0 (2.0)	1.9 (1.8)	-0.1 (-0.4,0.3)
Time-on-task (% intervals on-task)	11	66.1	-	-
Academic Efficacy (score 1-5)	85	3.51 (0.80)	3.63 (0.83)	-
Disruptive Behaviour (score 1-5)	82	1.90 (0.95)	1.94 (0.98)	-
CHU-9D (score 0.33-1.0)	89	0.86 (0.10)	0.84 (0.10)	-
Positive Affect (score 1-5)	81	17.35 (3.44)	16.16 (3.36)	-
Negative Affect (score 1-5)	84	10.55 (3.28)	10.71 (3.48)	-
Length of school day = 390 minutes				

Table 3. Activity intensity during 60-minute PAL at follow-up and the equivalent lesson at baseline (excluding P.E. and drama); mean (SD).

	N	Baseline	Follow-Up	Mean Difference (95% C.I.)
Sedentary activity (minutes)	310	41.1 (8.4)	42.1 (8.6)	1.0 (-0.1,2.1)
Light activity (minutes)	310	17.9 (7.6)	16.9 (7.8)	-1.1 (-2.1,0)
Moderate activity (minutes)	310	0.8 (1.0)	0.9 (1.0)	0 (-0.1,0.2)
Vigorous activity (minutes)	310	0.2 (1.1)	0.2 (0.6)	0 (-0.1,0.1)

Table 4. Baseline and follow-up values for primary and secondary outcomes; mean (SD).

	Control School ^a				Intervention School ^a			
	N	Baseline	Follow-Up	Mean Difference (95% C.I.)	N	Baseline	Follow-Up	Mean Difference (95% C.I.)
Sedentary activity (minutes)	74	217.0 (32.4)	222.1 (36.2)	5.1 (-1.3,11.5)	96	236.4 (31.8)	237.7 (40.6)	1.3 (-6.2,8.7)
Light activity (minutes)	74	140.5 (26.0)	136.6 (31.9)	-4.0 (-10.1,2.2)	96	129.0 (26.8)	124.8 (31.2)	-4.2 (-10.5,2.1)
Moderate activity (minutes)	74	16.2 (7.5)	14.2 (7.8)	-2.0 (-3.2,-0.8)	96	11.1 (6.3)	10.1 (6.3)	-1.1 (-2.0,-0.1)
Vigorous activity (minutes)	74	5.5 (3.9)	4.7 (3.5)	-0.8 (-1.4,-0.2)	96	3.1 (3.0)	3.0 (2.9)	-0.1 (-0.6,0.4)
Time-on-task (% intervals on-task)	28 ^b	73.7	56.6	-	27 ^c	79.1	77.5	-
Academic Efficacy (score 1-5)	98	3.41 (0.71)	3.32 (0.71)	-	107	3.76 (0.64)	3.71 (0.76)	-
Disruptive Behaviour (score 1-5)	98	2.34 (1.23)	2.47 (1.19)	-	107	1.94 (0.94)	2.04 (1.01)	-
CHU-9D (score 0.33-1.0)	97	0.84 (0.10)	0.84 (0.09)	-	106	0.87 (0.09)	0.85 (0.10)	-
Positive Affect (score 1-5)	98	15.95 (3.33)	16.08 (3.53)	-	107	17.80 (3.10)	17.54 (3.74)	-
Negative Affect (score 1-5)	98	10.03 (3.30)	9.87 (3.14)	-	106	10.12 (3.47)	9.95 (3.06)	-

^a Length of school day varies: control school = 380 minutes, intervention school = 400 minutes

^b 14 students observed at baseline across 4 classes (all non-active lessons) and 14 students observed at follow-up across 4 classes (all non-active lessons). Students observed at baseline were different from students observed at follow-up.

^c 14 students observed at baseline across 4 classes (all non-active lessons) and 13 students observed at follow-up across 4 classes (3 active lessons, 1 non-active lesson). Students observed at baseline were different from students observed at follow-up.

Text Box 1.

"I really enjoyed them (active lessons), they (the students) enjoyed them as well, they seemed to get a lot out of them...it was good fun, it was nothing really any different to what I was normally doing, just with a few added extras" (Maths teacher, female).

"I thought they (the students) would enjoy going outside... I had high hopes for that but it was a Friday afternoon and I don't think they were ready for it... they were causing disruption, they tried to walk off" (English teacher, female).

"we concentrated more because it was more fun than just sitting around" (Year-7, male), and
"when you're sitting down you can get quite bored and get easily distracted whereas if you're moving about you've actually got something to do"(Year-7, female).