

# The impact of physically active learning during the school day on children's physical activity levels, time on task and learning behaviours and academic outcomes

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## Abstract

The benefits of physical activity in school settings and its impact on health and academic outcomes are of interest from public health and educational contexts. This study investigates how physically active learning (PAL): (i) contributes to children's physical activity levels, (ii) impacts on academic outcomes and (iii) influences children's focus and concentration, defined as time on task (ToT). **Methods:** Over a 2-week period, participants were exposed to PAL and non-active learning (NAL) lessons in a counterbalanced design. Physiological responses and ToT behaviour were recorded throughout PAL and NAL lessons. Academic outcomes were assessed the week before, during and the week after each mode of delivery. **Results:** Children were more active during PAL (196 542 steps per week) compared to NAL (152 395 steps per week,  $P = 0.003$ ). The physiological demands of PAL (73% HRmax), were significantly greater ( $P < 0.001$ ) than NAL (51% HRmax). Children's ToT was significantly higher ( $P < 0.001$ ) with PAL (97%) than NAL (87%). There were no differences in academic outcomes when PAL and NAL were compared. **Conclusions:** Modest levels of PAL increased activity levels. No evidence was found to suggest PAL had a negative effect on children's academic outcomes, and PAL could positively impact on children's concentration.

## Introduction

In the most recent review of physical activity, the British Chief Medical Officer (CMO) suggests that the health benefits of physical activity (PA) have become more compelling [1]. In adults, physical activity is seen as a protective factor for many health conditions, and in children, it could be associated with improved academic outcomes and mental health, and as a contributor to a healthy weight status and protective cardiovascular disease measure. This is further highlighted in the Health Survey for England 2017 [2] where adult obesity is linked to several common diseases (diabetes, cardiovascular disease and some cancers) and childhood obesity is linked to other health conditions (asthma, early-onset Type 2 diabetes, cardiovascular risk factors and negative outcomes linked to mental health). Given that both reports cite increasing PA as a protective measure, the role schools could play in contributing to and addressing levels of inactivity is an ongoing area of interest. Recent research [3, 4] suggests that whilst schools, by their very nature, contribute to child sedentary behaviour through desk-based activity of up to 8 h/day [3, 5], they also have the potential to enable increased participation in medium velocity PA through policy change and teaching approaches. Both studies not only cite the physical benefits but also explore the wider benefits on academic outcomes and emotional wellbeing.

In countries such as Finland, this knowledge has prompted changes in national policy by increasing

children's activity within schools [6]. Although appearing a simple solution, including PA across daily teaching is problematic and potentially a high-risk decision for UK-based school leaders who fear lowered academic outcomes. These perceived risks derive from an often-narrow curriculum, influenced by high stakes testing; the outcomes of which, hold school leaders accountable for the decisions they make [7–9]. The interplay between routine PA, academic development and physical and emotional health has therefore become a relevant and justified area of recent debate and research. The depth and breadth of research includes the broad effects of PA on improved cognition and academic outcomes [5, 10–13]; the mechanisms contributing to improved outcomes such as better concentration, improved self-regulation and behaviour, measured through time on task (ToT) [14–16]; the intensity of PA [17]; and finally the mechanisms that might underpin changes in cognition linked to executive function (EF) or academic outcomes [18–23]. ToT is important as it is seen as an easily observable measure of executive functioning linked to response inhibition and increased attention [24]. The wider impact of PA is also recognized through induced changes to brain structure and higher levels of EF associated with cognitive flexibility, working memory and mental flexibility [3, 25, 27, 28]. A new, widely accepted method for increasing PA within schools is the notion of physically active learning (PAL). PAL is the use of physical activity within lesson time, in conjunction with usual teaching materials. Because classrooms are teacher led, the inclusion of PA is therefore accepted by children as part of the learning material and process; PAL is therefore being incorporated in a number of schools. PAL has been shown to improve physical activity, cognition, academic performance and classroom behaviour when the intensity of PA is moderate or vigorous [3, 15].

The benefits of PAL within a school day are important for two distinct reasons. From a public health perspective, implementing PAL across the school day may increase physical activity levels and promote the associated, well-documented health benefits. From an educational context, improved physical

activity status, with the potential to improve concentration and academic outcomes, would enable school policy makers to justify PAL, with the integrated goal of improving children's life chances and cultural capital [10]. Based on this, the current study aims to investigate the impact of the impact of PAL compared to passive desk-based learning (non-active learning—NAL) on (i) children's activity levels [12, 13, 15], (ii) the children's ToT behaviour and (3) children's academic outcomes.

## Methodology

### Participants

Thirty-eight participants were recruited from a single mixed age UK primary school class (see Table I for pupil demographics). Children's weight status was determined using an age and gender-specific percentile for body mass index to allow for body composition and age, expressing this as a centile for age and gender [26]. Other population statistics were calculated and compared against UK averages [27]. Written informed assent and parental consent were obtained for all participating children, school participation agreement was obtained, and all procedures were approved by the Institutional Ethics Committee of the Cardiff Metropolitan University, Cardiff.

### Sampling and randomization

For ease of class teacher (CT) organization and to enable a counterbalanced study design, the study group was randomly split into two (Group A and B). The only adjustments to this randomization were

**Table I.** Baseline demographics of the included study population

	<i>N</i>	Body mass (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )
Class	36	37.4 ± 13.5	140 ± 8	18.8 ± 4.66
9 years	14	30.5 ± 5.6	141 ± 7	16.4 ± 2.49
10 years	22	41.8 ± 15.0	140 ± 8	20.4 ± 5.11
Male	21	38.9 ± 16.1	143 ± 10	18.6 ± 5.21
Female	15	36.0 ± 9.3	138 ± 6	18.6 ± 3.72

Data are presented as mean ± SD.  
BMI, body mass index.

where potential conflicting pupil pairings might exist, for example, some pupils with behaviour/Special Educational Needs and Disability plans were separated (see Table II for details).

### Study design

The study was undertaken over a 4-week period. To ensure equality of learning, PAL/NAL delivery was organized so that both groups received PAL or acted as the NAL control in a counter-balance repeated measures design (Fig. 1). Weeks 1 and 4 were normal teaching weeks with the exception of the learning outcome assessments. Teaching delivery for the PAL and NAL were led by the CT in their normal classroom space each day of Week 2 and 3 (2 × 5 sessions). The CT leading the PAL intervention was familiar with PAL as it was part of her normal daily practice. This reflects research guidelines which indicate this as a prerequisite of successful PAL delivery [4]. For this study, the emphasis was on learning, repetition and recalling of multiplication tables. During PAL, learning objectives (LOs) were delivered in combination with gross and fine motor actions. These were targeted at an intensity of between 3 and 6 metabolic equivalents of task (METs). Each PAL session was ±10 min within a 20-min maths lesson. This intensity was chosen as it would meet CMO and research recommendations [23, 24] which suggested lower MET levels might not illicit the highest cognitive benefits. Actions

used to raise heart rate, included on the spot stepping, marching, jogging, jumping, arm pulsing and some cross lateral arm and leg movements. To avoid children focusing purely (or too much) on movements at the expense of the LOs, movements were not presented as a routine. The NAL group received the same verbal delivery as the PAL group but received this inactively (seated, <3 METs).

### Protocols

#### Physiological measurements

*Activity tracking:* All children were fitted with a simple accelerometer activity tracker (Moki activity tracker, Moki Technology, Melksham, UK) to wear in school and at home in Week 1 (familiarisation week) and for the duration of Weeks 2 and 3. Each tracking unit was set by the manufacturer to detect any movement or PA above a light intensity and for the purpose of this study, total daily steps were recorded for all 7 days per week for each participant in each condition. This allowed for analysis at a group level across Weeks 2 and 3 and also at a condition level (PAL or NAL).

*Heart rate:* Heart rate monitors (Polar RS400, Polar Electro, UK) were used to measure heart rate responses to all PAL and NAL lessons in a subset of eight participants. Mean heart rate (HR) was calculated for the whole subgroup across all lessons for the week in both PAL and NAL conditions. The intensity of each session was then calculated as a

**Table II.** Baseline Socioeducational Composition of Included Study Population and Group Composition

	Group A (N = 18)	Group B (N = 18)
Male (non-disadvantaged/non-SEND)	5	5
Male (disadvantaged/non-SEND)	0	2
Male (non-disadvantaged/SEND)	3	3
Male (disadvantaged/SEND)	1	1
Female (non-disadvantaged/non-SEND)	4	5
Female (disadvantaged/non-SEND)	4	1
Female (non-disadvantaged/SEND)	0	0
Female (disadvantaged/SEND)	0	2

*Note:* Disadvantaged children are defined in the UK as children who are: (i) eligible for free school meals or have been in the last 6 years; (ii) Looked After Children (LAC), or those who have previously looked after by the state but are now adopted or are subject to a special guardianship order, a child arrangement order or a residence order; and (iii) children with parents in the armed forces.

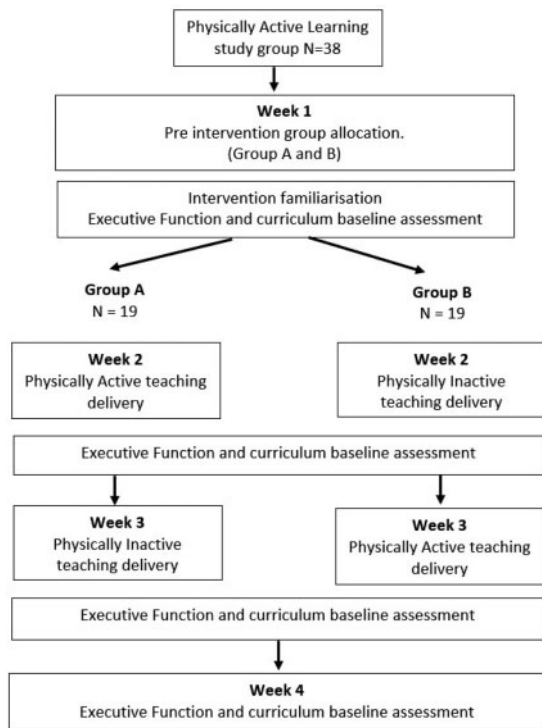


Fig. 1. Schematic outlining the study design.

percentage of predicted HR<sub>max</sub>. The formula for HR<sub>max</sub> was derived from American College of Sports Medicine (ACSM) guidelines using the Astrand model for estimating HR<sub>max</sub> ( $HR = 216.6 - [0.84 \times \text{age}]$ ).

### Academic outcomes

Four assessments of curricular learning were made. These were in the week before either intervention, at the end of the intervention week and 1 week after the intervention. All pre- and post-intervention learning assessments happened on the last day of each week and within 1 h of the last CT input in Weeks 2 and 3. The final assessment of medium-term retention happened at the end of Week 4. As a component of these assessments was delivered verbally, the CT delivery of assessments was to all children, at the same time. Curricular assessments aimed to evaluate working memory and recall linked

to LOs delivered by the CT (see Fig. 2). Pupil responses were recorded on a standardized answer sheet marked by the CT at the end of the session, and these scores used as the measure of academic outcome. For this study, immediate and applied recall of multiplication was chosen as the primary learning focus and was selected from a range of teen numbers (13–19) outside the children's normal curriculum. Curricular assessments were delivered at three levels to assess three different levels of cognition. These were: (i) five immediate recall questions (e.g.  $3 \times 13$ )—verbally delivered with 3 s cognition time; (ii) five intermediate applied recall questions—verbally delivered in a number sentence (e.g. There are 13 sweets in a bag. How many sweets in 3 bags?) with 6 s cognition time and, (iii) two layered applied recall—a verbally delivered contextual written problem with a space to record calculations. These had 20 s cognition time.

### Time on task behaviour

Assessments of cognitive and EF are viewed in this study from the perspective of observable characteristics. This approach is adopted so that any findings could have a transitional research value and reflect the everyday observations and experiences of teachers [3, 4]. The observations made specifically related to the EF characteristic of regulation, defined as ToT [23]. ToT observations were only made in the PAL/NAL weeks during the teaching sessions. Observations aimed to identify behaviours and events where possible changes in self-regulation occurred. Assessed aspects of regulation included: (i) responding and participating in physical or verbal responses, either together or singularly; (ii) inhibiting off task behaviours (not joining in, looking away, gesturing or face pulling to other children, yawning or disengaging), and (iii) Emotional regulation—particularly for participants who find change or challenge difficult.

The ToT protocol broadly followed those detailed by other researchers [10–12]. ToT was measured through momentary time sampling based on direct observation of student behaviour through a series of observational sweeps from the front side of the

Name .....

Date .....

**Quick thinking**

Immediate recall: **verbally delivered** (<3 seconds cognition time). e.g. 13 x table, (1 mark / question).

What is 6 x 14?, What is 14 x 2?, What is 14 x 10?, What is 5 x 14?, What is 14 x 4

1		
2		
3		
4		
5		

**Word Problems**

Intermediate applied recall: **verbally delivered with key numerals provided and no mental jottings** (<6 seconds cognition time). e.g. 13 x table, (2 marks / question).

4 children are each given 14 sweets, how many sweets do I give the children? A block of flats has 14 flats on each floor. There are 8 floors. How many flats are there all together? Each Quidditch team has 14 players. How many players are there from the 4 Hogwarts houses? What is 65 divided by 14?, There are 14 grapes on a bunch. How many grapes are there in 6 bunches?

6		
7		
8		
9		
10.		

11

Ken buys 3 large boxes and 8 small boxes of chocolates.  
Each large box has 20 chocolates. Each small box has 14 chocolates.

How many chocolates did Ken buy altogether?

12

As a reward for helping with jobs in the house, 4 children are given 14 sweets. If they saved all their sweets for 10 weeks, how many sweets we they have altogether?

$4 \times 14 \times 10 =$

Fig. 2. Example of academic outcome assessment answer sheet.

classroom, so the investigator is able to observe facial and physical engagement. The order of sweeps followed a predetermined and repeated direction across the classroom. The timing of each single observation was 2 s through an in-ear metronome. Behaviours were electronically marked as on-task (1) or off-task (0). A ToT score was then calculated as a percentage of total observations for a given session.

### Statistical analysis

Mean data for heart rate, physical activity level and ToT were compared for PAL and NAL weeks using a paired samples *t*-test as data was normally distributed. A repeated measures ANOVA was used to compare the means for PAL and NAL academic outcomes. *Post hoc* tests were used to identify significant main effects. All statistical analyses were performed in SPSS version 24.0 with a statistical significance set at  $P < 0.05$ .

## Results

### Population analysis

Participant characteristics indicate that the children recruited for this study are broadly in line with national averages for male/female and obese/overweight composition (Table I). Deprivation indicators place the school 14% above national averages for this element of school population. This is reflective of the school's own local authority statistics, which place the school's catchment in the lowest and second lowest quintile for deprivation. This may also contribute to the 10% higher than

national average statistics for SEND pupils (Tables II and III).

### Physiological responses to physically active learning

#### Heart rate

Analysis of mean HR responses suggest that during PAL, average intensity levels (mean = 73%HRmax) reflected moderate to vigorous activity and that in the NAL, intensity levels fell within the very light to light intensity range (mean = 51% HRmax) (see Table IV and Fig. 3). There was a significant physiological effect ( $P < 0.001$ ) of PAL activities inducing a higher HR response ( $152.12 \pm 10.569$  b.p.m.) than NAL activities ( $101.96 \pm 12.994$  b.p.m.).

#### Physical activity

Mean cumulative weekly steps indicated that in PAL week, children were significantly ( $P = 0.003$ ) more active ( $196\,542 \pm 18\,466$  steps per week) than in the NAL week ( $152\,395 \pm 23\,512$  steps per week, see Fig. 4).

**Table IV.** Average Heart Rate for the PAL Lessons and the NAL Lessons

	HR (b.p.m.)	% HRmax (%)
PAL week	$153 \pm 10$	$73 \pm 5$
NAL week	$110 \pm 3$	$51 \pm 1$

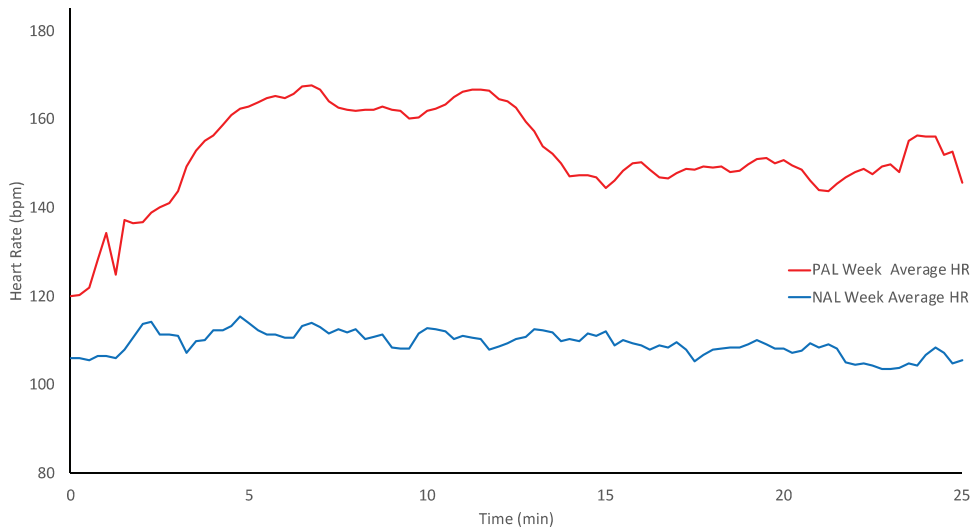
Data are presented as mean  $\pm$  SD.  
HR, heart rate,  $n = 8$ .

**Table III.** Sample Population Characteristics

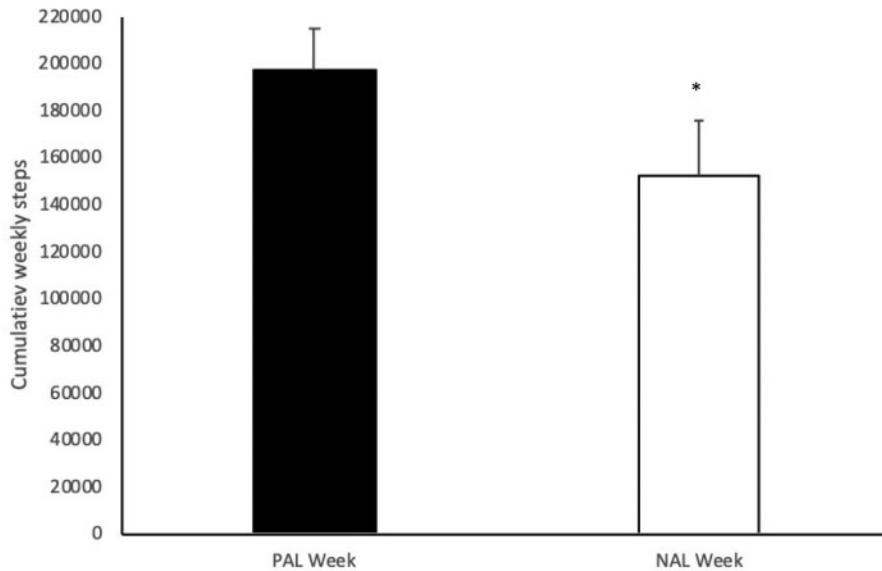
	Gender		Learning characteristics		Body composition		
	Male	Female	SEND	Disadvantage	Underweight	Overweight and obese	Obese
School	58%	42%	28%	25%	8%	31%	19%
National	55%	45%	14.6%	15.7%	5%	30%	17%

SEND, Special Educational Needs and Disability.





**Fig. 3.** Physically active learning (PAL) and non-active learning (NAL) weekly average heart rate plots for the lesson duration for an individual participant.



**Fig. 4.** Cumulative weekly steps in the Physically active learning (PAL) and non-active learning (NAL) weeks. \*Denotes a significant difference between PAL and NAL weeks,  $P < 0.05$ , data are presented as mean  $\pm$  SD.

### Cognitive responses to physically active learning

For the academic test, any children absent for any of the pre-teaching sessions were excluded ( $n=7$ ) from analysis, leaving  $n=29$  included in statistical calculations.

### Academic outcomes

Teaching had a significant effect ( $P < 0.001$ ) in raising pupil outcomes across both learning conditions from the pre-intervention starting point, to the assessment at the end of the intervention, (pre PAL to Post-PAL 1, +2 marks; pre-NAL to post-NAL +3 marks, see Fig. 5). No differences ( $P > 0.05$ ) were observed in test scores at the end of either intervention and at both post-activity assessment points (post-PAL1 8 marks; post-NAL1 7 marks and post-PAL2 6 marks and post-NAL2 6 marks).

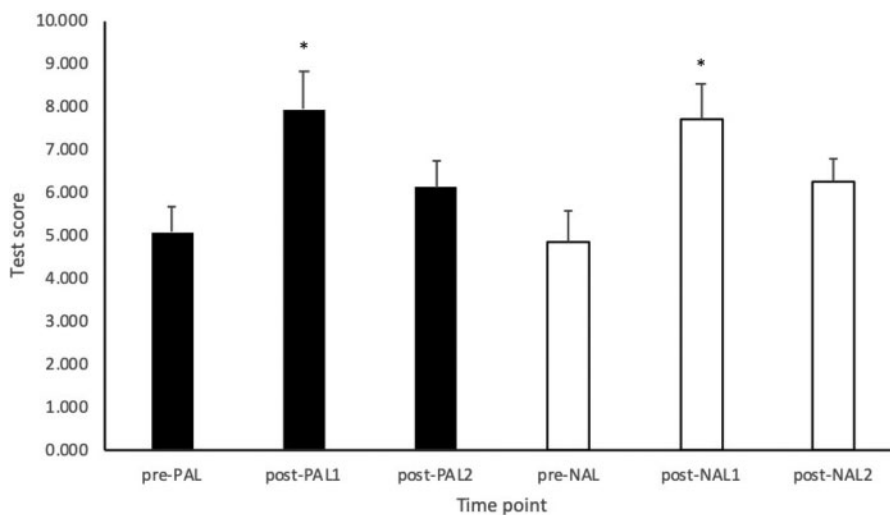
The retention of learning from the end of the intervention week (post-PAL1/post-NAL1) to the assessment 7 days later (post-PAL2/post-NAL2), indicated that for both learning conditions, knowledge had not been significantly retained ( $P > 0.05$ ) compared to the pre-intervention assessment (see Fig. 5).

### Time on task

There was a statistically significant 10% improvement ( $P < 0.001$ ) 10% in ToT, suggesting greater attention to task during PAL (97%) than NAL (87%, see Table VI).

## Discussion

The aim of this study was to investigate the benefits of PAL within a school day. The key findings from this study were: (i) PAL significantly increased physical activity levels in school children, suggesting that PAL could be implemented as a strategy to increase PA within a school setting; (ii) PAL improved ToT behaviour, indicating that PAL could have a role in regulating behaviour and maximising concentration; and (iii) PAL did not improve academic outcomes compared to NAL, demonstrating that PAL does not adversely affect children's academic performance. These findings have importance for both public health and school settings. From a public health perspective, this study demonstrates that using PAL across the school day



**Fig. 5.** Academic outcomes for physically active learning (PAL) and non-active learning (NAL) assessment weeks. Pre-PAL, before PAL week, post-PAL1 end of PAL week; post-PAL2, 1 week post end of PAL week; Pre-NAL, before NAL week, post-NAL1 end of NAL week; post-NAL2, 1 week post end of NAL week. \*Denotes a significant difference between pre-assessment week and post-intervention,  $P < 0.05$ , data are presented as mean  $\pm$  SD.



**Table V.** Mean Cumulative Weekly Steps for PA and NAL Test Weeks

	Cumulative step count
PAL week	196 542 ± 18 466
NAL week	152 395 ± 23 512

Data are presented as mean ± SD.

**Table VI.** Mean Time on Task Behaviour for PA and NAL Test Weeks

	Time on task (%)
PAL week	97 ± 1
NAL week	87 ± 4

Data are presented as mean ± SD.

increases activity levels and could have potential wider health benefits. From a school perspective, improvements in concentration without impacting academic outcomes provide compelling evidence to school policy makers to justify PAL from an improved life chance and cultural capital perspective.

### Physical activity levels and potential health benefits

The two measures of PA during the test period were cumulative weekly steps and HR monitoring. Statistical analysis from both measures indicated that children's activity levels were higher during PAL than NAL. This supports the findings of other research which specifically report on increased activity levels [5, 28], and suggests that PAL is an effective way to increase PA across the school day. In addition, the data from the HR monitoring indicates that PAL provided a meaningful moderate-vigorous intensity physical activity stimulus, whilst using movements that are already embedded in children's behaviour and are simple, uncomplicated and easily replicable. Current research identifies this as an essential component for sustained PAL [4, 5, 11, 12], and achieving the moderate-vigorous physical activity stimulus is fundamental as this is the intensity

that is associated with health benefits. This further highlights the important role schools could play in enabling and facilitating increases in medium velocity movement while children are at school [5, 9, 11, 28, 29]. Teachers capitalizing on the use of PAL could have significant cumulative movement and health benefits for both themselves as well as the children they teach. Including PAL in the classroom setting is integral as the classroom is a teacher led environment. Children therefore accept PAL as part of their curriculum and as a normal delivery mode, without there being a deliberate change in behaviour that is driven internally. From a practical perspective, teachers adopting this simple PAL approach in their daily practice requires little preparation but brings marked physiological gains during the week [4, 10].

### Cognition and academic outcomes

The increased ToT during PAL in the present study is supported by previous research indicating children's ability to maintain focus and manage distractions is significantly higher during PAL than NAL [14–17]. Firstly, despite the approach being familiar to the children in this study, the simple movements used by the CT were presented randomly and therefore required children to continue to shift their focus between learning and movement. Focus shifting meant that those pupils who may easily become distracted had to use their focus to keep up with changes. This meant that their behaviour, which may have been a distraction to themselves and others in a NAL, did not regress [30, 31, 32]. It also meant that their attention shifts were limited and their focus was always brought back to the CT [33]. The second component is that these movements lacked complexity, but did require a low-level dual task focus. This dual task focus has been highlighted in promoting aspects of executive functioning such as inhibition and development of working memory [34, 35]. Neurochemical or physiological changes resulting from the PAL in this study are beyond the scope of this analysis, but have been implicated in improving cognition in children during physical activity [36]. Therefore, it is not unreasonable to suggest that

factors such as increases in neurotransmission chemicals or increased cerebral blood flow and oxygen delivery may have impacted on concentration or moderated behaviour responses in the present study.

From an academic outcome perspective, although there were no real differences in outcomes between PAL and NAL, what was evident was that PAL did not seem to impact negatively on academic outcomes [9, 10, 12, 37–39]. In both conditions, pupils were able to demonstrate academic progress, with similar retention of new knowledge. Together with the health benefits of PA, PAL may enable academic outcomes to be achieved and behaviour to be regulated in settings in which social class may be acting against the educational interests of disadvantaged children [40]. In our opinion, this continues to support a justification to promote the wider use of PAL approaches in schools.

### Limitations

The small sample size of the participants potentially weakened the effect size, regardless of mean outcomes with statistical significance and the narrow age range of participants may limit the generalization of these results for all children across the age range. The CT leading the PAL intervention was familiar with PAL, although this was a prerequisite in this study as it reflected recent research recommendations to support meaningful PAL [4], it may mean the children were not distracted by this mode of teaching or were more responsive/engaged during PAL compared to NAL. It may also mean that the PAL replication has some limitations in other schools [10]. Missing participants within the test period impacted on the total sample for some academic outcomes and as data were excluded if a full data set was not obtained. The MOKI activity trackers provided a cumulatively useful continuous measure of pupil physical activity for 14 days (24 h/day); however, there were some missing data points outside of school hours, which may reflect units not being worn. Although providing a compelling snapshot of physical activity, this data should be viewed with a degree of caution as the

MOKI trackers were pre-set to detect activity that was above a light level in terms of METs and therefore information across different intensities of PA is lacking.

### Conclusions

This key findings from this study suggest that PAL may be a successful approach to increase physical activity across the school day, which is fundamental from a public health perspective. Importantly, PAL did not result in a decrease in academic outcomes for participants, indicating that PAL does not distract students from achieving learning outcomes. Furthermore, this study supports the notion that including PAL in lessons could support positive behaviour choices and increase children's ToT, which may improve academic outcomes in the long term. The integration of these factors may improve children's long-term life chances in addition to decreasing their risk of adverse health conditions linked to inactivity.

### Acknowledgements

We would like to thank the participants for their time.

### Conflict of interest statement

None declared.

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