



Original research

A pilot primary school active break program (ACTI-BREAK): Effects on academic and physical activity outcomes for students in Years 3 and 4

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ABSTRACT

Objectives: To assess the feasibility and efficacy of a 6-week pilot active break program (ACTI-BREAK) on academic achievement, classroom behaviour and physical activity.

Design: Pilot cluster randomised controlled trial.

Methods: 374 children in Year 3 and 4 (74% response) were recruited from six schools across Melbourne, Australia. Schools were randomised to the ACTI-BREAK intervention or usual teaching practice. The intervention involved teachers incorporating 3 × 5 min active breaks into their classroom routine daily. Academic achievement was assessed using 1-min tests in reading and mathematics; classroom behaviour at the individual and whole class level was observed by teachers; and physical activity levels were assessed using accelerometers. Multilevel mixed effects linear regression models were conducted using intention to treat (ITT) and per protocol (PP) analyses.

Results: Significant intervention effects were found for classroom behaviour at the individual level (ITT $B = 16.17$; 95% CI: 6.58, 25.76); effects were stronger for boys ($B = 21.42$; 95% CI: 10.34, 32.49) than girls ($B = 12.23$; 95% CI: 1.52, 22.92). No effect was found for classroom behaviour at the whole class level, reading, math or physical activity. PP findings were similar.

Conclusions: Implementing active breaks during class time may improve classroom behaviour, particularly for boys. There was no evidence to suggest that implementing active breaks had any adverse effect on academic achievement or classroom behaviour, which may encourage classroom teachers to incorporate active breaks into their routine.

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1. Introduction

Multiple health benefits can be attained when children participate in physical activity,¹ including improving children's academic achievement and classroom behaviour^{2,3} via potential cognitive benefits. It has been proposed that physical activity increases availability of brain derived neurotrophic factor (BDNF),⁴ which has been linked to improved cognitive function in children,⁵ which may lead to enhanced classroom behaviour and academic achievement.⁶ Despite these potential benefits, less than 20% of children meet the physical activity guidelines of 60 min/day of moderate- to vigorous-intensity physical activity (MVPA), with compliance rates decreasing with increasing age.^{7,8} This low level may have important implications for health and academic-related outcomes.

Although schools are ideal settings for the promotion of physical activity, adding physical activity to the school day can be difficult. Time constraints are often found to be major barriers to implementing school-based physical activity⁹ often due to curriculum demands in key learning areas¹⁰ and associated academic accountability pressure.¹¹ Time-efficient physical activity promotion strategies that benefit academic outcomes are needed. Short bursts of physical activity done in the classroom as a break from learning tasks (active breaks)¹² may provide such a solution.

Previous studies have shown that active breaks improved children's cognitive function,¹² classroom behaviour,¹³ and academic achievement.¹⁴ However, existing active break programs have limitations restricting their translation potential. Many stipulate active breaks of 10–15 min.¹⁵ However, teachers indicate they prefer short active breaks (≤ 5 -min) to limit time away from academic pursuits.¹⁶ This discrepancy between evidence and practice highlights the importance of involving teachers in the development phase to maximise feasibility and sustainability of such programs outside of the research context. In addition, most previous interventions were implemented by researchers rather than teachers.¹⁵

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While active breaks of at least 10-min have been shown to be effective for improving academic-related outcomes, few studies have investigated the effect of shorter active breaks.^{12–14} Four-minute vigorous-intensity breaks (e.g. jumping jacks) have been shown to be effective,^{12,17} while 5-min moderate- to vigorous-intensity active breaks (e.g. marching, jumping and running in place) were not, for improving academic-related outcomes,^{13,14} suggesting that short active breaks need to be of a vigorous-intensity to elicit academic benefit. However, this approach may not be feasible. Teachers view vigorous-intensity active breaks as disruptive (e.g. as students removed jumpers and needed drinks) and frequent (multiple times daily) short moderate-intensity active breaks to be feasible.¹⁸ A recent study suggests that frequent active breaks hold promise. In that study, selective attention scores (measured via the ‘SkySearch’ subtest of the ‘Test of Selective Attention in Children’)¹⁹ were better among children who participated in two compared to one 20-min active break per day.²⁰ While it is possible this result is due to the higher dose of physical activity, investigation of frequent shorter active breaks is warranted given they may be more feasible.

A further limitation of previous studies relates to choice of academic outcome measure. Most used standardised tests to assess short duration (6-weeks to 8-months) intervention effects on academic achievement.¹⁵ However, standardised tests are designed to assess long-term (i.e. yearly) impacts and may miss short-term changes. Curriculum-based measures, in contrast, are sensitive to small changes in academic achievement, and can be administered frequently (e.g. weekly).²¹ In addition, sex differences in outcomes of active break interventions are rarely reported^{13,14} but indicate important differences in on-task behaviour (better among girls) following 5 min active breaks¹³ and mathematics performance (improvements for girls but not boys) following 10 and 20 min active breaks.¹⁴ Lastly, objective measures have rarely been used to determine intervention effects on MVPA.¹⁵ Students in classrooms with active breaks had 3.14 min/day more MVPA than children in control classrooms,²² highlighting the potential for active breaks to contribute to overall physical activity and the need for sensitive measures of physical activity.

The ACTI-BREAK program was designed to address limitations associated with existing programs by: (1) involving teachers in the development phase; (2) using appropriate measures of academic achievement to assess short-term interventions; and (3) objectively measuring physical activity. The primary aim of this study was to assess the potential efficacy of the ACTI-BREAK program for improving academic achievement in mathematics and reading among primary school students. Secondary aims were to assess intervention effects on classroom on-task behaviour and objectively-measured school day physical activity.

2. Methods

The design, conduct and reporting of the ACTI-BREAK study adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines for pilot cluster randomised controlled trials, and is guided by the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) statement. Ethical approval was attained from Deakin University Human Research Ethics Committee, Melbourne, Australia (2016-020) and the Victorian Department of Education and Training (2016-002962). Principals, teachers and parents provided written informed consent to participate in the study, which took place during Terms 1 and 2 (February–June 2017). The study is registered with the Australia New Zealand Clinical Trials Registry (identifier ACTRN12617000602325).

Briefly, the study design involved a pilot cluster randomised controlled trial. Schools were randomised to either the ACTI-BREAK

intervention or wait-list control group after enrolment in the study and prior to baseline measures. Baseline assessment occurred after randomisation for logistical reasons (e.g. so teacher training sessions and intervention commencement could coincide with the collection of activity monitors). Allocation concealment was carried out by a researcher not involved with schools or participants, using a computer generated random number sequence. Participants, teachers and research staff were not blinded to study outcomes.

The intervention targeted Year 3 and 4 classes (aged approximately 8–10 years). Twenty-one Government primary schools located within a 30 km radius of Deakin University with a middle socioeconomic position (4th–6th decile of Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Advantage and Disadvantage in Victoria) were invited to participate. For feasibility reasons, the aim was to recruit 6 schools. Schools where composite classes mixed Year 3 or Year 4 students with other grades (e.g. Year 2/3 or Year 4/5 composites) were not eligible. All children in classes randomised into the intervention group received the ACTI-BREAKS, however data was only collected from children with parent consent. Data from children with diagnosed behavioural or learning problems (e.g. ADHD, Autism, etc.), as reported by classroom teachers, were excluded from analyses (n = 27).

Detailed information about the ACTI-BREAK program and teacher training has been published previously.¹⁸ Briefly, following a 45-min training session, teachers implemented 5-min moderate-intensity active breaks, three times daily in their classrooms for 6 weeks. The ACTI-BREAK activities incorporated a variety of elements including: drama, games, following instructions, and technology, adapted (with written permission) from a range of sources.^{24–26} For example: (1) Elbow chair: students move around the classroom as the music plays. When the music stops, the teacher calls out a body part and the students return to their chair and place the selected body part on their chair. The music starts again and play continues; (2) Over, under, around, and through: Students go over, under, around and through real and imaginary objects as directed by their teacher.

Instructions for each of the ACTI-BREAK activities (n = 30) were presented on small task cards, and teachers completed a log of the ACTI-BREAKS completed over the intervention period. Scheduling of ACTI-BREAKS was left to teacher discretion, consistent with teacher preferences in the development phase. Teachers at control schools continued with their usual teaching practices. To increase adherence to study protocols, the ACTI-BREAK program was implemented via assisted roll-out: in week one the teacher and researcher implemented ACTI-BREAKS together; in week two, teachers implemented ACTI-BREAKS with the researcher observing and providing support and encouragement; and from week 3 teachers delivered ACTI-BREAKS independently without the researcher present.

Intervention assessments were taken at baseline (week prior to intervention commencement) and end-intervention (week 6). The primary outcome was academic achievement in reading and mathematics. Reading achievement was assessed using the Wheldall Assessment of Reading Passages (WARP) Test.²⁷ The WARP is a curriculum-based measure designed to track reading fluency of children in Years 2–5, and is developed for the Australian school context.²⁷ This test requires children to read aloud for 1-min from a 200-word passage. Following a standardised protocol²⁷ the assessor tallies words read incorrectly and subtracts these from 200 (or the total words read) to provide a measure of reading fluency. Curriculum-based measures of reading fluency have been shown to correlate with other standardised tests of reading performance (r = 0.67).²⁸ A member of the research team (AW) with a primary school teaching qualification and experience administered this test individually to each participant at baseline (1-week prior to intervention) and during the final week (week 6) of the intervention.

Mathematics achievement was assessed using the Westwood One Minute Tests of Basic Number Facts.²⁹ This test is developed for use within the Australian school context, and consists of four 1-min tests (33 items each), each focusing on one of each of the following number operations: addition, subtraction, multiplication and division. The number of problems completed correctly in 1-min is a measure of the student's mathematics achievement. This test has good test-retest reliability (0.88–0.94 depending on age).²⁹ The subtraction test was chosen for this study to ensure alignment with the Year 3 and 4 Term 1–2 curriculum.³⁰ Children experience multiplication and division in the latter half of the school year and an addition test would have the potential for ceiling effects. A member of the research team (AW) with a primary school teaching qualification administered this test to the whole class as baseline (1-week prior to intervention) and end (week 6) of intervention. Only data from children with parent consent were used in analyses. The reading and mathematics assessments were conducted at a time that suited each classroom teacher.

Classroom behaviour was assessed at the individual level using a tool adapted from the Direct Behaviour Rating Scale; a hybrid of direct observation and behaviour rating scales.³¹ Using this tool, classroom teachers indicated on a scale from 1 to 10 (0–100%), the percentage of time each child (with parent consent) was on-task during the observation period. Behaviour at the whole class level (no identifying information was collected) was assessed using modified version of the Classroom Behaviour and Assets Survey-Teacher.³² Using this tool, teachers indicated the proportion of the class displaying on-task behaviour during the observation period on a scale from 0 (0 students) to 7 (all of the class).³² Group and individual behaviour was assessed simultaneously as these assessments take only a few seconds and are similar to standard monitoring teachers do routinely. Teachers were required to record observations of classroom behaviour during a seated lesson (i.e. while seated at desks) for 3 time-points on three separate days over the course of a week (e.g. on a Monday, Wednesday and Friday) at baseline (the week prior to intervention) and again in the final week of the intervention. Due to variation in schedules across classes, teachers chose the time of the behaviour observations but ensured all observations for their class were conducted at the same time each day (e.g. 11 am) at least 30 min after doing an ACTI-BREAK for consistency and to ensure sustained rather than acute effects were captured. Teacher reports of behaviour using similar methods have previously been shown to be reliable ($\alpha = 0.85$).²² This tool provides a valid measure of classroom behaviour compared with direct observation ($r = 0.81$ – 0.87).³³ and has strong evidence of reliability ($r = 0.91$).³¹ Data were included for analyses if teachers had recorded at least two observations at both baseline and end of intervention.

Waist-worn ActiGraph GT3-X accelerometers were used to provide a valid and reliable measure of children's school day physical activity.³⁴ Participants wore accelerometers during waking hours for 7 consecutive days at baseline and the final week of the intervention. The recording epoch for this study was 15-s³⁵ and non-wear time defined as ≥ 20 min of consecutive zero's.³⁶ Data were included if the accelerometer was worn for ≥ 5 school hours on ≥ 1 school day, similar to previous studies.³⁷ Participants had an average of 3.30 (SD = 1.27) valid days at baseline and 3.09 (SD = 1.44) valid days at intervention end. 'Freedson' cut-points were used to provide an accurate classification of MVPA (≥ 555 counts per 15 s; ROC-AUC = 0.90).^{38,39} Physical activity across the whole school day was examined to allow for exploration of potential compensation during recess and outside school.

Statistical analyses of primary and secondary outcomes were conducted using Stata 14 and alpha levels set to $p < 0.05$. Multi-level mixed-effects linear regression models were used to assess the impact of treatment (ACTI-BREAK or control) on reading and

Table 1

Baseline characteristics of students randomised to the intervention and control groups.

	Intervention (n = 123)	Control (n = 218)
Male	50%	46%
Age; years mean (SD)	9.22 (0.61)	9.07 (0.63)
Grade 3	44%	50%
Math scores; mean (SD) ^a	16.26 (7.09)	12.93 (6.34)
Reading scores; mean (SD) ^b	122.54 (40.14)	109.58 (39.60)
% time in on-task behaviour	78 (15.86)	70 (15.84)
Minutes spent in MVPA (school hours)	35.41 (11.74)	34.40 (11.24)

^a The age-based norm for mathematics scores at age 9 years is 13.

^b The grade-based benchmarks for reading scores is 93 for Year 3 students, and 121 for Year 4 students.

mathematics achievement, on-task behaviour, and MVPA on school days. The models were adjusted for baseline levels of the corresponding variable, baseline physical activity, and clustering by class. The fixed effect of school was added to the model to account for the unit of randomisation. All analyses were completed on the whole sample, and also stratified by sex. Analyses were conducted using an intention-to-treat (ITT) approach, and repeated per protocol. Per protocol was defined as completion of ≥ 2 ACTI-BREAKS on $\geq 70\%$ of days, based on teacher logs. This threshold represents an approximate median split (≥ 2 ACTI-BREAKS were completed by three teachers on 43–53% of days and four teachers on 73–80% of days).

3. Results

The flow of participants through the trial is reported in Fig. 1. From the six schools, informed consent was obtained from 374 children (74% response). Six participants withdrew consent during baseline citing not wanting to wear the activity monitor ($n = 5$) and family illness ($n = 1$), and 27 students were excluded from analyses due to diagnosed behaviour or learning problems (teacher-reported), resulting in a final sample of 341 participants. Table 1 displays baseline demographic information.

Table 2 shows the intervention effects on academic and physical activity outcomes. Results showed on-task behaviour at the individual level increased in the intervention group, with larger improvements observed for boys. However, there was no intervention effect on on-task classroom behaviour at the group level ($B = 0.30$ (95% CI: $-0.18, 0.78$)). No intervention effects were found for mathematics, reading or physical activity across the school day. Three classes, from two intervention schools, were excluded from per protocol analyses. Included classes completed 22 ($n = 1$ class) and 24 ($n = 3$ classes) of the 30 required ACTI-BREAKS. Results for per protocol analyses demonstrated identical patterns to ITT analyses.

4. Discussion

This is one of the first studies to investigate the impact of frequent, short active breaks on academic and physical activity outcomes. While no intervention effects were found for the primary outcomes of reading or math achievement, analyses of secondary outcomes showed short active breaks improved on-task classroom behaviour at the individual level, with larger improvements observed for boys than girls. However, there was no intervention effect on classroom behaviour and the whole class level, physical activity across the school day.

While no intervention effect was found for classroom behaviour at the whole class level, results showed classroom behaviour improved at the individual level, particularly for boys. This suggests that active breaks may affect classroom behaviour differently

Table 2
Intervention effects of the ACTI-BREAK program.

Outcome	Total B (95% CI)	Boys B (95% CI)	Girls B (95% CI)
ITT analysis			
Reading (n = 311)	-0.13 (-8.08, 7.81)	-2.23 (-12.17, 7.71)	0.88 (-10.95, 12.71)
Math (n = 312)	1.86 (-0.01, 3.73)	2.57 (-0.12, 5.25)	1.41 (-1.18, 4.00)
On-task behaviour (n = 226)	16.17 (6.58, 25.76)*	21.42 (10.34, 32.49)*	12.23 (1.52, 22.92)*
MVPA (school hours) (n = 289)	1.26 (-3.78, 6.30)	3.35 (-5.48, 12.17)	-1.60 (-7.72, 4.52)
PP analysis			
Reading (n = 264)	5.32 (-0.07, 10.71)	4.29 (-2.57, 11.16)	7.40 (-0.81, 15.61)
Math (n = 265)	-0.34 (-1.74, 1.05)	-0.11 (-1.99, 1.76)	-0.77 (-2.86, 1.33)
Classroom behaviour (n = 216)	17.40 (6.67, 28.14)*	21.94 (10.90, 32.97)*	12.14 (1.11, 23.16)*
MVPA (school hours) (n = 254)	-0.20 (-3.40, 2.99)	1.64 (-4.42, 7.69)	-1.43 (-5.30, 2.44)

Adjusted for baseline levels of the corresponding variable, baseline physical activity, and clustering by class.

* p < 0.05.

for different students. The positive effects of active breaks on on-task behaviour are consistent with results from studies using longer active breaks.^{22,40} However, longer active breaks may not be feasible outside of the research context due to time constraints within busy classroom schedules and briefer sessions may be more likely to be adopted by teachers.¹⁶ The two prior studies that investigated effects of shorter (5-min) active breaks on classroom behaviour reported inconsistent results. Howie et al.¹³ showed 5-min moderate- to vigorous-intensity active breaks performed once daily had no effect on on-task classroom behaviour. In contrast, Ma et al.⁴¹ reported 4-min vigorous-intensity active breaks performed once daily reduced off-task classroom behaviour. The results of the current study lend support for the potential benefit of short duration active breaks on classroom behaviour.

It is possible that teachers would consider longer duration active breaks more acceptable if they incorporated lesson content. In one study, during qualitative interviews some teachers expressed a preference for active breaks with curriculum content, however most preferred active breaks without,⁴² perhaps due to the ease of implementation. In contrast, another study showed most teachers preferred active breaks that incorporated academic content due to time constraints and curriculum pressures.¹⁰ Teacher preferences warrant further exploration.

Results from the current study showed intervention effects on classroom behaviour were stronger for boys than girls. A previous study showed more time among girls and less time among boys in on-task behaviour immediately following 5-min active breaks.¹³ That study investigated immediate effects, whereas the current study investigated more general effects on classroom behaviour, which may explain these divergent findings. Boys may take longer to settle immediately following active breaks, however once settled may be more on-task across the school day.⁴³ Further, boys in the current study displayed less on-task behaviour at baseline compared with girls and therefore had more room for improvement. However, these assertions remain speculative.

While the current study showed frequent short active breaks had a positive effect on on-task classroom behaviour, no effect was found for reading or mathematics. In contrast, other studies using curriculum-based measures designed to detect small changes in academic achievement, as in this study, have reported improvements in mathematics and reading achievement.^{14,44} While only a

pilot trial, based on post-hoc sample size calculations, the current study was powered to detect differences in mathematics but not reading achievement. However, it is possible that the intervention was not delivered as intended, which may explain the null effect on reading and mathematics. Another study found that 5 min active breaks were not sufficient to elicit improvement in mathematics scores, however 10 and 20 min active breaks were.¹⁴ Intervention fidelity will be explored separately in a process evaluation. Importantly, no detrimental effects on academic achievement were found despite time taken out of the curriculum to perform active breaks.

Results showed no intervention effect on physical activity, consistent with the findings of a recent meta-analysis.¹⁵ This may be because children compensate for the additional physical activity by being less active later in the day⁴⁵ or an issue of fidelity of delivery, which will be assessed separately in process evaluation. In contrast, a previous study reported that children participating in active breaks performed 47 min/week more physical activity than a control group.⁴⁶ However, that study used self-report measures of physical activity, which may be subject to bias and a possible explanation for these divergent results.

Teacher logs of ACTI-BREAKS showed that most teachers (5/7) implemented at least two ACTI-BREAKS on most (>50%) days but some struggled to consistently deliver three. As intention to treat and per protocol findings were similar, this suggests that two daily ACTI-BREAKS may be most feasible and similarly effective for improving classroom behaviour.

Strengths of the current study include the RCT design, involvement of teachers in the development phase, use of an objective measure of physical activity, and use of curriculum-based measures to assess intervention effects on short-term academic achievement. Some limitations should also be noted. The current study utilised observations of classroom behaviour recorded by the same teachers who delivered the intervention and thus had potential for bias. Further, teachers in this study found it difficult to complete all required behaviour observations, resulting in missing data for a large number of children. Sedentary time was not examined in this paper, but could be examined in future studies. Lastly, despite the large sample of children, few classes were involved. It is possible that poor protocol compliance among one teacher could skew results.

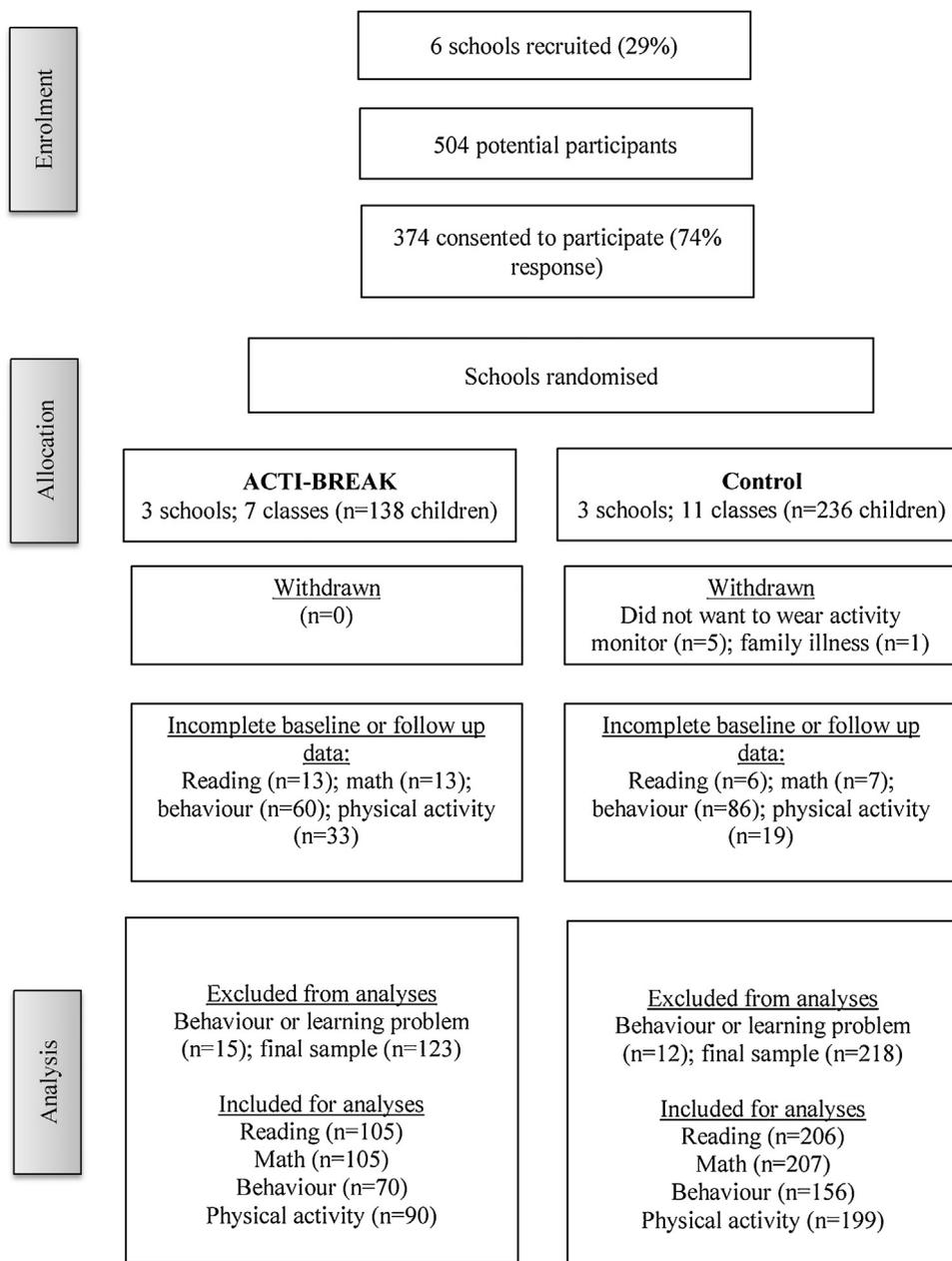


Fig. 1. Flow diagram of participants through the ACTI-BREAK study.

5. Conclusion

The minimal time commitment required and positive effect on on-task classroom behaviour may make this an appealing intervention for schools. Although improvements in academic achievement were not observed, importantly there were no detrimental effects. Longer-term studies, with larger sample sizes, will be important for understanding the value of active breaks for academic and physical activity related outcomes.

Practical implications

- Incorporating frequent short physical activity breaks into the classroom routine led to an increase in on-task classroom behaviour, particularly for boys.

- There was no evidence to suggest that implementing active breaks had any adverse effect on academic achievement or classroom behaviour.
- The intervention did not have an effect on school day physical activity levels.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jsams.2018.09.232>.

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