



A short-medium time point evaluation of active breaks on selective and sustained attention in primary school: a pilot quasi-experimental study

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ARTICLE INFO

Keywords:

Executive function
Physical activity
Psychophysical well-being
Bells test
School-based interventions
Holistic education

ABSTRACT

Background: A growing body of evidence demonstrates the positive relationship between physical activity and executive function in children.

Aims: This study aimed to examine the time course of the effectiveness of active breaks (ABs) in enhancing attention levels among second-grade primary school children compared to traditional teaching methods over a three-month period.

Methods: Parents/guardians and teachers of both the experimental group (EG) and the control group (CG) completed a questionnaire assessing the psychometric characteristics of the sample. The EG participated in daily 10-min active breaks for three months, while the CG followed regular teaching methods. Selective attention (SeA, at 30 s) and sustained attention (SuA, at 120 s) were assessed at baseline and monthly (T0, T1, T2, and T3).

Results: The EG consisted of 17 children (8.42 ± 0.39 years, 10 females), while the CG included 18 children (8.37 ± 0.42 years, 11 females). The EG generally exhibited higher psychometric scores, although teacher and parent perceptions varied in both groups. SeA levels improved significantly in both groups overtime, but EG demonstrated greater improvements, particularly three months after the introduction of active breaks ($p < 0.001$). A similar trend also for SuA ($p < 0.001$). A huge effect size shows larger increases during the third month for both SeA ($ES = 1.97$) and SuA ($ES = 1.46$) in favor of EG.

Conclusions: Active breaks positively influenced both SeA and SuA. Their effectiveness increased over time, suggesting that a minimum duration of three months is necessary to achieve significant benefits compared to traditional teaching methods in primary education.

1. Introduction

Concentration and attention are fundamental cognitive functions essential for effective learning and academic achievement (Diamond, 2015). These abilities enable individuals to focus on relevant stimuli while filtering out distractions, processes primarily regulated by the prefrontal cortex. However, attention deficits are frequently observed in children, often resulting in diminished academic performance, frustration, and disengagement from educational activities (Caponi et al., 2009). Addressing these challenges requires innovative and evidence-based strategies to support cognitive development and maintain focus in classroom settings.

Research has increasingly highlighted the positive impact of physical activity (PA) on cognitive functions, including attention, memory, and executive functioning. PA enhances cerebral blood flow up to an

intensity of 60 %, promotes neurogenesis through the production of brain-derived neurotrophic factor (BDNF), and improves synaptic plasticity via sympathetic nervous system activity, all of which are crucial for optimal brain function (Hillman et al., 2008). Moreover, PA has been linked to the release of neurotrophic factors such as brain-derived neurotrophic factor, which supports the growth and survival of neurons and strengthens neural connections critical for learning and attention (Ratey & Hagerman, 2008).

Active Breaks (ABs) represent a practical application of these findings within educational settings. Active breaks are brief, structured PA sessions, typically lasting 5–10 min, embedded into the school day. They are designed to interrupt prolonged periods of sedentary behavior, which have been associated with negative effects on physical and cognitive health (Calella et al., 2020). ABs are implemented during regular classroom hours, making them an additional opportunity for

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<https://doi.org/10.1016/j.mhpa.2025.100703>

Received 28 February 2025; Received in revised form 26 May 2025; Accepted 19 June 2025

Available online 19 June 2025

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movement beyond traditional physical education. They are easily incorporated into the school routine as they require minimal space and equipment, allowing for widespread and scalable adoption. ABs are believed to alleviate mental tensions accumulated during the academic tasks, allowing students to recharge their cognitive resources. Studies have demonstrated that these ABs can reduce mental fatigue, enhance working memory, and improve selective attention (Ma, Shane, & Brendon, 2015; Pesce et al., 2016). By fostering global activation, ABs also promote the release of endorphins and dopamine, which are associated with improved mood and motivation, key factors for sustained engagement in academic tasks (Harveson et al., 2019).

Prolonged sedentary behavior is a growing concern in modern educational systems, where children often spend hours seated in classrooms. Sedentary behavior has been shown to impair cognitive flexibility and reduce attention span, particularly in younger populations (Tremblay et al., 2011). Incorporating ABs into the school routine addresses this issue by breaking up long periods of inactivity, thereby mitigating its detrimental effects on cognition and overall well-being (Arufe-Giráldez et al., 2024).

The importance of integrating physical activity into daily routines has been widely recognized by global health organizations. The World Health Organization (WHO) emphasizes the role of Active Breaks in fostering psycho-physical well-being and recommends their inclusion in schools to combat sedentary lifestyles (World Health Organization, 2018, 2020). These recommendations are supported by empirical evidence demonstrating that short bursts of activity can significantly reduce disruptive behaviors and create a more conducive learning environment (Watson, Timperio, Brown, Best, & Hesketh, 2017).

Numerous studies highlight the multi-dimensional benefits of ABs. For instance, a study by Watson et al. (Watson, Timperio, Brown, & Hesketh, 2017) found that primary school students who participated in daily ABs exhibited improved on-task behavior and enhanced cognitive performance compared to peers in control groups. Similarly, Fiorilli et al. (Fiorilli et al., 2021) demonstrated that structured physical activity breaks positively influenced executive functions, including working memory and attentional control, in primary school children.

From a psychological perspective, ABs have been shown to reduce stress and anxiety, fostering a positive classroom environment conducive to learning (Ma, Le Mare, & Gurd, 2015). In Italy, programs supported by organizations such as “Sport e Salute” have demonstrated the feasibility and effectiveness of ABs in promoting both physical fitness and academic engagement among students (Pause attiva, 2024).

Building on the growing body of evidence supporting the effectiveness of ABs in improving cognitive functions in primary school children, the present study explores the relationship between ABs and attentional improvements over a three-month period. However, there is a paucity of studies examining the time-dependent effects of ABs on distinct components of attention, such as selective and sustained attention. This study aims to examine the time course of ABs’ related improvements in these attentional domains to identify the minimum duration of intervention necessary to produce a tangible impact on cognitive functions, rather than merely alleviating the negative effects of mental fatigue and sedentary behavior within the school routine. Understanding the temporal dynamics of ABs’ cognitive effects is crucial to informing evidence-based school policies and maximizing the educational potential of movement-based interventions.

2. Methods

2.1. Study design and participants

This pilot quasi-experimental study involved one intervention group and one control group and was conducted in 2 s-grade classes at the full-time primary school “Salvo D’Acquisto” in Casciana Terme Lari (Italy). Recruitment began in January 2024. The inclusion criterion was enrollment in the second grade of primary school. The exclusion

criterion for the analysis of results, but not for participation in the teaching intervention, was having a certified special educational needs status. Consequently, the experimental group (EG) included 17 children (mean age 8.4 ± 0.4 years; 10 females, 55.5 %), while the control group (CG) comprised 18 children (mean age 8.4 ± 0.4 years; 11 females, 61.1 %).

At baseline, the Strengths and Difficulties Questionnaire (SDQ) was administered to assess potential psychometric differences that might compromise the reliability of subsequent results. Selective and sustained attention were assessed using the Bells Test, administered before, during, and after the intervention for both groups.

All children participated voluntarily after their parents/guardians received a detailed explanation of the procedures and methodology. Written informed consent was obtained from parents/guardians in accordance with the Declaration of Helsinki (2013). The study was approved by the Bioethics Committee of the University of Florence (Protocol No. 0173384). The study was conducted following the guideline for quasi-experimental study (Cook & Campbell, 1979).

2.2. Psychometric characteristics

The Italian version of Strength and Difficulties Questionnaire (SDQ) (Goodman, 1997) was administered prior to the intervention to both parents/guardians and teachers of students in both classes to evaluate the students’ psychometric profile in school and extracurricular contexts.

The questionnaire consists of 25 items divided into five domains: Behavior (items: 5, 7, 12, 18, 22), Emotionality (items: 3, 8, 13, 16, 24), Attention-Deficit Hyperactivity Disorder (items: 2, 10, 15, 21, 25), Relationality (items: 6, 11, 14, 19, 23), and Prosociality (items: 1, 4, 9, 17, 20). Each item is scored on a 0–2 frequency scale (0: not true; 1: somewhat true; 2: certainly true). The scoring for items 7, 11, 14, 21, and 25 is reversed.

Mean and standard deviation were calculated for each item, and total scores were computed for each dimension and the overall questionnaire.

2.3. Active-breaks

Between January and April 2024, the EG participated in an ABs program lasting 11 weeks, with a total of 55 sessions. Following the guidelines of Colella et al. (Colella et al., 2020), the sessions were scheduled at specific times during the school day to optimize both children’s and teachers’ needs: Monday and Tuesday at 10:30 a.m., Wednesday and Friday at 3:00 p.m., and Thursday at 9:30 a.m. Sessions were conducted in the classroom, either interrupting regular curricular lessons or immediately after the morning break and before the next lesson.

Each AB session lasted 10 min and included three phases: 3 min of warm-up activities, 5 min of High-Intensity Interval Training (HIIT), and 2 min of cool-down activities (Masini et al., 2020, 2023). The exercises were adapted from typical HIIT workouts, tailored to the children’s age and motor skills (Mulato & Riegger, 2022). During the 20-s rest intervals in the HIIT phase, children were given cognitive tasks requiring quick responses. These tasks were based on topics from the recently concluded lesson or aimed to activate prior knowledge for the upcoming lesson.

The CG continued with their usual teaching routine, which included typical activities to foster attention, such as brainstorming, authentic tasks, logic exercises, and problem-solving.

2.4. Selective and sustained attention

The Bells test (Gauthier et al., 1989), adapted to the Italian context by Mancuso et al. (Mancuso et al., 2019), was administered to both groups in order to evaluate changes in attention levels across four time points: baseline (T0) and subsequent monthly assessments (T1, T2, T3). While the full version of the Bells Test is primarily employed in clinical

Table 1
Student characteristics.

Variables	EG (n = 17) Mean ± SD or %	CG (n = 18) Mean ± SD or %
Age (n, years)	8.42 ± 0.39	8.37 ± 0.42
Female (n, %)	10 (55.5 %)	11 (61.1 %)

settings for the diagnosis of unilateral spatial neglect, it was selected in this study for its adaptability in evaluating general attentional processes. Specifically, it was selected for its reliability in assessing attentional performance over time, providing information on both short-term attention span and long-term attention persistence under controlled conditions. Furthermore, its use has proven useful during primary school age and across a wide range of sociodemographic variables (Carrión et al., 2024; Jablonská et al., 2024).

The testing environment was carefully controlled to optimize performance. Each session was conducted individually in a quiet, distraction-free room adjacent to the classroom, ensuring that participants felt comfortable and could maintain focus without external disturbances. During the task, participants were instructed to identify as many bells as possible on a visual display containing a total of 35 target bells interspersed among 280 distractor stimuli. Two key aspects of attention were measured:

Selective Attention (SeA): assessed based on the number of bells correctly identified within the first 30 s of the task.

Sustained Attention (SuA): evaluated using the total number of bells identified over the 120-s duration of the test.

The total accuracy score was utilized, omitting the asymmetry score, to focus on global attention capacity rather than spatial biases. The task was administered using the Millisecond software, integrated with the “Inquisit 6” application (Millisecond software), which enabled precise measurement and standardization of task parameters across participants and sessions.

2.5. Statistical analysis

Statistical analysis was performed using SPSS (Statistical Package for Social Science) (SPSS Inc. Chicago, IL, USA). Mean, SD and total score of SDQ were calculated following the guidelines (Marzocchi et al., 2002). The Bells Test scores of the two classes were statistically analyzed and compared, to obtain the final results of the experimentation. Differences in continuous variables from baseline to follow-up were analyzed within groups, using the paired-samples *t*-test for continuous variables. Between-group differences over time were analyzed using analysis of covariance (ANCOVA) adjusted for baseline and intermediate measures.

To estimate the magnitude of the observed differences over the three-month intervention period, effect sizes (ES) were calculated using Cohen’s *d* and Sawilowsky’s *r* (Sawilowsky et al., 2011). Effect sizes were classified as follows: *d* ≤ 0.2 small, 0.5 moderate, > 0.8 large; *r* ≤ 0.1 small, 0.25 moderate, > 0.4 large. Given the relatively small sample size and the absence of an a priori power analysis, a post hoc observed power analysis was conducted using G*Power 3.1 (Faul et al.,

Table 2
Psychometric characteristics evaluated through Strength and Difficulties Questionnaire (SDQ).

	EG			CG			
	Parents	Teachers	Within p-value	Parents	Teachers	Within p-value	Between p-value
Behavior	1.4 ± 0.4	2.2 ± 0.6	0.108	2.1 ± 0.5	1.9 ± 0.7	0,322	0.279
Emotionality	3.2 ± 0.7	3.4 ± 0.7	0.344	1.7 ± 0.6	2.1 ± 0.6	0,387	0.036
ADHD	2.8 ± 0.6	4.6 ± 0.7	0.006	4.1 ± 0.7	4.3 ± 0.8	0,455	0.301
Relationality	0.9 ± 0.5	2.3 ± 0.6	0.023	1.1 ± 0.4	1.1 ± 0.4	0,454	0.006
Prosociality	8.7 ± 0.4	5.4 ± 0.6	<0.001	7.6 ± 0.5	6.6 ± 0.7	0,029	0.031
Total Score	17.0 ± 0.6	17.9 ± 0.6	0.312	16.7 ± 0.6	15.9 ± 0.7	0,322	<0.001

Within-group assessment about the differences in scores given to the same children by parents or teachers. Between-group assessment refers to differences between EG and CG in scores given by teachers.

2007).

3. Results

3.1. Study participants

A total of *n* = 35 students were enrolled in the study. The general characteristics of the participants were displayed in Table 1.

3.2. Psychometric characteristics

The study involved the administration of the Strengths and Difficulties Questionnaire (SDQ) by teachers for all students in both classes, while a subset of parents also participated, with 12 parents in the EG and 15 parents in the CG completing the questionnaire.

A comparative analysis of the two groups revealed significant differences in the psychometric characteristics of students, as evaluated by teachers (Table 2). Specifically, students in the EG exhibited higher scores in Emotionality and Relationality, but lower scores in Prosociality compared to their CG counterparts. Interestingly, despite these differences, the EG achieved a higher total SDQ score overall.

Discrepancies in perception between teachers and parents were also observed, particularly within the EG. Teachers reported higher levels of Attention Deficit Hyperactivity Disorder (ADHD) traits and Relationality, whereas parents tended to evaluate their children as exhibiting higher Prosociality. Importantly, the total SDQ score showed no significant differences between evaluations made by the two groups of adults, suggesting a degree of overall consistency in their assessments.

3.3. Attention

Change in attention at 30” and 120” between EG and CG before and after the intervention is represented in Table 3. The performance in both attention tests at 30” and at 120” was significantly improved in both groups from baseline to follow-up. Moreover, even after adjusting for baseline there were significant between-group differences in favor of EG.

The effect size was large for attention test 30” and moderate for attention test 120”. Using these effect sizes, with $\alpha = 0.05$ the post hoc power analysis indicated an observed power for SeA: > 0.99 and for SuA: ≈ 0.97–0.99. These results demonstrate that the statistical power to detect the observed effects was high, supporting the robustness and reliability of the findings despite the limited sample size.

3.4. Time point evaluation

Table 4 represented the size of the effect considering all the 4 point evaluations compared between groups. These results show that initially the CG group had an advantage in the 30” attention test, but over time the ABs group improved significantly especially during follow-up. In the 120” test, the difference between the groups becomes evident test by test and increased in the follow-up.

Table 3
Attention levels assessed with Bells Test. Data are expressed as mean \pm SD.

	EC				CG				Effect size (r)			
	T0	T1	T2	T3	Within p-value	T0	T1	T2		T3	Within p-value	Between p-value
SeA	8.77 \pm 0.55	10.35 \pm 0.47	12.17 \pm 0.73	16.77 \pm 2.49	<0.001	9.89 \pm 0.87	10.44 \pm 0.53	11.53 \pm 0.54	12.33 \pm 2.00	<0.001	<0.001	0.70
SuA	26.9 \pm 0.98	30.35 \pm 0.66	31.82 \pm 0.65	34.94 \pm 0.24	<0.001	26.89 \pm 1.02	30.11 \pm 0.84	31.61 \pm 0.73	32.89 \pm 1.97	<0.001	<0.001	0.59

Legend. T0: baseline; T1: after 1 month; T2: after 2 months; T3: after 3 months. SeA: Selective attention at 30'', SuA: Sustained attention at 120''.

^a Within group changes are compared using paired-T-Test.

^b Between groups are compared using ANCOVA adjusting for baseline and intermediate values.

4. Discussion

Overall, the results confirmed our hypothesis that ABs represent a cost-effective and scalable intervention to promote cognitive functions in school-aged children. Integrating movement into daily school routines has been shown to enhance academic performance and overall well-being (Pause attive, 2024).

While the majority of existing literature highlights the benefits of ABs, some studies have reported limited or inconsistent effects, particularly when interventions are of shorter durations, lower intensity, or insufficient cognitive engagement (Infantes-Paniagua et al., 2021). To address this, our study implemented monthly assessments over a three-month intervention period, with a specific focus on attention and student well-being, to support the integration of ABs into the school curriculum.

At baseline, students in the EG demonstrated higher levels of emotional well-being and relational engagement but lower prosocial behaviors compared to the CG. However, both groups exhibited strong interpersonal skills and prosocial tendencies, including cooperation, empathy, and altruism. The lack of significant differences in ADHD traits and overall behavior between the groups supports the conclusion that the observed outcomes were not influenced by inherent psychometric disparities.

The evaluations provided by parents and teachers revealed some inconsistencies. Both groups identified similar levels of disruptive behaviors, such as argumentative tendencies and difficulties with concentration. However, parents in the EG perceived their children as less defiant and hyperactive compared to teachers' reports. Conversely, teachers attributed higher relational skills to students in the EG, while parents rated their children's relationality as comparatively lower. Despite these variations, both parents and teachers consistently acknowledged the children's strong social and prosocial abilities. Parents, in particular, emphasized their children's empathy and altruism, underlining a positive perception of their interpersonal competencies.

Although these findings are consistent with much of the current literature, it is worth noting that other studies have reported more limited effects of ABs, particularly when interventions were shorter or lacked structured cognitive components (Wilson et al., 2016; van den Berg et al., 2016). In our study, the impact of ABs became particularly evident from the second month onward, where the effect size (d) exceeded 0.8, indicating a significant difference between the two groups in selective attention at 30''. At the three-month follow-up, selective attention exhibited particularly high effect values. Improvements in sustained attention at the 120'' mark also became significant by the third-month follow-up. These increasing effect sizes suggest a growing divergence in outcomes between the EG and CG over time. Although the CG also showed improvements, these did not match the levels achieved by the EG. The consistent integration of physical activity into the school day appears to provide an effective stimulus for enhancing cognitive functioning, reinforcing the mind-body connection. In line with recent meta-analyses, our findings suggest that even greater gains might be observed with longer intervention periods (Infantes-Paniagua et al., 2021).

The choice of the grade level was deliberate, aiming to validate the consistency of experimental data already reported in the literature (de Greeff et al., 2018; Hillman et al., 2014; Muñoz-Parreño et al., 2021). A key objective was ensuring that ABs sessions were of moderate-to-vigorous intensity, as such levels have been shown to significantly enhance attention, as demonstrated in studies and reviews by Daly-Smith et al. (Daly-Smith et al., 2018), Watson et al. (Watson, Timperio, Brown, Best, & Hesketh, 2017) and Janssen et al. (Janssen et al., 2014).

The ABs activities lasted for 10 min and were implemented daily. They combined moderate-to-vigorous intensity physical exercise with cognitive challenges engaging executive functions such as problem-solving, attention, cognitive flexibility, and inhibition. These elements

Table 4

Time point evaluation of the magnitude of the effects in the differences in selective and sustained attention between the two groups during the three months. Data are expressed as mean \pm SD.

Time Point evaluation	EG SeA	CG SeA	Effect size (d)	Effect size (r)	EG SuA	CG SuA	Effect size (d)	Effect size (r)
T0	8.77 \pm 0.55	9.89 \pm 0.87	-1.54	-0.61	26.94 \pm 0.98	26.89 \pm 1.02	0.05	0.02
T1	10.35 \pm 0.47	10.44 \pm 0.53	-0.18	-0.09	30.35 \pm 0.66	30.11 \pm 0.84	0.32	0.17
T2	12.17 \pm 0.73	11.53 \pm 0.54	0.99	0.47	31.82 \pm 0.65	31.61 \pm 0.73	0.30	0.15
T3	16.77 \pm 2.49	12.33 \pm 2.00	1.97	0.70	34.94 \pm 0.24	32.89 \pm 1.97	1.46	0.59

Legend. T0: baseline; T1: after 1 month; T2: after 2 months; T3: after 3 months; SeA: Selective attention at 30''; SuA: Sustained attention at 120''.

proved essential in designing more effective ABs aimed at fostering behavioral, metacognitive, and attentional improvements (Mazzoli et al., 2021). Structuring physical movement to promote neuronal activation—rather than merely serving as an opportunity for leisure—was a deliberate choice to maximize attention gains (Infantes-Paniagua et al., 2021; Masini et al., 2020). Research by Mazzoli et al. (Mazzoli et al., 2021) and Diamond (Diamond, 2015) further underscores that combining physical activity with cognitive engagement enhances executive and cognitive functions. This synergistic activation of body and mind fosters both cognitive growth and overall well-being (Infantes-Paniagua et al., 2021), a concept encapsulated in Embodied Education, a broader pedagogical approach that integrates physical activity, sensory perceptions, cognitive tasks, and social interaction throughout the learning process (Francesconi & Tarozzi, 2012).

Consistent with the findings of Janssen, Toussaint, van Mechelen, and Verhagen (2014), our study demonstrated that moderate-to-high-intensity ABs significantly enhance attention in primary school students following 1 h of cognitively demanding instruction. While the studies used different assessment tools and evaluation timelines, the overall findings were comparable.

Nonetheless, the study's relatively small sample size (35 students) and the intervention duration (three months) represent key limitations affecting the generalizability of the findings. A larger sample would have produced more robust results, less susceptible to random variation. To ensure consistency in AB implementation, school routines, and teaching methods, the study focused on children from the same class.

A longer intervention period would have provided a more comprehensive evaluation of AB effects, potentially revealing long-term benefits and consolidating observed improvements. However, logistical constraints within the Italian school system limited the intervention's duration. Schools typically begin on September 15 and end on June 10, and administrative delays postponed the intervention until January, following the Christmas holidays. The subsequent Easter break made it impractical to extend the study by only a few weeks, as a shorter follow-up period would likely have yielded unreliable results. Despite these limitations, the study duration exceeded that of many similar studies in the literature.

Given these considerations, this study should be considered a pilot study, providing valuable insights for designing future large-scale research to thoroughly assess the impact of ABs on attention. These findings contribute to the expanding body of literature supporting the benefits of physical activity for cognitive function and well-being. They also provide guidance for future research protocols and ongoing discussions on the integration of movement-based interventions into the school day. For ABs to be effectively implemented in school curricula, it is crucial that teachers incorporate them into daily routines as a strategy to restore students' attention and motivation. Comprehensive teacher training is essential to ensure awareness of the benefits ABs offer for learning and classroom climate. One of the main challenges encountered during the implementation phase was effectively demonstrating to educators the potential of ABs and fostering their consistent, daily use.

5. Conclusion

Active Breaks represent a promising strategy to enhance attention and cognitive performance in primary school children while addressing the challenges posed by prolonged sedentary behavior and mental fatigue. This study explored the relationship between ABs and attention levels in primary school students, focusing on identifying the time frame required for their effectiveness. The results, based on multiple assessment time points during the three-month intervention, emphasize the importance of performing ABs regularly for at least two to three months, for 10 min per day, to yield significant improvements in selective and sustained attention in second-grade primary school students.

CRedit authorship contribution statement

Giada Ferrara: Writing – original draft, Visualization, Investigation, Data curation, Conceptualization. **Alice Masini:** Writing – original draft, Methodology, Formal analysis, Data curation. **Gabriele Mascherini:** Writing – original draft, Supervision, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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