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Active Breaks and Cognitive Performance in Pupils: A Systematic Review

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Abstract

The purpose of this study was to conduct a systematic review of interventions using active breaks (ABs) in the school setting to identify the key characteristics (duration of the AB, intensity and type of activities) that an active break needs to have to deliver greater cognitive performance, such as concentration and attention in pupils. A systematic review was conducted following the PRISMA method with the following inclusion criteria: a) studies published between 2010 and 2020 (both inclusive), b) written in Spanish or English, c) active breaks as the main topic, d) articles written in the school setting. The Web of Science, Scopus and PubMed databases were queried. A total of 19 articles were included, all of them showing improvements in pupils' attention and concentration after the implementation of an active break intervention programme in a school setting. The significant influence of the intervention duration, type and intensity variables on the improvement of pupils' cognitive performance was observed. Finally, it was concluded that greater benefits were found in active breaks with a short duration, vigorous intensity and through an activity with a higher cognitive load.

Keywords: active breaks, physical activity, review, school.

Introduction

Physical activity (PA) is a key health factor (WHO, 2020) in children's physical and psychological development (Blanco et al., 2020; Strong et al., 2005), as it improves motor development (Williams et al., 2008), self-esteem (Ulrich, 1997) and cardiorespiratory fitness (Okely et al., 2001). Similarly, sedentary lifestyles and physical inactivity are also associated with different health problems such as coronary heart disease, musculoskeletal pathologies, high blood pressure, high cholesterol, diabetes, depression and anxiety (Piercy et al., 2018). World Health Organisation (WHO, 2020) data show that 84% of girls and 78% of boys aged between 11 and 17 years do not meet the recommended daily PA for this age group, *i.e.* 60 minutes of moderate-to-vigorous physical activity (MVPA) every day of the week and including at least two minutes of muscle strengthening (WHO, 2010). These data are mirrored in Spain by the PASOS study (2019), which shows that 63.3% of the child and adolescent population does not comply with the recommendations, while 40.6% of schoolchildren between 6 and 9 years of age are overweight, a problem which gets worse as they grow older, and more so in girls than in boys.

This declining PA performance seems to be partly related to our society's sedentary lifestyles (Watson et al., 2019; Janssen & Leblanc, 2010), albeit also to a school syllabus packed with contents that are not very hands-on and highly sedentary, in which most of the educational process unfolds in the classroom (Brindova et al., 2014). This has contributed towards a change in children's lifestyles, steering them away from options which allow them to be physically active. This is crucially important at school age, seen as a sensitive stage in which they acquire many of the habits that they will maintain in the course of their lives (Buhring et al., 2009).

This situation would appear to lie at the opposite end of the spectrum to those that regard schools as an ideal environment for promoting PA. This is because in spite of the data presented, the school setting provides great possibilities, such as being a venue for shared interaction that affords ideal learning opportunities and facilitates interaction with the immediate surroundings. However, there are also significant barriers, to wit the aforementioned syllabus and the meagre time spent on experimentation or experiential learning, compounded by cramped learning spaces (Center on Education Policy, 2007). Curricular demands in the so-named instrumental areas of learning cover a large part of the school timetable, which has led authors such as Van Stralen et al. (2014) to observe that children aged 6 to 12 years spend 64% of their school time in sedentary activities and only 5% in MVPA. It is therefore clear that PA levels need to be stepped up in the school setting, where there are different times and spaces for being active, such as physical education classes, playtime, active breaks and commuting to school, which are significant in terms of the weekly amount of physical activity performed by schoolchildren (Pastor-Pradillo, 2007; Martínez-Martínez et al., 2012), although it is also true that they are determined by conditioning factors specific to each educational community.

These healthy times and spaces for action include active breaks (AB), which are short periods of PA (Martínez-López et al., 2018) built into the school timetable, providing pupils with high PA levels. This should not have a negative impact on their learning time; on the contrary, it can improve cognitive performance (Contreras-Jordán et al., 2020). The paper by Hillman et al. (2011) shows how acute bouts of PA appear to improve children's attentional performance. Altenburg, Chinapaw and Singh (2016) found that pupils who were given two 20-minute ABs per week improved in selective attention compared to the control group with only one AB. Similarly, the research by Mavilidi et al. (2019) also uncovered beneficial effects of shorter active breaks in improving attention, task concentration and working memory. Cognitive functions (attention, concentration, working memory) therefore seem to be improved after ABs. Here, it is important to make a distinction between cognitive and executive functions. Cognition refers to a set of mental processes that human beings are capable of carrying out. On the other hand, executive functions are a construct used to shape a series of cognitive capacities involved in controlling thought and behaviour (Zelazo & Carlson, 2012, 2020), including skills such as suitable target selection, initiation and maintenance of a plan of action and flexibility in strategies to achieve a goal (Banich, 2009; Soprano, 2003). They

are also essential for adapting to the environment and for appropriate social functioning.

However, although ABs are known to improve cognitive functions such as attention and concentration (Donnelly & Lambourne, 2011), there is some uncertainty about their structure (Chacón-Cuberos et al., 2020). This is because the literature reviewed does not clearly stipulate the recommended duration or frequency of interventions or the intensity or type of activity to be done in ABs (Laberge et al., 2012; Janssen et al., 2014), even although the importance of these variables as moderators of the proposal are known (De Greeff et al., 2017). In this regard, a study by Hillman et al. (2011) did not find any positive effects for interventions based on simple aerobic exercise, although they did for cognitively demanding activities. Therefore, in view of the existing literature, there would appear to be no consensus on the features that active breaks should have in order to improve cognitive functions.

Consequently, the purpose of this study was to conduct a systematic literature review based on the PRISMA methodology, about school-based interventions using ABs to identify the key features (duration of the AB, intensity and type of activities) required to improve cognitive performance.

Methodology

The information in this study was compiled by means of a systematised review in the Web of Science, Scopus and PubMed databases. The first two were selected because they are the multidisciplinary databases with the largest number of articles included, while the third was chosen because it is the most specific database for health-related articles. The search was performed following the main PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) steps, including the PICO strategy for sourcing articles in each one of the databases: participants (e.g. primary, pupils, children), intervention (e.g. programme, test), comparators (e.g. physical education, sport setting), outcomes (e.g. screening, selection). The search strategy used for these databases consisted of the following: (*cognitive* OR *attention* OR "*executive function**") AND ("*Primary School*") AND ("*physical activity*" OR "*active breaks*"). Subsequently, the four main steps of the PRISMA method were followed: identification, screening, eligibility and inclusion (Moher et al., 2009). This strategy yielded 425 articles (Web of Science-147; Scopus-205; PubMed-73), plus another three articles that were included from external sources, making a total of 428 articles for our literature review.

Selection criteria were applied to all the articles found. The inclusion criteria for this literature review were: a) studies published between 2010 and 2020 (both inclusive), b) written in Spanish or English, c) active breaks as the main topic, d) articles written within the school setting. In addition, qualitative and quantitative articles were included to broaden the range of available articles and thus obtain a greater amount of information on the topic to be studied.

All the articles were exported to Mendeley Reference Manager. After filtering for duplicates, the total number of articles was 301 (127 articles eliminated). After this second filtering, and based on our inclusion criteria, a total of 237 articles were discarded after the year, title and abstract had been reviewed. Finally, 64 articles remained for a full reading to ascertain whether they fulfilled all the inclusion criteria. After this last step, 19 articles were finally selected and used for the in-depth literature review, and 45 papers which following the exhaustive analysis did not meet the inclusion criteria were ultimately discarded.

Articles that did not meet the publication date were discarded in the first step. All the articles that met our inclusion criteria were selected for the review. The resulting PRISMA flowchart is shown in Figure 1 below.

Results

The 19 articles selected for inclusion in this review are presented in Table 1, which details the sections on authors and year of publication of the article, main objective of the study, sample (age and number), instrument for measuring the variables, variables to be studied and research outcomes.

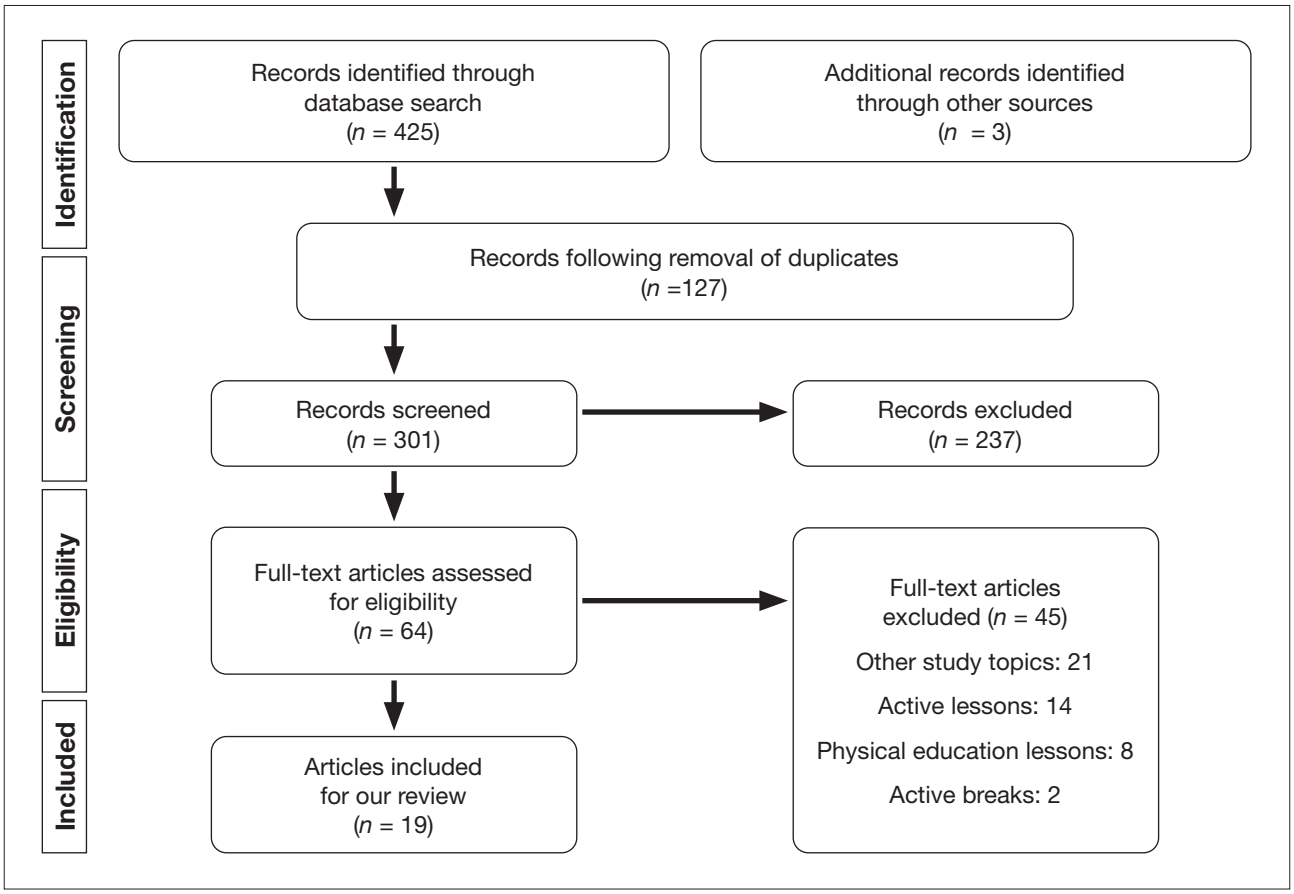

Figure 1
Literature selection flowchart.

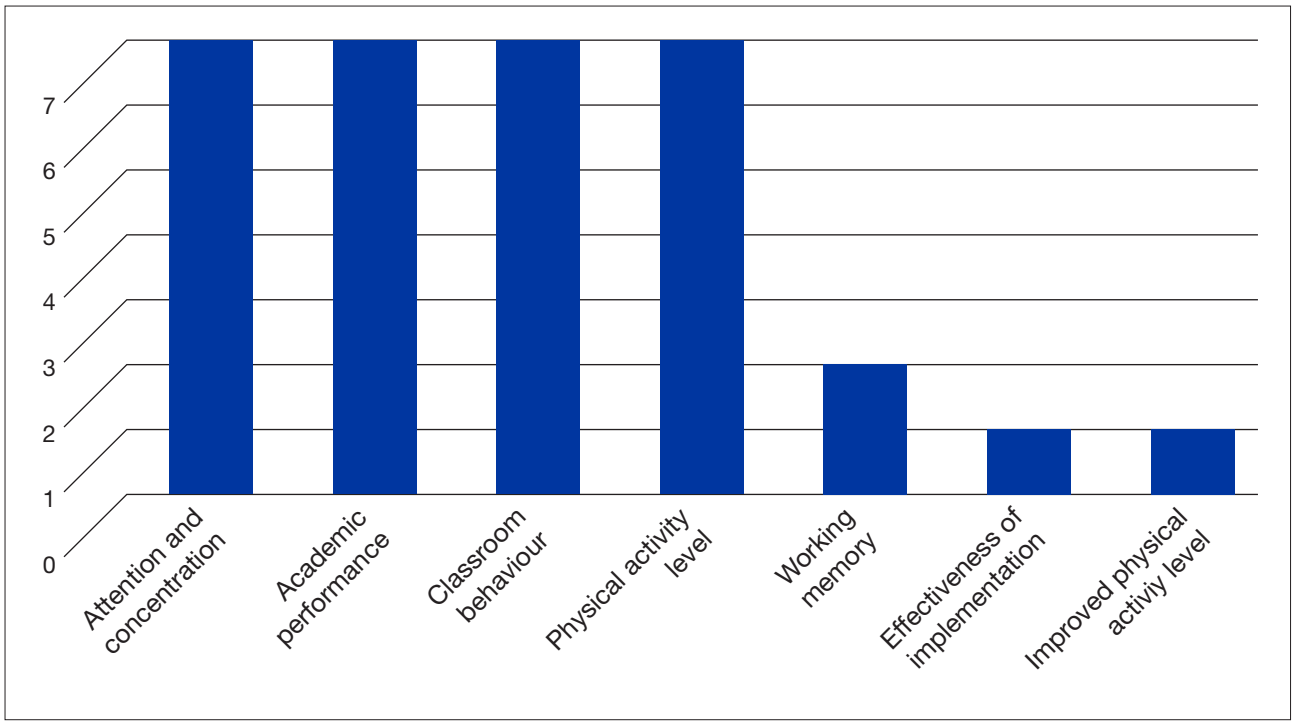

Figure 2
Number of publications grouped by subject matter addressed in the articles included in the review.

Table 1
Characteristics of the articles analysed.

Article	Study objective	Sample	Measurement instrument	Variables	Outcomes
Contreras-Jordán et al. (2020)	Ascertain the influence of AB on children's attention and concentration	*N* = 73 children aged 9-11 years	d2 Test of Attention	Attention and concentration	Significant improvement in attention and concentration after 10 sessions of 15 minutes of AB.
Watson et al. (2019)	Assess the feasibility and efficacy of a 6-week active break pilot programme on academic achievement, classroom behaviour and physical activity.	*N* = 374 children aged 8-10 years	Wheldall Assessment of Reading Passages (WARP) Test Westwood One Minute Test of Basic Number Facts ActiGraph GT3-X accelerometer Direct Behaviour Rating Scale	Academic achievement PA Classroom behaviour	On-task behaviour at the individual level was shown to increase in the intervention group, with greater improvements observed in boys. However, there was no intervention effect on classroom on-task behaviour at whole class level. No intervention effects were found for mathematics, reading or PA during the school day.
Janssen et al. (2014)	The objective of this study was to gain an insight into the acute effects of a short bout of physical activity on selective attention in primary school children.	*N* = 123 children aged 10-11 years	TEA-Ch test	Attention in the classroom	Attention scores after the PA break were significantly better ($p < .001$) than after the 'no break' condition. Attention scores were best after the moderate intensity PA break.
Egger et al. (2019)	The objective of the study was to examine the effects of AB with high physical exertion and high cognitive engagement (combo group), high physical exertion and low cognitive engagement (aerobic group), or low physical exertion and high cognitive engagement (cognition group).	*N* = 142 children aged 7-9 years	Self-Assessment Manikin ActiGraph GT3X Eriksen flanker task Heidelberger Rechentest Hamburger Schreib-Probe (HSP 1–10) Salzburger Lese-Screening PAQ-C	PA level Academic performance Cognitive outcomes (mathematics, spelling and reading, etc.)	The combo group benefited by showing improved cognitive demand. The cognition group benefited only in terms of academic performance, while the aerobic group remained unaffected. The inclusion of cognitively engaging PA breaks seems to be a promising way to enhance schoolchildren's cognitive functions.
Mok et al. (2020)	Evaluate the effectiveness of a programme in changing children's attitudes toward PA.	*N* = 3036 pupils aged 8-11 years	Attitudes toward Physical Activity Scale (APAS)	Attitudes toward doing PA	This study provides evidence about improvements in terms of learning experience, attitudes towards PA and personal motivation.

Table 1 (Continuation)
Characteristics of the articles analysed.

Article	Study objective	Sample	Measurement instrument	Variables	Outcomes
Schmidt et al. (2016)	Ascertain the separate and/or combined effects of physical exertion and cognitive engagement induced by physical activity breaks on primary school children's attention.	*N* = 92 children aged 11-12 years	D2 Test PANAS-C	Pupils' attention	Physical exertion had no effect on any measure of children's attentional performance. Cognitive engagement was the crucial factor leading to increased focused attention and enhanced processing speed.
Suarez-Manzano et al. (2018)	Analyse studies assessing the effect of integrated PA performance during school breaks on attention in children and adolescents.	Systematic review		Pupils' attention	All the studies used physical exercise of moderate-vigorous intensity lasting between 5 and 30 min. Seven studies showed improvement and two showed no change. Differences were found according to sex. Finally, the influence of the duration and intensity of the intervention was observed.
Paschen et al. (2019)	Investigate the effects of exercise with low and high cognitive demands on speed of processing and accuracy of performance in tasks examining inhibition, working memory and cognitive flexibility in children.	Systematic review		Working memory Inhibition Cognitive flexibility	Ten studies with a total of 890 participants revealed positive effects on working memory performance after exercise with low cognitive demands compared to seated rest, mixed results for inhibition after exercise with high and low cognitive demands and mixed results for cognitive flexibility with low cognitive demands.
Mavilidi et al. (2020)	Investigate whether physical activity could decrease anxiety levels and improve maths test performance in sixth-grade children.	*N* = 68 children aged 11-12 years	The Cognitive Anxiety test Questionnaire Math Test	Anxiety levels Academic performance	Low-anxiety level pupils performed better in the maths test than high-anxiety level children. No differences were found for any of the variables between the activity break condition and the control condition.

Table 1 (Continuation)
Characteristics of the articles analysed.

Article	Study objective	Sample	Measurement instrument	Variables	Outcomes
Mavilidi et al. (2019)	This study examined the effects of different types of classroom physical activity breaks on children's ontask behaviour, academic achievement and cognition.	*N* = 87 pupils aged 9-11 years	Behaviour observation of pupils in schools The Applied behaviour analysis for teachers Individual Basic Facts Assessment Tool The Flanker test	On-task behaviour Academic performance Executive functions	Significant effects were found for on-task behaviour. Academic performance in mathematics was improved. No effect on executive functions was found.
Schmidt et al. (2019)	Investigate the effects of specifically designed physical activities on foreign language vocabulary learning and attentional performance.	*N* = 104 children aged 8-10 years	Cued Recall Test D2 Test	Academic performance Attention	Embedded learning with PA was more effective in teaching children new words than the control condition. However, children's focused attention did not differ across the three conditions.
Masini et al. (2020)	Investigate the effects of AB on PA levels, classroom behaviour, cognitive functions and academic performance in primary school children.	Systematic review		PA level Classroom behaviour Cognitive functions Academic performance	A significant effect was found in increasing PA levels in primary school children. Regarding classroom behaviour, time spent on task during lessons significantly increased. On the other hand, the effects on cognitive functions and academic achievement (mathematics, reading) were not conclusive.
Mazzoli et al. (2019)	Assess the feasibility of implementing a cognitively challenging motor task as an AB in schools.	*n* = 12 teachers and *n* = 34 pupils	Interviews	Effect of implementing ABs in classrooms	Teachers viewed the cognitively challenging motor task as appropriate and potentially beneficial for children. Children reported enjoying the ABs. Teachers in special schools viewed the task as complex and potentially frustrating for children.
Buchele-Harris et al. (2018)	This study examined the effects of 4-week, daily 6-minute ABs on attention and concentration in school-aged children.	*N* = 116 pupils age 10 years	D2 Test	Attention and concentration	Significant increases in processing speed and attention span were found compared to the control group. There was significant improvement in the pupils' concentration performance.

Table 1 (Continuation)
Characteristics of the articles analysed.

Article	Study objective	Sample	Measurement instrument	Variables	Outcomes
Mahar (2011)	The study's objective was to describe the measurement of on-task behaviour and review the research on the effects of short physical activity breaks on attention-to-task in primary school pupils.	Systematic review		Attention	The limited evidence suggests a small improvement in attention-to-task following PA breaks. Pupils who participated in classroom-based physical activities that incorporate academic concepts demonstrated significantly better improvements in attention-to-task than control group participants.
Routen et al. (2017)	The aim of this study was to determine the extent to which ABs are implemented and also investigate how they affect school performance.	5 classes of 9-10 year-olds	The Children's Activity Rating Scale The School Physical Activity Promotion Competence Questionnaire Actigraph accelerometer (GT3X or GT3X+) D2 Test	Cognitive functions PA level	No results were found, as the programme has not been implemented.
Rizal et al. (2019)	The purpose of this study was to measure the effect of this programme on the stages of change, decisional balance, processes of change, self-efficacy and leisure-time exercise among Malay ethnic primary school children.	*N* = 322 children aged 10-11 years	Godin Leisure-Time Exercise Questionnaire (GLTEQ) The process of change questionnaire Plotniko 10-item decisional balance scale The three-factor, 18-item self-efficacy scale originated from Bandura	Processes of change Decisional balance Self-efficacy	It showed significant changes in cognitive processing. In addition, a significant interaction effect was observed for stages of change.
Morris et al. (2019)	Show improvements in PA and educational benefits such as executive function and academic performance using The Daily Mile (TDM).	*N* = 303 8.99 ± 0.5 years	EF tests (Trail Making Task; Digit Recall; Flanker; Animal Stroop) Maths fluency test (Maths Addition and Subtraction, Speed and Accuracy Test). GT9X, GT3X + accelerometers	Executive functions Academic performance PA	TDM revealed significantly greater PA (+10.23 min) and reduced sedentary time (–9.28 min) compared to control. Academic performance improved significantly.
Ruiz-Hermosa et al. (2019)	Evaluate the link between active commuting to and from school and academic achievement in children and adolescents.	Systematic review		Cognitive performance and academic achievement	No differences were found in executive functions. There was insufficient evidence regarding the relationship between active commuting to and from school and cognitive performance and academic achievement.

Objectives

The main study objective of seven of the 19 articles was ABs and their impact on pupils' attention and concentration (Contreras-Jordán et al., 2020; Janssen et al., 2014; Schmidt et al., 2016; Suarez-Manzano et al., 2018; Schmidt et al., 2019; Buchele-Harris et al., 2018; Mahar, 2011). In addition, another seven articles studying the effect of ABs on academic performance, classroom behaviour and PA level were identified (Routen et al., 2017; Watson et al., 2019; Egger et al., 2019; Mavilidi et al., 2020; Morris et al., 2019; Mavilidi et al., 2019; Masini et al., 2020). Finally, five studies on different topics examined the influence of ABs on improving PA performance (Mok et al., 2020) and working memory (Rizal et al., 2019; Paschen et al., 2019) and also explored the effectiveness of their implementation (Mazzoli et al., 2019), with the exception of a final article assessing the relationship between active commuting to and from school and cognitive performance (Ruiz-Hermosa et al., 2019).

Sample

Five of the 19 selected articles have a sample size of less than 100 pupils (Contreras-Jordán et al., 2020; Schmidt et al., 2016; Mavilidi et al., 2020; Mavilidi et al., 2019; Mazzoli et al., 2019).

Similarly, seven of the studies selected present a sample of between 100 and 400 pupils (Watson et al., 2019; Janssen et al., 2014; Egger et al., 2019; Schmidt et al., 2019; Buchele-Harris et al., 2018; Rizal et al., 2019; Morris et al., 2019). Conversely, only one of them has a sample size of over 400 pupils (Mok et al., 2020). Finally, there were five systematic reviews (Paschenet al., 2019; Suarez-Manzano et al., 2018; Masiniet al., 2020; Mahar, 2011; Ruiz-Hermosa et al., 2019), hence their sample sizes are unknown. In addition, all the articles were included in the primary education stage, mostly between 8 and 12 years of age.

Measurement instruments

Excluding the five systematic reviews (Paschenet al., 2019; Suarez-Manzanoet al., 2018; Masini et al., 2020; Mahar, 2011; Ruiz-Hermosa et al., 2019), six of the 19 selected articles used these instruments to measure attention, such as the d2 Test, the TEA-Ch Test and the PANAS-C. ActiGraph GT3-X accelerometers were also used to measure PA level. To observe academic performance, five articles used different instruments, including the Wheldall Assessment of Reading Passages (WARP) test and the Westwood One Minute Test of Basic Number Facts, Maths Test and the Cued Recall Test. Moreover, two articles examined PA level using PAQ-C and the School Physical Activity Promotion Competence Questionnaire. Finally, two studies utilised other tools such as interviews or the Attitudes toward Physical Activity Scale (APAS) questionnaire.

Variables

Seven of the 19 articles selected included attention as a variable. Similarly, seven articles included academic performance as one of their variables. In addition, five articles included PA level as one of their main variables. There were five articles for executive cognitive functions. Finally, other variables included attitude towards PA, working memory and inhibition, the effect of implementing ABs (Mazzoli et al., 2019) and change and self-efficacy processes.

Results

Ten of the 19 studies found improvements in attention following AB implementation (Contreras-Jordán et al., 2020; Janssen et al., 2014; Suarez-Manzano et al., 2018; Mahar, 2011; Buchele-Harris et al., 2018; Masini et al., 2020; Morris et al., 2019; Rizal et al., 2019; Schmidt et al., 2016; Egger et al., 2019). However, Schmidt et al. (2019) found no effect on attention in their study. Another five studies observed improvements in academic performance (Paschen et al., 2019; Mavilidi et al., 2020; Mavilidi et al., 2019; Mahar, 2011; Schmidt et al., 2019). Conversely, three studies found no benefits in academic performance after AB implementation (Masiniet al., 2020; Watson et al., 2019; Ruiz-Hermosa et al., 2019). Finally, improvements were identified in four studies in terms of pupils' PA level (Mavilidi et al., 2019; Masiniet al., 2020; Mazzoli et al., 2019; Moket al., 2020).

Discussion

The purpose of this study was to conduct a systematic review of the use of ABs in primary school as a strategy to improve pupils' cognitive performance. To this end, Web of Science, Scopus and PubMed were used as the main databases to source articles published in the last 10 years related to this topic, leading a total of 19 articles to be included.

Most of the published articles found evidence that an AB helps to improve pupils' attention in the classroom, as is also demonstrated by other studies that focused on improving this variable using this kind of break (Donnelly & Lambourne, 2011; Wilson et al., 2016). These PA breaks also generated positive effects on academic performance (Paschenet al., 2019; Mavilidi et al., 2020; Mavilidi et al., 2019; Mahar, 2011; Schmidt et al., 2019).

An AB's impact on attention is most effective shortly after a moderate PA break. This effect is related to the inverted-U hypothesis, which establishes that cognitive performance is significantly improved with a moderate level of arousal (McMorris & Graydon, 2000). The optimal level of arousal for adult attention is reached after a bout of moderate PA (Brisswalter et al., 2002). Arguably, this optimal level is the same in children because attentional control is fully developed from the age of 7 years (Rueda et al., 2005). It could therefore be inferred that attention and PA are closely related to be able to generate a positive effect.

As mentioned above, there are several aspects which directly influence the variables to be studied about an AB, such as its duration, type (cognitive or mechanical) and intensity.

In terms of the duration of these breaks, authors such as Kubesch et al. (2009) examined changes in cognitive aspects after 5 and 30-minute breaks, showing that improvements were generated after five minutes at vigorous intensity compared to 30 minutes at moderate intensity. Furthermore, when the effect of including PA in breaks for at least four minutes was studied, short-term improvements in attention were found (Ma et al., 2014). Consequently, this may suggest that greater benefits are gained through a short break (5-10 minutes) at high intensity than through a moderate 30-minute AB.

Coe et al. (2006) measured the effect of break intensity through MVPA interventions in ABs in 214 children aged 10-11 years, observing that the moderate-intensity group presented no change, whereas the vigorous intensity group showed significant improvements compared to the control group. It might therefore be interpreted that a vigorous intensity PA bout produces greater improvements in pupils compared to moderate intensity.

Another key factor may be the type of activity carried out, *i.e.* whether it is more cognitive or mechanical. In a study included here, Watson et al. (2019) used mostly cognitive load activities and found significant improvements, although this was not conclusive since they were not compared with other more PA-focused activities. Similarly, Schmidt et al. (2016) compared groups with AB, another with AB and cognitive load and another group with cognitive exercises only and concluded that cognitive engagement was the key factor in greater attention and improved processing speed, rather than PA load. Furthermore, in their study, Buchele-Harris et al. (2018) found improvements in processing speed, attention and concentration through coordinated-bilateral PA breaks. This study also concluded that pupils who participated in non-cognitive activities with a physical load did not differ from the control group. It can therefore be inferred that cognitive load is a crucial factor in significantly improving attention and concentration in pupils.

This makes sense to the extent that Ruiz-Hermosa et al. (2019) argue that MVPA has a direct impact on cerebral function. Thus, improving cardiorespiratory capacity triggers angiogenesis, *i.e.* the physical process that forms new blood vessels from existing ones, thereby increasing blood flow and improving cerebral vascularisation (Hillman et al., 2008). Moreover, doing PA also fosters an increase in brain-derived neurotrophic factor, which regulates cell survival and brain plasticity (Huanget al., 2014), leading to an improvement in cognitive elements (Leckieet al., 2014). Accordingly, doing PA would apparently help to increase levels of attention and concentration, thus supporting the need to add PA to the school syllabus.

Conclusion

The results of this systematic review suggest that ABs are a good strategy to achieve higher cognitive performance. Furthermore, differences were found by duration, type and intensity, whereby an AB lasting 5-10 minutes was more suitable than an AB of 20 minutes, at vigorous versus moderate intensity and with the type of activity having a more cognitive than mechanical load. It could therefore be argued that the benefits that ABs appear to deliver in terms of cognitive performance might enable pupils to improve their classroom attention and concentration and gain in academic performance and even in motivation. Moreover, in specific domains such as sports, these cognitive improvements play a role in the successful completion of numerous tasks that have to be tackled during physical activity.

Finally, this research has one minor limitation, although it also holds some potential. The limitation is that few articles have been published in the last 10 years on the implementation of AB programmes, *i.e.* most, or the bulk of them, have been published since 2017, as can be seen in this literature review. Similarly, there is the potential and a need to continue to work in this field, since including ABs in the classroom is associated with the emerging methodologies and the boom in new technologies. Furthermore, it should also be remembered that although the physical education syllabus is firmly established, it is not easy to work in this field due to the number of variables that have to be taken into consideration and are sometimes difficult for teachers to control, not to mention the need for a clear commitment by all the stakeholders to carry out this type of intervention programme (Romero-Cerezo, 2007).

Practical applications

The results found are designed to continue this research strand in PA and cognitive performance. This PA has been embodied in ABs. Thus, the first practical application of this paper is to provide a foundation for other researchers focusing on this research strand to be able to replicate the outcomes reported here and thus contribute knowledge to this field. Secondly, these results should be given due consideration by primary school teachers so that they can follow the guidelines for the appropriate implementation of an effective AB. Aspects such as intensity, duration and frequency should be reviewed when an AB programme is implemented. Thirdly and finally, education policymakers should be mindful of the benefits of ABs for pupils' cognitive performance so as to deliver training courses on AB programmes for schools.

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