

Physical activity in students and its association with attention. A systematic review Actividad física en escolares y su relación con la atención. Una revisión sistemática

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Abstract. Despite the recommendations for physical activity in children and adolescents, sedentary behaviors that may affect health are frequent in today's schools. Evidence suggests that physical activity has a beneficial effect on the development of attention, however, there is no clarity on the characteristics that physical activity should have to optimize the improvement of attention in schoolchildren. A search for articles in databases published between 2013 and 2023 was performed, and after applying the inclusion and exclusion criteria and after analyzing their results, thirty-three articles were identified. The results suggest that the practice of physical activity has a positive effect on attention, mainly selective attention, but it is not possible to establish the characteristics in relation to frequency, time, intensity, or type of exercise that yield the best results, probably due to the heterogeneity of the interventions and populations studied. More experimental studies are therefore required to help identify the characteristics of physical activity that best contribute to the development of attention as a cognitive indicator.

Keywords: Attention, physical activity, school children, sedentary behaviors, cognitive indicators.

Resumen. A pesar de las recomendaciones de actividad física en niños y adolescentes, en la escuela actual no es infrecuente el desarrollo de comportamientos sedentarios que pueden afectar la salud. La evidencia sugiere que la actividad física tiene un efecto benéfico en el desarrollo de la atención, sin embargo, no hay claridad de las características que la actividad física deba tener para optimizar la mejora de la atención en escolares. Se realizó una búsqueda de artículos en bases de datos publicados entre 2013 y 2023, y luego de aplicar los criterios de inclusión y exclusión y tras analizar sus resultados se identificaron 33 artículos. Los resultados sugieren que la práctica de actividad física presenta un efecto positivo con la atención, principalmente con la atención selectiva, sin que sea posible establecer las características en relación de frecuencia, tiempo, intensidad o tipo de ejercicio que mejores resultados arrojan, esto probablemente sea debido a la heterogeneidad de las intervenciones y poblaciones estudiadas. Se requieren, por lo tanto, más estudios experimentales que ayuden en la identificación de las características de la actividad física que mejor contribuyan al desarrollo de la atención como indicador cognitivo.

Palabras clave: Atención, actividad física, escolares, comportamientos sedentarios, indicadores cognitivos.

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Introduction

The World Health Organization (WHO) published guidelines on physical activity (PA) and sedentary behaviors (SB), where it recommends the amount of PA that children and adolescents should perform, describing the values to be considered in frequency, intensity, and duration. The document recommends that children and adolescents aged five to 17 years accumulate at least 60 minutes of moderate to vigorous intensity physical activity (MVPA) per day, with muscle strengthening activities at least three days per week (WHO guidelines on physical activity and sedentary behaviour., 2021). In turn, Miko et al. (2020) defines PA as activity that includes any form of movement in which the contraction of skeletal muscles results in increased energy consumption. Similarly, SB are defined as those characterized by an energy expenditure ≤ 1.5 MET (Metabolic rate unit of measure) in a sitting, reclining, or lying posture. (Tremblay et al., 2017).

PA seems to have a positive effect on some cognitive indicators (CI) such as attention, especially selective attention (Martínez-López et al, 2018; Rosa et al., 2020; Ruiz-Ariza et al., 2021). Despite this evidence, educational centers generally focus their teaching-learning processes on prolonged periods of time in a seated position, thus, causing a prevalence of SB in most of the school timetable (Ma. J et al., 2015; Van den Berg et al., 2018). In the current school context, where students are influenced by multiple

distractors, maintaining the attention span of children and adolescents has become a challenging task for teachers and managers of educational institutions (Gunnell et al., 2019). According to global estimates, children can have up to eight hours of SB daily (Bauman et al., 2018), and may experience various problems of concentration in learning, especially in primary schools, due to excessive use of technological devices (Komari et al., 2024), therefore, being able to replace teaching - learning activities with high SB with movement-based learning activities could contribute to the physical health (Ruiz-Ariza et al., 2021) and attentional processes of schoolchildren. (Altermann & Gröpel, 2022).

The school is recognized as an important space to promote the health and well-being of children (Kuzik et al., 2022; Maldonado et al., 2023) and the physical education (PE) class provides the enabling context for the development of strategies such as the promotion of PA and exercise (Alvarado et al., 2019; Romero-Martínez et al., 2024). However, outside the PE class, long periods of SB occur in schoolchildren that are unfavorably associated with body composition, physical fitness, prosocial behavior and self-esteem (Saunders et al., 2022) therefore, for managers and teachers to implement PA programs in the classroom, they need to be convinced that these programs benefit students and facilitate academic processes (Mahar, 2019). In this sense, the practice of PA and exercise becomes a strategy supported by great scientific evidence that

demonstrates a broad impact on strengthening health (WHO guidelines on physical activity and sedentary behaviour., 2021), and CI such as attention (Altermann & Gröpel, 2023; Gallotta et al., 2015; Polevoy, 2022; Rosa et al., 2021; Tseng et al., 2021).

Attention is defined as a cognitive process that allows selective concentration on one aspect of the environment while ignoring others (Rodríguez-Negro & Yanci, 2021) and generates a control mechanism that plays a fundamental role in the hierarchical organization of not only neurocognitive but also motivational processes (Rosa et al., 2020). Similarly, Hillman et al. (2003) defines attention as a crucial mental process that participates in the learning process of both simple and complex skills, being a central mediator of cognition. Likewise, De Greeff et al. (2017) states that attention participates in the selection, integration, and comprehension of a vast amount of contextual information, which underpins the learning process. Attention is, therefore, a vital component for learning, and it deserves to be promoted in schools through PA-oriented interventions (Schmidt et al., 2015).

Attention is classified according to Sohlberg, cited by Lai & Chang (2020) in five dimensions, sustained attention, selective attention, focused attention, alternating attention, and divided attention. For this review, selective attention and sustained attention have been considered, as they are the main dimensions addressed in the articles reviewed. Thus, selective attention has been defined as the cognitive function that directs attention to objects or stimuli that are relevant and avoids distraction from those that are not (Introzzi et al., 2019). As for sustained attention, it is defined as a type of voluntary attention that responds to the ability to maintain the same behavior over time and fatigue (Maureira Cid & Flores, 2017).

Few systematic reviews and meta-analyses have delved into the effects of PA on attention as a CI. The systematic review by Hajar et al. (2019) analyzed the relationship of PA with sustained attention, describing beneficial effects in the participants of most studies, while De Greeff et al. (2017) in their meta-analysis, addresses intervention studies that investigated the effects of PA in different domains, showing positive effects on attention in children and preadolescents who participated in acute PA programs, similarly, describes effects of longitudinal PA on the domains of executive functions, academic performance and attention. Researchers such as Domínguez-González et al. (2018) and Rosa et al. (2019) have found positive relationships between physical condition, especially cardiorespiratory fitness and selective attention, however, scientific evidence shows no conclusive results, since studies are presented with PA programs with different designs and applications that do not reveal positive effects in the domains of attention (Gelabert et al., 2023; Gilbert

et al., 2023). Thus, the present review stands out for its innovative approach in the analysis of recent studies with distinctive designs and methodologies, addressing different domains of attention, with emphasis on selective and sustained attention.

Having described the above, the present review documentarily analyzed the scientific evidence on PA interventions and their relationship with attention as a CI, determining whether the effects are acute or chronic. Therefore, this article aims to: i) Determine whether there is a dose-response relationship between PA and selective or sustained attention as CI in schoolchildren aged six to 18 years. ii) Demonstrate whether the results presented by the studies reflect a change in relation to the type of PA used, duration of activity, intensity, and frequency of the interventions.

Method

This review was registered in the Prospero international prospective registry of systematic reviews with ID CRD42023447339. For its methodological development and the organization of variables, the PICO strategy was used (P = Population "schoolchildren aged six to 18 years", I = Intervention "PA and exercise", C = Comparison "compared with usual activity", O = Outcomes "improves attention as CI") (Oviedo & Soria Viteri, 2015), also following the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses- PRISMA (Page et al., 2021). The review focused on the search and analysis of original articles published in peer-reviewed journals that examined the measurement or implementation of PA programs in schoolchildren aged six to 18 years and their association with domains of attention such as CI.

Search strategy.

The databases consulted for the selection of articles were PubMed, Scopus, and Web of Science (WOS). The search was performed in PubMed as it is the most important database in health-related, Scopus and WOS as they are the databases with the largest number of articles from high impact research journals. The search was restricted to the last 10 years (January one, 2013 - March 30, 2023) and included original articles in English and Spanish. Reviews, meta-analyses, and case studies were not included.

To perform the search in the databases, the words (physical activity, exercise, attention, cognitive and school indicators) were required to appear in the title, keywords or abstract of the article. Boolean operators AND and OR were used to better delimit the search and the filters of full text article, time, language and human studies were applied. The search equations are shown in table one.

Table 1.

Search equations.

Database	Search filter	Articles found
Pubmed	((("physical activity"[MeSH Terms] OR "exercise"[MeSH Terms]) AND ("attention"[MeSH Terms] OR "cognition"[MeSH Terms]) AND ("adolescent"[MeSH Terms] OR "child"[MeSH Terms]))	141
Scopus	("physical activity" OR "exercise") AND (("attention" OR "cognitive function")) AND (("schoolchildren" OR "students" OR "adolescents"))	588
Web Of Science	("physical activity" OR "exercise") AND ("attention" OR "cognitive function") AND ("schoolchildren" OR "students" OR "adolescents")	333

For the article selection process, the exploration was carried out by applying the search filters in the three databases described above, identifying 1062 articles, then the metadata of the articles were exported to the Rayyan collaboration and research platform for systematic reviews. In this platform, eighty articles were identified and eliminated due to duplicity, leaving 982 documents. Subsequently, the following steps were carried out: i) Blind

reading by the researchers, taking into account the title and abstract for the selection of articles, ii) After consensus by the researchers, 933 articles that were not directly related to the subject were excluded, iii) finally, 49 articles were added to the Mendeley bibliographic manager for full text reading and subsequent application of the inclusion and exclusion criteria, leaving 33 studies for the systematic review.

Table 2.

Criteria for inclusion or exclusion of articles.

N.	Inclusion criteria
1	Study design: Original articles in English and Spanish of experimental type, randomized clinical trials (RCT), quasi-experimental and observational, that allow the analysis of the evaluation or application of physical activity programs and their association with attention as a cognitive indicator.
2	Study population: Studies with school population between 6 and 18 years of age.
3	Intervention: Articles that address the evaluation or implementation of physical activity or exercise programs and their association with attention as a cognitive indicator.
4	Results: Studies presenting conclusions on the impact of the evaluation or implementation of physical activity or exercise programs, and their association with the different dimensions of attention.
Exclusion criteria	
1	Articles that address interventions in students with health alterations, pathologies, or special cognitive capacities.
2	Studies that do not directly present the relationship between physical activity or exercise and attention.
3	Articles that are published outside the delimited time frame.
4	Review articles, meta-analysis, abstracts of academic events, theses, monographs, or reports.
5	Articles that do not meet the inclusion criteria.

Results

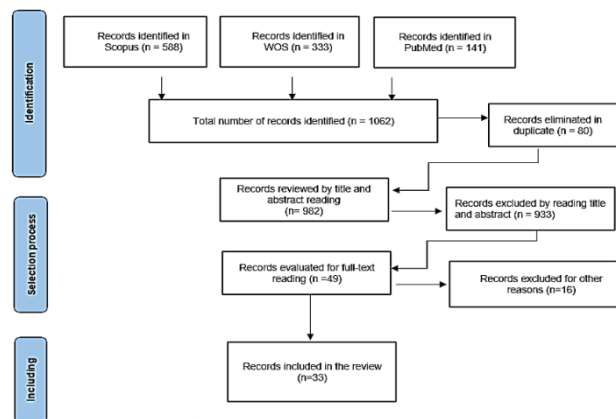


Figure 1. Prisma flow diagram of the selection of studies.

Evaluation of the methodological quality of the studies

The methodological quality and measurement of bias were assessed using Cochrane RevMan software. Due to the low homogeneity of the studies included in the systematic review, the Forest Plot was performed considering only the randomized clinical trials that used the D2 test tool to measure attention as a CI. Figure two shows the forest plot comparing PA vs non-PF interventions; the forest plot data

show $I^2 = 0\%$, suggesting high homogeneity in these five studies. In the study by (Martínez-López et al, 2018), the sedentary population of the experimental group was considered for the data to elaborate the forest plot. Similarly, figure three shows the risk of bias plot made according to the criteria of two researchers, and in the case of discrepancy, the opinion of a third researcher was considered.

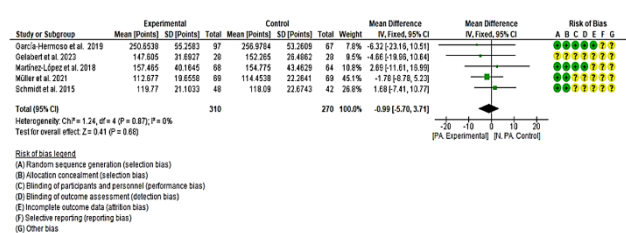


Figure 2. Forest Plot of physical activity vs no physical activity application



Figure 3. Graph of risk of bias in the opinion of the researchers on the articles included in the review

Main characteristics of the studies

To respond to the objectives set out in the study, an analysis matrix was prepared in the Microsoft Excel program where the data of the articles were included as follows: main author, year of publication, country, population size and ages, sex, type and duration of PA, attention evaluated and type of effect (acute or chronic), the attention evaluation instrument and the main conclusions. In this graph, in addition to describing the main characteristics of the selected studies, they have been organized by year of publication, starting from the oldest to show the progress and analysis of the information over the last 10 years. See table three.

Of the 1062 articles found in the databases, 33 original articles were finally analyzed, 25 of them experimental and eight observational, including 12.133 schoolchildren aged six to 18. Twenty studies were conducted with children aged six to 13 years, six studies with adolescents aged 14 to 18 years and seven studies present a general population of children and adolescents.

The research was carried out in twenty countries, with Spain being the country where the relationship between PA and attention was examined the most, with six studies (see Figure four). Similarly, it is important to highlight that the same study was developed in six European countries (Vanhelst et al., 2016). The most used tool (16 of the 33 articles, 48 %) to measure attention and its dimensions was the D2 attention test and its recent version D2-R, this tool determines the ability to pay attention to a stimulus, while omitting distracting letters (Gall et al., 2018). The overall results of the studies analyzed show that the dose-response relationship between PA and attention presents facilitating effects on performance in several domains of attention (25 of 33 items. 76 %). In relation to articles that evaluated physical fitness, the studies by Rosa et al. (2021) and Pérez-Lobato et al. (2016) argue that adolescents who had better aerobic fitness and physical fitness respectively presented better selective attention. No study reported a decrease in attention after PA implementation. Eight of the articles analyzed in this review, did not evidence significant changes in attention (Gall et al., 2018; García-Hermoso et al., 2020; Gelabert et al., 2023; Gilbert et al., 2023; Leong et al., 2015; Lima et al., 2017; Van den Berg et al., 2018; Vanhelst et al., 2016).

The reviewed studies consider variables such as exercise duration, frequency, and intensity, and are evidenced through strength and speed sessions (Polevoy, 2022b), endurance and flexibility (Müller et al., 2021), coordination (Latino et al., 2021) traditional PE class (Polevoy, 2022a), HIIT (High-intensity interval training) (Ma. J et al., 2015; Martínez-López et al., 2018), physically active breaks (Ruiz-Ariza et al., 2021), dance (Gall et al., 2018; Leong et al., 2015), sports such as karate (Lima et al., 2017), soccer, basketball, field hockey and handball (Spitzer & Hollmann, 2013), racquet practice and running (Gallotta et al., 2020), cycling (Van den Berg et al., 2018), physical warm-up in PE classes (Silva-Capella et al., 2021),

yoga practice (Vhavle et al., 2019) and activities that mix cognitive effort and physical effort (Gallotta et al., 2015).

The results of the studies show benefits of the practice of PA and exercise in dimensions of attention such as selective, sustained, divided, and executive attention, among others. Regarding the types of attention, selective attention was the dimension that was most evaluated in the studies with 19 of the 33 articles (57%). Of the 19 articles that evaluated selective attention, 12 (63%) claimed an improvement in its levels in relation to the initial parameters, these interventions varied in number of sessions between one single session (Rosa et al., 2021) up to 12 weeks (about three months) with two weekly sessions (Martínez-López et al., 2018). Similarly, the intensities and timing of the applications varied, ranging from four minutes of high-intensity activities (Ma. J et al., 2015) to 90 minutes (about one and a half hours) of light activity. (Tseng et al., 2021). Sustained attention was evaluated in four studies (12%), where conclusions evidencing changes in sustained attention were presented in two studies (50%) from activities involving physical effort accompanied by cognitive effort (Gallotta et al., 2015) and practice of 60 minutes of open dexterity activity (racket) (Gallotta et al., 2020).

In relation to intensity, the results presented by the studies evidence improvements in attention with high intensity interventions (Ma. J et al., 2015; Rosa et al., 2020). In the same line, Martínez-López et al (2018) implemented a high-intensity intervallic training (HIIT) program, where they found that the experimental group (EG) increased selective attention by 14, 2% in relation to the control group (CG).

For their part, Booth et al. (2013) evaluated the PA of 4,755 children between the ages of 11 and 13 years and concluded that MVPA may be beneficial for attention processes in adolescence and especially in boys. Interventions with moderate intensities also had favorable effects on attention in children and adolescents; studies such as the one developed by Ruiz-Ariza et al. (2021) affirm that both high and low intensity active breaks have a significant effect on attention immediately after the stimulus ends.

In terms of frequency, there are studies that showed improvements in attention with a single session (Schmidt et al., 2015). The study by Rodríguez-Negro & Yanci (2021) also with a daily session, but for eight weeks (about two months) found that PA based on the tactical games model, has specific effects on attention. López-Vicente et al. (2016) suggests that children who exercise twice a week present better levels of attention than those who exercise once a week. Altenburg et al. (2015) highlights in their study that two daily sessions of 20 minutes of MPA could improve selective attention in children aged 10 to 13 years and maintain its effect up to 110 minutes (about two hours) after the end of the activity, a conclusion similar to that described in the studies by Samuel et al. (2017) and Schmidt et al. (2015) who concluded that the practice of PA can improve attention 60 and 90 minutes (about one and a half hours) after the effort has been made.

Of all PA interventions that showed positive effects on attention domains, six presented one session per week and ranged from one week to two months, six studies applied two sessions per week and ranged from one week to five months. The intervention by Spitzer & Hollmann (2013) developed three sessions per week for four months and evidenced improvements in attention following physical exercise. The studies by Ma, J et al. (2015) and Martínez-López et al (2018) found acute effects on selective attention after applying high-intensity interventions, while Altenburg et al. (2015) and Rosa et al. (2021) found acute effects on selective attention with MPA interventions, Ruiz-Ariza et al. (2021) evidenced acute effects on selective attention with both high and low intensity active breaks, likewise, Gallotta et al. (2020) found acute effects, but on sustained attention with racquet practice activities.

Regarding the duration of the sessions and the interventions applied in the studies, as was the case with the frequency and intensity variables, they presented extremely

high heterogeneity, and some studies lack detailed information. To highlight the study by Vanhelst et al. (2016) who made an anthropometric measurement and PA assessment for seven days to 273 adolescents aged 12 to 17 years in different countries in Europe, and presented data suggesting that the PA thresholds that best discriminated attention span were 41 minutes for MPA, 12 minutes per day for VPA and 58 minutes per day for MVPA. Interventions that affected attention as CI ranged from four minutes (Ma, J et al., 2015), to two studies that conducted a 90-minute intervention per session (Rodríguez-Negro & Yanci, 2021; Tseng et al., 2021).

Regarding the duration of the intervention programs, there were three studies of one single session, one with two sessions, one with two weeks, the largest number of studies with interventions of equal time were five studies and eight weeks (about two months). Polevoy (2022) was the longest duration with five months.

Table 3.

Article analysis matrix.

Studio	Population	Type of physical activity	Duration Physical activity	Type of effect and attention affected	Attention instrument	Main conclusions
Booth et al. (2013) United Kingdom.	4755 children. Measurement at 11 and 13 years.	(PA) daily monitored by accelerometer.	Accelerometer measurement 7 consecutive days in wake, monitoring at least three days and ten hours per day.	Executive attention	Test of Everyday Attention for Children (TEA-Ch) 11 years old and Cognitive Drug Research (CDR)	MVPA may be beneficial for adolescent attention, especially in boys. Higher levels of MVPA have benefit with executive attention.
Spitzer et al. (2013) Germany.	Two studies with different populations: 1. (IG. 12.5 years, 15 boys and 9 girls) 2. (IG. 12.4 years, 33 boys and 22 girls) (G.C: 21 boys and 12 girls)	Study 1 and 2. Physical exercise was performed: football, basketball, hockey, hip hop dance.	3 lessons per week. 4 months. 10 min football or basketball or hockey or handball or Hip Hop. Change every 10 minutes. 30 min daily.	Attention.	D2 test of attention	1: The IG exceeded the CG in D2 Test, however, did not reach a statistical significance. 2. Exercise increases attention performance more in the IG than in the CG.
Ma et al. (2015) Canada.	88 children aged 9 - 11 (44 males and 44 females)	FUNtervals.	4 min. intervals. 20 sec high intensity for 10 sec rest, repeated 8 times. 3 weeks.	Selective attention Acute effects.	D2 test	Students improved on the D2 test, after the application of FUNtervals. This program can improve selective attention for children aged 9 to 11.
Gallotta et al. (2015) Italy.	116 children, 8 -11 years old, 36 children 8-9 years, 26 children 9-10 years, and 54 children 10-11 years.	3 groups: 1. Cognitive effort, 2. Physical effort 3. Cognitive and physical.	Each session of 50 minutes (MVPA).	Sustained attention	D2 test	Acute physical exercise influences the cognitive function of attention, improving especially in the third group after the intervention.
Leong et al. (2015) Malaysia.	81 female students aged 16.	(PA) aerobic (Dance)	1 hour, twice a week for 6 weeks	Sustained attention	Digit Vigilance Test (DVT; Lewis, 1995).	Aerobic intervention has no effect on sustained attention. Nor was any effect evident when accompanied by milk consumption.
Schmidt et al. (2015) Switzerland.	90 children between 10 and 11 years. (41 boys and 49 girls) CG. 42 and IG. 48.	Coordinating exercises.	1 class of 45 minutes. Immediate and delayed effects were measured. 90 minutes after activity.	Attention	D2-R Test (Brickenmp, 2010)	Attention levels increased not immediately but within 90 minutes of EG activities. A cognitively demanding (PA) session can improve attention.
Altenburg et al. (2015) Australia.	56 children, 30 boys and 26 girls between the ages of 10 and 13.	Aerobic training 20 minutes moderate activity.	One group without (PA), another group 20 minutes (PA) mid-morning, third group two sessions (PA) 20	Selective attention Acute effects.	'Sky Search' of the Test of Selective Attention in Children (TEA-Ch).	A daily session does not present effect. Two 20-minute (MPA) sessions improve children's selective attention compared to sitting all morning.

			minutes at the beginning and mid-morning.			
López et al. (2016) Spain.	2,897 children between the ages of 7 and 10 from 36 schools in Barcelona – Spain.	Extracurricular exercise and active displacement were evaluated.	Behaviors were evaluated for one year. They were evaluated four times a year, every three months.	Selective attention	Task Attention Network (TAN)	Children who exercised twice a week had better scores on the attention test than children who exercised once a week.
Vanhelst et al. (2016) Europe.	273 adolescents between 12.5 and 17.5.	Daily (PA) was evaluated for 7 days.	Anthropometric and (PA) measurements for 7 days.	Attention	D2 Attention Test	Analyses revealed that the thresholds for (PA) that best discriminated attention span were 41 min per day for moderate, 12 min per day for vigorous and 58 min per day for (MVPA).
Pérez et al. (2016) Spain.	149 adolescents 14 and 16 years (77 males and 72 females)	(CC) and (PC). Explosive force. Horizontal jump test, Speed. 5 x 10 meters, Vo2. Navette	Anthropometric and (PC) measurement	Selective attention	D-2 Attention Test (Brickenmp, 2002)	Adolescents who practiced (PA) regularly and had a better (PC), obtained a higher score in the overall attention rates, processed a greater number of hits.
Van den Berg et al. (2016) Netherlands.	179 students aged 10 to 13	Randomly assigned class, 3 classes (aerobic, coordination and strength)	Three sessions each 12 minutes, each session 2 minutes warm-up and 10 minutes of exercise. Wanted to find acute effects of the (PA).	Selective attention No acute effects found.	D-2 Attention Test (Brickenmp, 2002)	12-minute sessions of exercise with low to moderate intensity have no acute effects on selective attention. Moderate intensity time in aerobic exercise may be insufficient to cause significant improvements in selective attention.
Samuel et al. (2017) Israel.	20 children and adolescents between the ages of 8 and 17 (12 boys and 8 girls)	Cardiopulmonary exercise test in ergometer bicycle. Acute exercise of maximum intensity.	CPET protocol included ramp increment of 10-, 15- or 20-watts min. It ends when the participant could not maintain the rate of 60 RPM for more than 5 sec.	Selective attention	Digit span. WISC-IV (Wechsler, 2003)	The study presents improvements in attention capacity after the application of the test and a recovery of 60-minute after the stress test.
Lima et al. (2017) Brazil	66 children between the ages of 8 and 11 (36 Karatekas and 30 non-karatekas)	Karate	Karatekas were compared to non-karatekas.	Selective attention	Test Stroop (Teresa, 2014; Graf, 1995; Treneri, 1989)	The results show that there is a notable difference between 8 to 10 students who practice Karate and those who do not practice Karate, and a marginally significant difference in 11-year.
Van den Berg et al. (2018) Netherlands	119 adolescents aged 11 to 14	Moderate exercise (riding a cycling)	Moderate to vigorous exercise lasting 10, 20 or 30 minutes. Wanted to find acute effects of the (PA).	Selective attention No acute effects found.	Short version of the ANT test (Fan et al, 2002).	The study concluded that there were no significant effects of the exercise on selective attention.
Gall et al. (2018) South Africa.	663 children, 8 to 13 years, 339 girls, 324 boys	Physical activity - music	20 weeks. 4 parts: 2 classes (PA) weekly, 1 class weekly music in motion, breaks for activities and adaptation of infrastructure.	Selective attention	D-2 Attention Test (Brickenmp, 2002)	The (PA) had a positive effect on academic performance, but not on selective attention.
Martínez-López et al. (2018) Spain.	184 adolescents from four schools between the ages of 12 to 16. (CG n = 94) and (EG n = 90).	(HIIT) More than 85% of its HR max.	12 weeks, 24 sessions of 16 min. 4 min. warm-up, running and stretching.	Selective attention No acute effects found.	D2 Test (Brickenkamp 2012)	The experimental group increased selective attention relative to the control group by 14.2%. These improvements are more evident in the inactive students.
García-Hermoso et al (2019) Chile	170 children between the ages of 8 and 10 in three low socio-economic public schools.	Active start. Physical games of moderate to vigorous intensity.	5 sessions per week, 8 weeks with a daily session of 30 min.	Selective attention	D2 Attention Test	The study concluded that there were no statistically significant changes in attention.
Rosa et al. (2020) Spain	44 schoolchildren. 20 girls and 24 boys aged 9-10.	Aerobic capacity (Course-Navette test)	Aerobic capacity was evaluated.	Selective attention	Perception of Signs and Differences Test (R-Faces) Thurstone (2012).	Those with higher aerobic capacity have better selective attention.
Vhavlé et al. (2019) India.	802 students (yoga 411) (physical exercise 391)	Yoga and physical exercise.	1 hour daily of yoga or physical exercise for 2 months	Attention	Trail making test (TMT)	Yoga improves attention with the same effectiveness as a physical exercise intervention in schoolchildren and adolescents

Gallotta et al. (2020) Italy.	36 children (18 girls and 10 boys) 8 to 13	Open (racket) and closed (run) dexterity activity	2 training sessions of 50-60 minutes. Determine acute effects of sports.	Sustained attention. Acute effects.	D2 Test	The results of the study showed that open sports practice and training session positively affect the attentional performance of children.
Rosa et al. (2020) Spain.	24 boys and 20 girls, aged 9 and 10	(PA) of high intensity.	8 weeks, 16 sessions of 40 - 50 minutes per session. Strength exercises - muscle endurance and cooperative challenges.	Selective attention and attentional effectiveness	Test of perception of similarities and differences (face test).	The study results show that the (PA) program had a positive effect on attention, especially selective attention, attentional efficacy, and inhibitory control.
Latino et al. (2021) Italy.	60 students aged 14 and 15, 30 boys, 30 girls.	Low to moderate intensity, coordinated movements	12 weeks, twice a week, 40 minutes of activity	Spatial visual attention	Cognitive test 'Corsi's block- tapping test'.	A 12-week program of coordinating skills was able to improve coordination skills and aspects of cognitive functioning.
Müller et al. (2021) Germany.	162 schoolchildren. 54 % girls, 46 % boys between 6 and 7.	Short breaks. Warm-up, strength, endurance, and flexibility.	2 weeks with 10 minutes daily intervention after 90 minutes of class.	Attention.	D2- R Test	The (PA) and mindfulness breaks revealed specific effects on attention.
Tseng et al. (2021) Taiwan.	55 children, 13 and 15 years, 28 girls and 27 boys	7 neuromuscular exercises with 5 variations. 24 motor performance exercises.	8 weeks with a weekly session of 90 min.	Selective, alternating, and divided attention	Chinese version of the attention scale for primary school children.	A total of 8 weeks of intervention improves attentional skills.
Silva-Capella et al. (2021) Spain.	160 students (77 girls and 83 boys) 12 and 17 years old. EG: (n = 106) CG: (n = 54)	Physical warm-up of moderate intensity 60-75%.	10-minute warm-up, moderate intensity with and without quick decision-making stimuli.	Selective attention	D2 Test	Results showed no significant differences in attention.
Ruiz-Ariza et al. (2021) Spain.	136 adolescents aged 12 – 14 years.	Low and high intensity active breaks	CG. Sitting in class, EG 1. Low intensity active breaks and EG 2 high intensity exercises.	Selective attention Acute effect.	D2 Test (Brickenkamp 2012)	Low- and high-intensity active breaks show a significant effect of increased immediate attention in adolescents after stimulation.
Rosa et al. (2021) Spain.	88 schoolchildren (48 boys and 40 girls) 9 and 10 years	(PA) aerobic	5 minutes warm-up of dynamic joint mobility, then mile test. Determine acute effects.	Selective attention Acute effect.	Perception of Similarities and Differences Test (Faces Test)	An aerobic exercise session could favor the increase of selective attention in schoolchildren and perform a physical exercise as the mile test is associated with higher levels of selective attention.
Rodríguez-Negro et al. (2021) India.	168 students from 8 – 12 years.	Direct Instruction Model (DIM) and Tactical Games Model (TGM)	8 weeks with a weekly session of 90 min.	Attention.	CARAS-R Test (Thurstone & Yela, 2012).	The TGM model based on tactical games managed to improve students' attention, the traditional model had no improvement.
Polevoy (2022) Russia.	141 schoolchildren 15 and 16 years	Pre- and post-class (PE) attention was evaluated	5 months, twice a week 45 min.	Current level of attention	Trondyke Test	Children who exercised significantly increased the test results. There is influence of the (PA) of schoolchildren on attention indicators.
Polevoy (2022) Russia.	40 schoolchildren aged 13 and 14. C.G: 12 boys, 8 girls, E.G: 12 boys, 8 girls.	Exercises based on speed and strength.	(PE) class twice a week for 40 minutes, for three months.	Ability to change attention.	Method of numbers	Indicators of attentional change in 13–14-year will improve if they perform speed and strength physical exercises in the physical education lesson at school.
Altermann et al. (2022) Austria.	80 adolescents, 15 to 18 years	Acute exercise. strength, endurance, or coordination.	25 minutes of exercise	Attention	D2 Test	All three trainings led to improvements in post-exercise attentional performance compared to the previous and control group.
Gilbert et al. (2023) United Kingdom.	76 young people 12 and 13 years. (39 females, 37 males)	(PE) class. (PA) based on a football game on a rubber field.	One 60-minute session (PE class)	Selective attention	Stroop Test	The game-based (PE) lesson had no significant effect on attention.
Gelabert et al. (2023) Spain.	56 schoolchildren between the ages of 11 and 12.	Interval exercise of moderate-high intensity.	7 weeks, three weekly sessions, 30 minutes per session. 48 hours recovery between each session.	Selective and sustained attention (No) Chronic effect	D2 Test CSAT-II	The intervention did not produce significant results in sustained or selective attention. The aim was to establish whether their chronic effects.

Note: (PA) = Physical activity, (MPA) = Moderate physical activity, (MVPA) = Moderate to vigorous physical activity, (PC) = Physical condition, (CG) = Control group, (IG) = Intervention group, (EG) = Experimental group, (PE) = Physical education.

Discussion

The differences presented in the conclusions of the studies, may be a result of the heterogeneity of the intervention duration periods, the frequency and intensity of PA, the ages of the participating population, the dimensions and attention assessment tools used by the researchers, as well as by the socioeconomic conditions of the population, example of this, is evidenced in the studies by Gall et al. (2018) and García-Hermoso et al. (2020). This heterogeneity in the studies makes their analysis difficult and does not allow us to deliver data that responds concretely to the stated objectives.

Regarding the discussion of the main objective of this review that sought to determine the relationship between PA and attention as CI, we can highlight the studies that presented a benefit in attention after the practice of PA that involved a cognitive load in its development. Studies such as the one conducted by Rodríguez-Negro & Yanci (2021) that compared two teaching models in PE and concluded that the game-based model was more effective in improving attention than the traditional model of direct instruction, by involving aspects of higher cognitive load, which is close to what was presented by Latino et al. (2021) and Schmidt et al. (2015) who pointed out that the intervention of practices based on coordination exercises, which involve a higher cognitive load, present an increase in attention in relation to traditional exercise.

In the same line of the previous discussion, the study of Gallotta et al. (2015), who developed an intervention with three groups of elementary school students with the aim of evaluating attention before and after performing a PA session, stands out. The first group performs cognitive work, the second group, traditional PE class and the third group receives PE class with cognitive stimulation, concluding that the third group presents better results just after the end of the test and 50 minutes after the end of the test.

Another study that strengthens this argument is also presented by Gallotta et al. (2020) when they show that open sport exercises such as racquet practice, which involves cognitive stimuli such as temporal precision, reaction time and coordination, may present a superior relationship in attentional performance compared to closed, continuous and repetitive practices such as running.

The above results may be associated with biological mechanisms of activation of cognitive functions induced by PA (Rosa et al., 2020) and manifested in increased blood flow and cerebral oxygenation (Faulkner et al., 2016), high cardiorespiratory fitness associated with healthier neural tissue (García-Hermoso et al., 2020), increased levels of neurotrophic factors such as brain-derived neurotrophic factor (BDNF), a protein that enhances synapses (Hillman et al., 2009; Vanhelst et al., 2016), improved neurophysiological activity (Flores et al., 2019) and favors changes in brain activity that facilitate cognitive functions (Gallotta et al., 2020).

Many the studies analyzed in this review were carried out in school environments, which represented a difficulty for some researchers due to situations such as non-attendance of students due to different circumstances on the days of intervention and the unwillingness of some teachers to apply the various scientific designs (Spitzer & Hollmann, 2013).

Conclusions

The results of the studies analyzed in this review suggest that the practice of PA and exercise have a positive relationship with attention, mainly selective attention, and especially with activities of moderate to vigorous intensity; likewise, it can be observed that activities with greater cognitive load seem to have greater efficacy. However, it can be observed that the interventions with positive effects on attention vary in **duration** (from four minutes to 90 minutes), **intensity** (high intensity, moderate and low intensity PA), **frequency** (a single session, up to two months with three weekly sessions), which prevents the delivery of conclusive results that allow determining the most favorable characteristics for the improvement of attention.

As described above, it is suggested that more experimental research be conducted, especially in school settings, to learn more about this topic.

Based on the findings, it is suggested that educational institutions consider the implementation of more appropriate activities and environments within their curricula to comply with international recommendations on the practice of PA, not only because of the already proven effects on health, but also because of the possible effects on CI such as attention. Likewise, it is hoped that this review will contribute to the advancement of this important subject of study.

Strengths and limitations

One of the review's strengths was that it gave an overview of the topic by including articles with different research designs and methods, allowing it to be approached in greater depth and covering a larger population. Likewise, an updated review is presented, which could be useful in the field of study and guide future research.

A limitation of the review is the inability to provide conclusive results that fully answer concerns about the optimal characteristics for improving attention.

Conflict of interest

The authors declare that they have no conflict of interest in writing and publishing this article.

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Selective Attention as a Cognitive Indicator”, which is part of his research in the Doctoral Program in Education at Universidad de La Sabana, Colombia.

References

- Altenburg, T. M., Chinapaw, M. J. M., & Singh, A. S. (2015). Effects of one versus two bouts of moderate intensity physical activity on selective attention during a school morning in Dutch primary schoolchildren: A randomized controlled trial. *Journal of Science and Medicine in Sport*, *19*(10), 820–824. <https://doi.org/10.1016/j.jsams.2015.12.003>
- Altermann, W., & Gröpel, P. (2022). Effects of acute endurance, strength, and coordination exercise interventions on attention in adolescents: A randomized controlled study. *Psychology of Sport and Exercise*, *64*. <https://doi.org/10.1016/j.psychsport.2022.102300>
- Alvarado, J., Riveros, M., & Morales, N. (2019). Las prácticas deportivas como estrategia para fortalecer las competencias ciudadanas en escolares de un modelo educativo alternativo en Bogotá. In *Ed. Kinesis* (p. 182–187).
- Bauman, A. E., Petersen, C. B., Blond, K., Rangul, V., & Hardy, L. L. (2018). The Descriptive Epidemiology of Sedentary Behaviour. In *Epidemiology and Public Health* (pp. 73–106). https://doi.org/10.1007/978-3-319-61552-3_4
- Booth, J. N., Tomporowski, P. D., Boyle, J. M., Ness, A. R., Joinson, C., Leary, S. D., & Reilly, J. J. (2013). Associations between executive attention and objectively measured physical activity in adolescence: Findings from ALSPAC, a UK cohort. *Mental Health and Physical Activity*, *6*(3), 212–219. <https://doi.org/10.1016/j.mhpa.2013.09.002>
- De Greeff, J. W., Bosker, R. J., Oosterlaan, J., Visscher, C., & Hartman, E. (2017). Effects of physical activity on executive functions, attention, and academic performance in preadolescent children: a meta-analysis. *Journal of Science and Medicine in Sport*, *21*(5), 501–507. <https://doi.org/10.1016/j.jsams.2017.09.595>
- Domínguez-González, F., Moral-Campillo, L., Reigal, R., & Hernández-Mendo, A. (2018). Cuadernos de psicología del deporte. In Cuadernos de Psicología del Deporte (Vol. 18, Issue 2). [publisher not identified]. https://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1578-84232018000200004&lng=es&nrm=iso&tlng=es
- Faulkner, J., Lambrick, D., Kaufmann, S., & Stoner, L. (2016). Effects of upright and recumbent cycling on executive function and prefrontal cortex oxygenation in young healthy men. *Journal of Physical Activity and Health*, *13*(8), 882–887. <https://doi.org/10.1123/jpah.2015-0454>
- Flores, E., Maureira Cid, F., Díaz Muñoz, H., Navarro Aburto, B., Gavotto Nogales, O., & Matheu Pérez, A. (2019). Efectos de una sesión de ejercicio físico sobre la actividad neurofisiológica durante la resolución de una prueba de atención selectiva. *Retos*, *36*, 391–397. <https://doi.org/https://doi.org/10.47197/retos.v36i36.68960>
- Gall, S., Adams, L., Joubert, N., Ludyga, S., Müller, I., Nqweniso, S., Pühse, U., Du Randt, R., Seelig, H., Smith, D., Steinmann, P., Utzinger, J., Walter, C., & Gerber, M. (2018). Effect of a 20-week physical activity intervention on selective attention and academic performance in children living in disadvantaged neighborhoods: A cluster randomized control trial. *PLoS ONE*, *13*(11). <https://doi.org/https://doi.org/10.1371/journal.pone.0206908>
- Gallotta, M. C., Bonavolontà, V., Zimatore, G., Iazzoni, S., Guidetti, L., & Baldari, C. (2020). Effects of Open (Racket) and Closed (Running) Skill Sports Practice on Children’s Attentional Performance. *The Open Sports Sciences Journal*, *13*(1), 105–113. <https://doi.org/10.2174/1875399x02013010105>
- Gallotta, M. C., Emerenziani, G. P., Franciosi, E., Meucci, M., Guidetti, L., & Baldari, C. (2015). Acute physical activity and delayed attention in primary school students. *Scandinavian Journal of Medicine and Science in Sports*, *25*(3), e331–e338. <https://doi.org/10.1111/sms.12310>
- García-Hermoso, A., Hormazábal-Aguayo, I., Fernández-Vergara, O., González-Calderón, N., Russell-Guzmán, J., Vicencio-Rojas, F., Chacana-Cañas, C., & Ramírez-Vélez, R. (2020). A before-school physical activity intervention to improve cognitive parameters in children: The Active-Start study. *Scandinavian Journal of Medicine and Science in Sports*, *30*(1), 108–116. <https://doi.org/10.1111/sms.13537>
- Gelabert, J., De La Vega, R., Palou-Sampol, P., & Muntaner-Mas, A. (2023). The effects of a moderate-to-high intensity interval exercise training programme on selective and sustained attention in schoolchildren aged 11 and 12. *Journal of Human Sport and Exercise*, *18*(1), 209–223. <https://doi.org/10.14198/JHSE.2023.181.17>
- Gilbert, L. M., Dring, K. J., Williams, R. A., Boat, R., Sunderland, C., Morris, J. G., Nevill, M. E., & Cooper, S. B. (2023). Effects of a games-based physical education lesson on cognitive function in adolescents. *Frontiers in Psychology*, *14*. <https://doi.org/10.3389/fpsyg.2023.1098861>
- Gunnell, K. E., Poitras, V. J., LeBlanc, A., Schibli, K., Barbeau, K., Hedayati, N., Ponitfex, M. B., Goldfield, G. S., Dunlap, C., Lehan, E., & Tremblay, M. S. (2019). Physical activity and brain structure, brain function, and cognition in children and youth: A systematic review of randomized controlled trials. *Mental Health and Physical Activity*, *16*, 105–127. <https://doi.org/10.1016/j.mhpa.2018.11.002>
- Hajar, M. S., Rizal, H., & Kuan, G. (2019). Effects of physical activity on sustained attention: A systematic

- review. *Scientia Medica*, 29(2), 1–14. <https://doi.org/10.15448/1980-6108.2019.2.32864>
- Hillman, C. H., Pontifex, M. B., Raine, L. B., Castelli, D. M., Hall, E. E., & Kramer, A. F. (2009). The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children. *Neuroscience*, 159(3), 1044–1054. <https://doi.org/10.1016/j.neuroscience.2009.01.057>
- Hillman, C. H., Snook, E. M., & Jerome, G. J. (2003). Acute cardiovascular exercise and executive control function. *International Journal of Psychophysiology*, 48(3), 307–314. [https://doi.org/10.1016/S0167-8760\(03\)00080-1](https://doi.org/10.1016/S0167-8760(03)00080-1)
- Introzzi, I., Aydmune, Y., Zamora, E. V., Vernucci, S., & Ledesma, R. (2019). The development mechanisms of selective attention in child population. *Revista CES Psicología*, 12(3), 105–118. <https://doi.org/10.21615/CESP.12.3.8>
- Komari, A., Setyawan, H., Setyo Kriswanto, E., Vicente García-Jiménez, J., Pavlovic, R., Magdalena Nowak, A., Susanto, N., Wibowo Kurniawan, A., Aziz Purnomo Shidiq, A., & Malikul Ikhanda Putra, A. (2024). The Effect of Physical Education (PE) Class Management Using Badminton Materials to Improve Elementary School (ES) Students' Concentration. *Retos*, 55, 520–526. <https://doi.org/https://doi.org/10.47197/retos.v56.104609>
- Kuzik, N., da Costa, B. G. G., Hwang, Y., Verswijveren, S. J. J. M., Rollo, S., Tremblay, M. S., Bélanger, S., Carson, V., Davis, M., Hornby, S., Huang, W. Y., Law, B., Salmon, J., Tomasone, J. R., Wachira, L. J., Wijndaele, K., & Saunders, T. J. (2022). School-related sedentary behaviours and indicators of health and well-being among children and youth: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, 19:40(1), 1–32. <https://doi.org/10.1186/s12966-022-01258-4>
- Lai, Y. J., & Chang, K. M. (2020). Improvement of attention in elementary school students through fixation focus training activity. *International Journal of Environmental Research and Public Health*, 17(13), 1–13. <https://doi.org/10.3390/ijerph17134780>
- Latino, F., Cataldi, S., & Fischetti, F. (2021). Effects of a Coordinative Ability Training Program on Adolescents' Cognitive Functioning. *Frontiers in Psychology*, 12, 1–8. <https://doi.org/10.3389/fpsyg.2021.620440>
- Leong, I. T., Moghadam, S., & Hashim, H. A. (2015). Aggregated effects of combining daily milk consumption and aerobic exercise on short-term memory and sustained attention among female students. *Perceptual and Motor Skills*, 120(1), 57–66. <https://doi.org/10.2466/22.06.PMS.120v11x3>
- Lima, R. F., Da Silva, V. F., De Oliveira, G. L., De Oliveira, T. A. P., Filho, J. F., Mendonça, J. G. R., Borges, C. J., Militão, A. G., Freire, I. D. A., & Valentim-Silva, J. R. (2017). Practicing karate may improve the executive functions of 8-11-year-old schoolchildren. *Journal of Physical Education and Sport*, 17(4), 2513–2518. <https://doi.org/10.7752/jpes.2017.04283>
- López-Vicente, M., Forns, J., Esnaola, M., Suades-González, E., Álvarez-Pedrerol, M., Robinson, O., Júlvez, J., García-Aymerich, J., & Sunyer, J. (2016). Physical activity and cognitive trajectories in schoolchildren. *Pediatric Exercise Science*, 28(3), 431–438. <https://doi.org/10.1123/pes.2015-0157>
- Ma, J., Mare, L. Le, & Gurd, B. J. (2015). Four minutes of in-class high-intensity interval activity improves selective attention in 9- to 11-year-olds. *Applied Physiology, Nutrition and Metabolism*, 40(3), 238–244. <https://doi.org/10.1139/apnm-2014-0309>
- Mahar, M. T. (2019). Classroom-Based Physical Activity and On-Task Behavior. *Translational Journal of the ACSM*, 4(17), 148–154. <https://doi.org/DOI:10.1249/TJX.0000000000000099>
- Maldonado, J., Castillo-Quezada Humberto, Hernández-Mosqueira Claudio, & Sandoval-Obando Eduardo. (2023). Efectividad de programas de intervención escolar orientada a la reducción de la obesidad infantil: Una revisión Sistemática. *Retos*, 47, 603–609. <https://doi.org/https://doi.org/10.47197/retos.v47.95928>
- Martínez-López et al. (2018). 24 sessions of monitored cooperative high-intensity interval training improves attention-concentration and mathematical calculation in secondary school. *Journal of Physical Education and Sport*, 18(3), 1572–1582. <https://doi.org/10.7752/jpes.2018.03232>
- Maureira Cid, F., & Flores, E. (2017). Efectos del ejercicio físico sobre la atención: una revisión de los últimos años. *Revista Ciencias de La Actividad Física UCM (Universidad Complutense de Madrid)*, 18(1), 73–83. <https://revistacaf.ucm.cl/article/view/110>
- Miko, H. C., Zillmann, N., Ring-Dimitriou, S., Dörner, T. E., Titze, S., & Bauer, R. (2020). Effects of physical activity on health. *Gesundheitswesen, Supplement*, 82, 184–195. <https://doi.org/10.1055/a-1217-0549>
- Müller, C., Otto, B., Sawitzki, V., Kanagalingam, P., Scherer, J. S., & Lindberg, S. (2021). Short breaks at school: effects of physical activity and mindfulness intervention on children's attention, reading comprehension, and self-esteem. *Trends in Neuroscience and Education*, 25(100160), 1–10. <https://doi.org/10.1016/j.tine.2021.100160>
- Oviedo, C. P., & Soria Viteri, J. (2015). Pregunta de investigación y estrategia PICOT. *Revista Medicina*, 19(1), 66–69. <https://doi.org/https://doi.org/10.23878/medicina.v19i1.647>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R.,

- Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ (Clinical Research Ed.)*, *372*, n71., 1–9. <https://doi.org/https://doi.org/10.1136/bmj.n71>
- Pérez-Lobato, R., Reigal, R. E., & Hernández-Mendo, A. (2016). Relaciones entre la práctica física, condición física y atención en una muestra adolescente / Relationships between physical activity, fitness and attention in an adolescent sample. *Revista de Psicología Del Deporte*, *25*(1), 179–186. Retrieved from <https://www.proquest.com/scholarly-journals/relaciones-entre-la-practica-fisica-condicion-y/docview/2258217555/se-2>
- Polevoy, G. (2022a). The Effect of Physical Activity on Attention Indicators of Schoolchildren. *Annals of Applied Sport Science*, *10*(4), 1–7. <https://doi.org/10.52547/aassjournal.1149>
- Polevoy, G. (2022b). The influence of speed and strength training at school on the indicators of attention switching in children aged 13-14 years with different typologies. *Journal of Education and Health Promotion*, *11*(1), 11–23. https://doi.org/10.4103/jehp.jehp_413_21
- Rodríguez-Negro, J., & Yanci, J. (2021). Effects of two different physical education instructional models on creativity, attention, and impulse control among primary school students. *Educational Psychology*, *42*(6), 787–799. <https://doi.org/10.1080/01443410.2021.1988059>
- Romero-Martínez, J., Menescardi, C., García-Massó, X., & Estevan, I. (2024). Efectos de la actividad física durante las clases sobre la alfabetización motriz: una revisión sistemática Effects of class-based physical activity in physical literacy: a systematic review. *Retos*, *52*, 311–322. <https://doi.org/https://doi.org/10.47197/retos.v52.100143>
- Rosa, A., G., Canto, E. G., & Carrillo López, P. J. (2019). Relación entre capacidad aeróbica y el nivel de atención en escolares de primaria Relationship between aerobic capacity and level of attention in primary school children. *Retos*, *35*, 36–41. <https://doi.org/10.47197/retos.v0i35.60729>
- Rosa, A., García Canto, E., & Martínez García, H. (2020). Influencia de un programa de actividad física sobre la atención selectiva y la eficacia atencional en escolares Influence of a physical activity program on selective attention and attentional efficiency in school children. *Retos*, *38*, 560–566. <https://doi.org/10.47197/retos.v38i38.77191>
- Rosa, A., García Canto, E., & Martínez García, H. A. (2021). Ejercicio físico aeróbico y atención selectiva en escolares de educación primaria Aerobic physical exercise and selective attention in primary school children. *Retos*, *39*, 421–428. <https://doi.org/10.47197/retos.v0i39.81060>
- Ruiz-Ariza, A., López-Serrano, S., Mezcua-Hidalgo, A., Martínez-López, E. J., & Abu-Helaiel, K. (2021). Efecto agudo de descansos físicamente activos en variables cognitivas y creatividad en Educación Secundaria. *Retos*, *39*, 635–642. <https://doi.org/https://doi.org/10.47197/retos.v0i39.78591>
- Samuel, R. D., Zavdy, O., Levav, M., Reuveny, R., Katz, U., & Dubnov-Raz, G. (2017). The Effects of Maximal Intensity Exercise on Cognitive Performance in Children. *Journal of Human Kinetics*, *57*(1), 85–96. <https://doi.org/10.1515/hukin-2017-0050>
- Saunders, T. J., Rollo, S., Kuzik, N., Demchenko, I., Bélanger, S., Brisson-Boivin, K., Carson, V., da Costa, B. G. G., Davis, M., Hornby, S., Huang, W. Y., Law, B., Ponti, M., Markham, C., Salmon, J., Tomasone, J. R., Van Rooij, A. J., Wachira, L. J., Wijndaele, K., & Tremblay, M. S. (2022). International school-related sedentary behaviour recommendations for children and youth. *International Journal of Behavioral Nutrition and Physical Activity*, *19*:39. <https://doi.org/10.1186/s12966-022-01259-3>
- Schmidt, M., Egger, F., & Conzelmann, A. (2015). Delayed positive effects of an acute bout of coordinative exercise on children's attention. *Perceptual and Motor Skills*, *121*(2), 431–446. <https://doi.org/10.2466/22.06.PMS.121c22x1>
- Silva-Capella, V., González-García, R. J., & Pérez-Campos, C. (2021). Effects of physical warm-up on the attention of adolescent students. *Journal of Physical Education and Sport*, *21*(1), 406–415. <https://doi.org/10.7752/jpes.2021.01040>
- Spitzer, U. S., & Hollmann, W. (2013). Experimental observations of the effects of physical exercise on attention, academic and prosocial performance in school settings. *Trends in Neuroscience and Education*, *2*(1), 1–6. <https://doi.org/10.1016/j.tine.2013.03.002>
- Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S. F. M., Altenburg, T. M., Chinapaw, M. J. M., Aminian, S., Arundell, L., Hinkley, T., Hnatiuk, J., Atkin, A. J., Belanger, K., Chaput, J. P., Gunnell, K., Larouche, R., Manyanga, T., ... Wondergem, R. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, *14*:75. <https://doi.org/10.1186/s12966-017-0525-8>
- Tseng, W.-Y., Rekić, G., Chen, C. H., Clemente, F. M., Bezerra, P., Crowley-McHattan, Z. J., & Chen, Y. S. (2021). Effects of 8-Week FIFA 11+ for kids' intervention on physical fitness and attention in elementary school children. *Journal of Physical Activity and Health*, *18*(6), 686–693. <https://doi.org/10.1123/jpah.2020-0823>

- Van den Berg, V., Saliassi, E., Jolles, J., de Groot, R. H. M., Chinapaw, M. J. M., & Singh, A. S. (2018). Exercise of Varying Durations: No Acute Effects on Cognitive Performance in Adolescents. *Frontiers in Neuroscience*, 12(672), 1–11. <https://doi.org/10.3389/fnins.2018.00672>
- Vanhelst, J., Béghin, L., Duhamel, A., Manios, Y., Molnar, D., De Henauw, S., Moreno, L. A., Ortega, F. B., Sjöström, M., Widhalm, K., Gottrand, F., De Henauw, S., González-Gross, M., Gilbert, C., Kafatos, A., Sánchez, J., Hall, G., Maes, L., Meléndez, P., ... Gómez Lorente, J. J. (2016). Physical Activity Is Associated with Attention Capacity in Adolescents. *Journal of Pediatrics*, 168, 126-131.e2. <https://doi.org/10.1016/j.jpeds.2015.09.029>
- Vhavle, S., Rao, R., & Manjunath, N. (2019). Comparison of yoga versus physical exercise on executive function, attention, and working memory in adolescent schoolchildren: A randomized controlled trial. *International Journal of Yoga*, 12(2), 172. https://doi.org/10.4103/ijoy.ijoy_61_18
- WHO guidelines on physical activity and sedentary behaviour. (2021). *WHO guidelines on physical activity and sedentary behavior*. 2021. <https://www.who.int/es/publications/i/item/9789240014886>

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