# Impact of physical fitness on adolescent health and academic and cognitive performance: Systematic review[1]

# Impacto de la aptitud física en la salud y el rendimiento académico y cognitivo de los adolescentes: revisión sistemática

# Impacto da aptidão física na saúde e no desempenho acadêmico e cognitivo do adolescente: Revisão sistemática

[Review article]

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## Abstract

Among adolescents, physical activity can also improve academic performance and cognitive outcomes. Research on the impact of school-based physical activity interventions on students' academic performance is limited. This study conducts a systematic review of the impact of physical fitness and exercise on adolescent health, as well as academic and cognitive performance. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method was adopted. The results indicate that aerobic exercise can enhance memory and attention, hippocampal metabolism, and academic performance in adolescents, along with other aspects of physical and mental well-being. Additionally, the importance of introducing school programs that encourage physical activity to prevent a sedentary lifestyle and enhance learning among this age group is emphasized.

**Keywords**: adolescent, academic performance, cognitive performance, exercise training, physical exercise.

## Resumen

Entre los adolescentes, la actividad física también puede mejorar el rendimiento académico y los resultados cognitivos. La investigación sobre el impacto de las intervenciones de actividad física en la escuela en el rendimiento académico de los estudiantes es limitada. Este estudio realiza una revisión sistemática del impacto de la aptitud física y el ejercicio en la salud de los adolescentes, así como en el rendimiento académico y cognitivo. Se adoptó el método PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Los resultados indican que el ejercicio aeróbico puede mejorar la memoria y la atención, el metabolismo del hipocampo y el rendimiento académico en adolescentes, junto con otros aspectos del bienestar físico y mental. Además, se enfatiza la importancia de introducir programas escolares que fomenten la actividad física para prevenir el sedentarismo y mejorar el aprendizaje en este grupo de edad.

**Palabras clave:** adolescente, desempeño académico, rendimiento cognitivo, entrenamiento de ejercicio, ejercicio físico.

## Resumo

Entre os adolescentes, a atividade física também pode melhorar o desempenho acadêmico e os resultados cognitivos. A investigação sobre o impacto das intervenções de atividade física na escola no ensino acadêmico dos estudantes é limitada. Este estúdio realiza uma revisão sistemática do impacto da aptidão física e do desempenho na saúde dos adolescentes, bem como no desempenho acadêmico e cognitivo. Foi adotado o método PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Os resultados indicam que o exercício aeróbico pode melhorar a memória e a atenção, o metabolismo do hipocampo e o desempenho acadêmico em adolescentes, juntamente com outros aspectos do bem-estar físico e mental. Além disso, enfatizamos a importância de introduzir programas escolares que fomentem a atividade física para prevenir o sedentarismo e melhorar a aprendizagem neste grupo de educação.

**Palavras-chaves:** adolescente, desempenho acadêmico, desempenho cognitivo, treinamento físico, exercício físico.

## Introduction

In recent years, several studies have examined the effects of exercise on memory and attention in adolescents, particularly due to the significant decrease in physical activity levels among this age group. This phenomenon is concerning, as a lack of physical exercise (PE) can lead to various health problems, both in the short and long term (Lubans et al., 2021; Silva et al., 2020).

Physical fitness and exercise significantly impact adolescent health, as well as academic and cognitive performance (Silva et al., 2020; Solberg et al., 2021a; Lima, Soares, Bezerra, and Barros, 2020; Chu, Chen, Pontifex, Sun, and Chang, 2016; Syväoja et al., 2021; Liu et al., 2023). First, regular exercise enhances cardiorespiratory fitness, strengthens muscles and bones, and helps maintain a healthy weight. This reduces the risk of developing chronic diseases such as obesity, type 2 diabetes, and heart disease, which can negatively impact adolescents' long-term health. Moreover, exercise also has a positive effect on adolescents' mental health. Studies have demonstrated that regular physical activity is associated with reduced symptoms of anxiety and depression, improved mood and sleep, and increased self-esteem (Lubans et al., 2021; Silva et al., 2020).

Regarding academic performance, physical fitness and exercise can positively impact adolescents' cognitive abilities (Solberg et al., 2021a; Lima et al., 2020; Chu et al., 2016; Syväoja et al., 2021; Liu et al., 2023). Regular exercise enhances blood circulation, the delivery of oxygen and nutrients to the brain, and stimulates the release of chemicals essential for optimal brain function (Valkenborghs et al., 2022; Papasideris, Ayaz, Safati, Morita, and Hall, 2021). This can lead to improved memory, enhanced concentration, and better problem-solving skills, all of which can contribute to academic performance. Furthermore, physical education (PE) is also associated with improvements in executive functions, which involve skills such as self-regulation, cognitive flexibility, inhibition, and working memory (Lubans et al., 2021; Syväoja et al., 2021; Valkenborghs et al., 2022; Silva et al., 2020; Solberg et al., 2021a; Lima et al., 2020; Chu et al., 2016; Liu et al., 2023).

These skills are important for academic success, as they help adolescents concentrate, organize information, set goals, and control impulses. PE plays a fundamental role in adolescents' lives, offering a range of benefits from physical strengthening to promoting emotional well-being. Young people must be encouraged to engage in regular physical activity, thereby ensuring a better quality of life (QoL) and healthy development during this important phase of life.

Studies that focus on PE interventions for academic and cognitive performance reveal a significant number of applications, primarily in health and education sectors. We can infer that much of the available research aims to enhance adolescents' physical fitness and academic

performance. Accordingly, this study identifies research focusing on PE and fitness levels and their relationship with improved academic and cognitive performance. To investigate the relationship between physical fitness and cognitive aspects, the systematic mapping explored the use of PE in adolescents and presented the most relevant findings. To achieve this goal, the research is guided by the following question: To what extent do physical fitness and exercise impact adolescents' health and academic and cognitive performance?

## Methodology

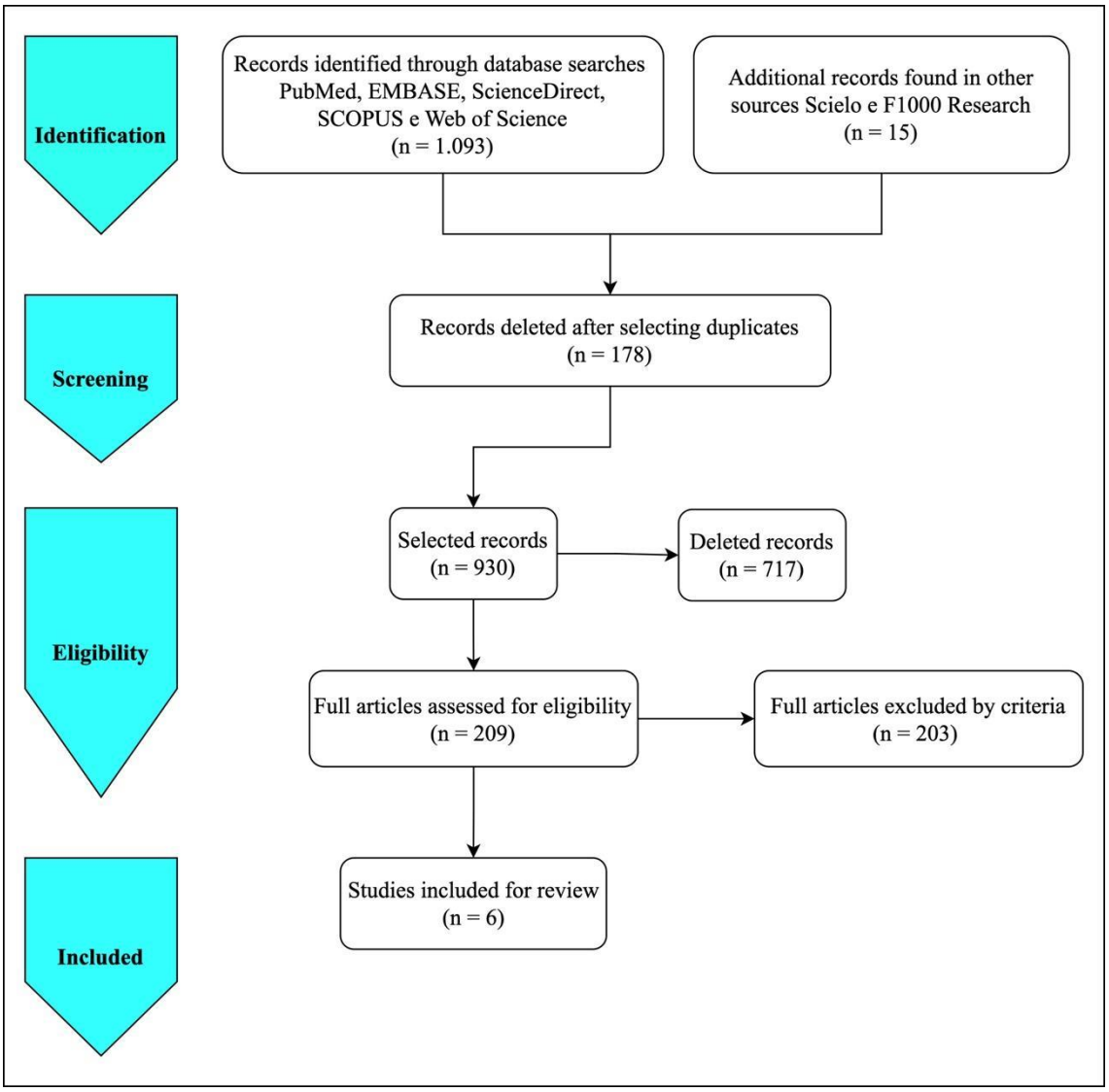
The study design adheres to the guidelines outlined in the PRISMA method (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher, Liberati, Tetzlaff y Altman, 2009).

### Research strategy

The following databases were used: Web of Science, Science Direct, Scopus, Embase, PubMed, Scielo, and F1000 Research. We reviewed existing research on the impact of physical fitness and exercise on adolescent health, as well as academic and cognitive performance, which allows for the identification of the fields of knowledge addressed by these studies. How the search string was constructed, incorporating relevant terms and the guiding question, is illustrated in Figure 1.

**Figure 1**

*Search string construction*




Source: Authors (2024).

The investigation was conducted in September 2023 using the electronic databases provided through CAPES (CAFe access). The search query needed to be modified for different databases to accommodate the unique features of each search engine, particularly concerning character limit restrictions. Articles written in Portuguese, English, and Spanish were considered. Restrictions were placed on the publication date, methodology, participants' ages, and open access to full texts.

### Eligibility criteria

The eligibility criteria included: a) a clear definition of the focus area and the problem to be addressed, b) detailed descriptions of interventions using a specific methodology, and c) a target audience consisting of adolescents. Articles with incomplete data or for which the full texts could not be found in databases searched were not included.

### Study selection

The study selection process was structured into three stages: a) Identification: the application of the search string to the databases. Duplicate studies were identified and excluded. b) Screening: titles and abstracts retrieved underwent a preliminary review to determine their relevance to the objectives of this review. c) Eligibility: studies considered potentially relevant were retrieved in full and thoroughly assessed to confirm that they met the eligibility criteria.

### Data extraction

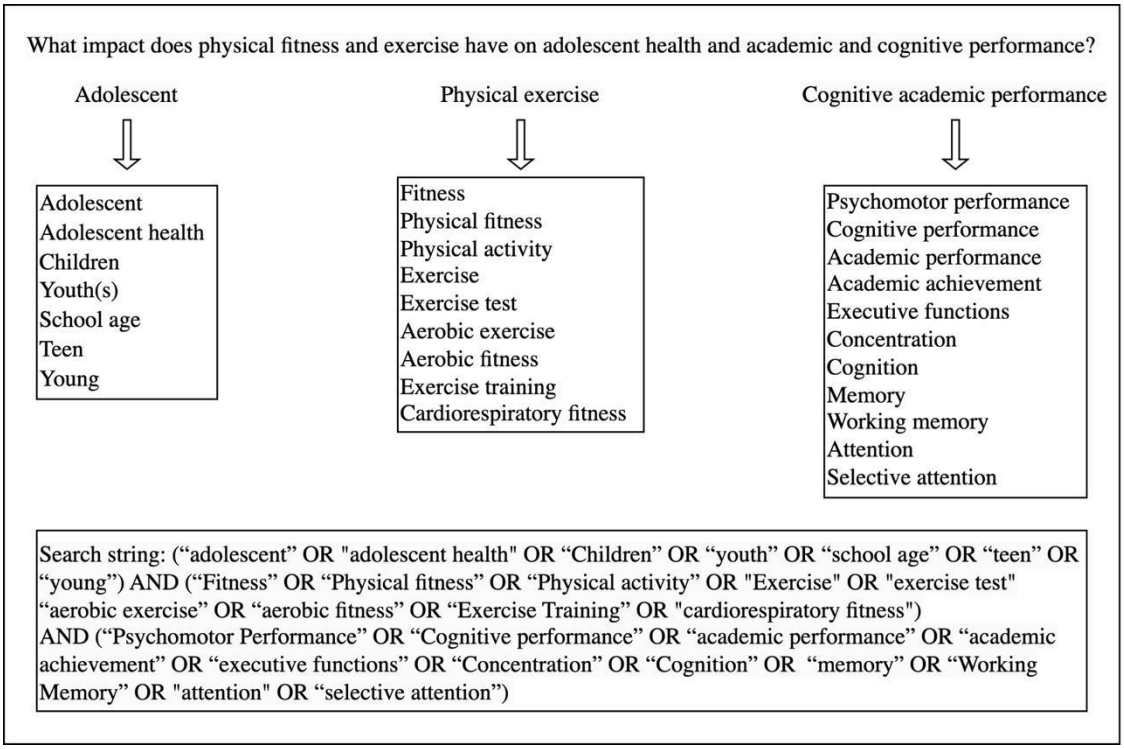
To present the collected data, we used a standardized extraction table. The rows correspond to the following data: a) Origin of the study: the country where the research was conducted; b) Characteristics of the target population: the number of participants; c) Duration of the study: specifying either the number of applications or the total time span of the study; d) Field of application; e) Problem addressed; f) Materials used; g) Data collection methods.

## Results

The literature search yielded a total of 1,108 studies, with 1,093 identified through databases and 15 through other sources; among these, 178 duplicate studies were identified. Subsequently, 717 studies were excluded after reviewing titles and abstracts, leaving 209 full articles. Of these, 203 studies were excluded as they did not meet the eligibility criteria, resulting in six studies for qualitative synthesis. The flow of studies selected for inclusion in the literature review is illustrated in Figure 2.

**Figure 2**

*Flow of selection of studies for the literature review. NOTE: Adaptation of the PRISMA diagram by Moher et al. (2009).*




Source: Authors (2024).

The primary characteristics of the studies pertinent to the objective of this review are presented in Table 1.

**Table 1**

*Main characteristics of the included studies.*

| Feature | | Studies | | | | | |
|---|---|---|---|---|---|---|---|
| | | Lubans et al., 2021 | Silva et al., 2020 | Solberg et al., 2021 | Lima et al., 2020 | Valkenborghs et al., 2022 | Solberg et al., 2021 |
| Origin | | Australia | Brazil | Norway | Brazil | Australia | Norway |
| Population characterization | | Adolescent | Adolescent | Adolescent | Adolescent | Adolescent | Adolescent |
| Duration | | 8 months | 9 months | 9 months | 6 months | 6 months | 9 months |
| | Sports medicine | ✓ | - | ✓ | - | ✓ | ✓ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Application area | Physical education | ✓ | ✓ | ✓ | - | ✓ | ✓ |
| | Public health | - | - | - | ✓ | - | - |
| | Psychophysiology | - | - | - | - | ✓ | - |
| | Preventive medicine | - | ✓ | - | - | - | - |
| Problem to be solved | Low levels of physical activity among adolescents. | ✓ | | | | | |
| | Increase physical activity and decrease sedentary behavior among students. | | ✓ | | | | |
| | Improving adolescents' cognitive performance and academic performance through physical activity interventions. | | | ✓ | | | |
| | Improve students' academic performance. | | | | ✓ | | |
| | Effects of exercise on the hippocampus during youth. | | | | | ✓ | |
| | Relationship between physical fitness, cognitive performance and academic performance in adolescents. | | | | | | ✓ |
| Materials | Cardiorespiratory fitness, muscular fitness, cognitive control and working memory tests; questionnaires on perceived stress, psychological difficulties, well-being, self-efficacy for interval training and | ✓ | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | motivation for exercise; assessment of physical activity and body composition; quantification of hair cortisol level. | | | | | | |
| | Physical fitness test; sociodemographic, physical activity, sedentary behavior and quality of life questionnaires; assessment of academic performance and body composition. | | ✓ | | | | |
| | Academic performance test; sociodemographic questionnaire; assessment of physical activity and body composition. | | | ✓ | | | |
| | Academic performance test; sociodemographic questionnaire. | | | | ✓ | | |
| | Aerobic fitness, muscular fitness, working memory and magnetic resonance imaging tests; assessment of physical activity and body composition. | | | | | ✓ | |
| | Aerobic fitness and academic performance tests; body composition assessment. | | | | | | ✓ |
| Data collect | Andersen test, 90° flexion, long jump, PsychoPy and n-back tests; Warwick- | ✓ | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Edinburgh, stress, interval training, psychological difficulties and behavioral regulation questionnaires during exercise; ActiGraph accelerometer, body mass index and cortisol. | | | | | | |
| | Progressive Aerobic Cardiovascular Endurance Run (PACER) Test; sociodemographic, physical activity, lifestyle questionnaires for sedentary behavior, Health-related quality of life (HRQoL) and study habits and grades; ActiGraph accelerometer and body mass index. | | ✓ | | | | |
| | Numeracy and reading test; sociodemographic questionnaire; ActiGraph accelerometer and body mass index. | | | ✓ | | | |
| | Numeracy test; sociodemographic questionnaire. | | | | ✓ | | |
| | Andersen test, 90-degree bending, long jump, PsychoPy and magnetic resonance spectroscopy; ActiGraph accelerometer and body mass index. | | | | | ✓ | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Andersen test (16m), numeracy and reading; body mass index. | | | | | | ✓ |

Source: Authors (2024).

The selected studies cover a diverse range of application fields, highlighting the existence of various possibilities for PE interventions aimed at adolescents. The two fields with the highest concentration of research are PE and sports medicine (Lubans et al., 2021; Silva et al., 2020; Solberg et al., 2021a; Valkenborghs et al., 2022; Solberg et al., 2021b). Other fields include public health (Lima et al., 2020), psychophysiology (Valkenborghs et al., 2022), and preventive medicine (Silva et al., 2020). Note that some studies were classified in more than one application field because they had a strong focus on more than one area.

Regarding the problem addressed, Solberg et al. (2021a), Solberg et al. (2021b), and Lima et al. (2020) aimed to enhance the cognitive and academic performance of adolescents through interventions involving physical activity. Lubans et al. (2021) and Silva et al. (2020) aimed to increase physical activity and reduce sedentary behavior among adolescents. Valkenborghs et al. (2022) examined the impact of a school-based physical activity intervention, which involved interval training, on hippocampal metabolism in adolescents.

The study methods were all based on randomized clinical trials. This method is considered the gold standard for evaluating the effectiveness of an intervention because it enables a more precise analysis of the effects compared to other types of observational studies, thereby minimizing selection bias and accounting for participants' individual differences.

The materials used in the investigations were similar, including cardiorespiratory fitness tests, academic performance assessments, sociodemographic questionnaires, and evaluations of physical activity and body composition among the most commonly used. Lubans et al. (2021) assessed muscle fitness, cognitive control, and working memory, and administered questionnaires on perceived stress, psychological difficulties, well-being, self-efficacy for interval training, and motivation to exercise, as well as measuring capillary cortisol levels. Silva et al. (2020) complemented their research with questionnaires on physical activity, sedentary behavior, and quality of life (QoL). Valkenborghs et al. (2022) used muscle fitness and working memory assessments, along with magnetic resonance imaging (MRI) of the brain.

Regarding various data collection methods, the most common include body mass index measurements, the use of accelerometers, Andersen tests, as well as numeracy and reading assessments, and sociodemographic questionnaires. Lubans et al. (2021) used the following tests: 90° bend, long jump, PsychoPy, and n-back, along with the following questionnaires: Warwick-Edinburgh, stress, interval training, psychological difficulties, and behavioral regulation in

exercise. Silva et al. (2020) included the Progressive Aerobic Cardiovascular Endurance Run (PACER), questionnaires on physical activity, lifestyle habits related to sedentary behavior, health-related quality of life (HRQoL), and study habits and grades. Valkenborghs et al. (2022) also used the 90-degree bend, long jump, and PsychoPy tests, along with magnetic resonance spectroscopy.

Regarding the study objectives and procedures, Lubans et al. (2021) evaluated the impact of an intervention based on high-intensity interval training (HIIT) on adolescents' cardiorespiratory fitness. Students who performed HIIT twice a week for 10 weeks significantly improved their cardiorespiratory fitness compared to those who received regular PE, indicating that HIIT is an efficient strategy for improving cardiovascular health in this age group.

Silva et al. (2020) described a protocol for testing the impact of a school program designed to promote physical activity and reduce sedentary behavior on various outcomes among Brazilian adolescents. The program comprises educational, environmental, and behavioral strategies designed to encourage students to be more active and to reduce sitting time throughout the day. The study assessed the impact of the program on participants' physical activity, sedentary behavior, physical fitness, body composition, mental health, academic performance, and quality of life (QoL).

Solberg et al. (2021a) examined the effects of a school-based physical activity intervention on the academic performance of 14-year-old adolescents. Schools received either the intervention or the standard PE curriculum. The intervention involved enhancing the frequency, duration, and intensity of PE classes while also integrating enjoyable and motivational components. Students in the intervention group experienced a significant improvement in their math and English grades compared to those in the control group, which demonstrates that physical activity can enhance learning.

Lima et al. (2020) analyzed the effects of a PE intervention on the academic performance of Brazilian adolescents, whereby participating schools were randomly assigned to either receive the intervention or follow the regular PE curriculum. The intervention involved enhancing both the quantity and quality of PE classes, emphasizing the development of motor, cognitive, and socio-affective skills. Students in the intervention group exhibited a significant improvement in their Portuguese and math grades compared to those in the control group, which demonstrates that PE can positively impact academic performance.

Valkenborghs et al. (2022) investigated the impact of HIIT on hippocampal metabolism in adolescents. They conducted an experimental study in which participants underwent a single session of HIIT or continuous moderate exercise (CME), followed by a functional MRI scan to measure regional cerebral blood flow. They found that HIIT elicited greater activation of the

hippocampus than CME, which suggests that HIIT can stimulate neurogenesis and plasticity in this brain region involved in memory.

Solberg et al. (2021b) investigated the role of aerobic fitness in mediating the effects of a school-based physical activity intervention on academic performance. They analyzed data from a previous study to test whether aerobic fitness mediated the effects of the intervention on students' grades (Solberg et al., 2021a). Aerobic fitness partially mediated the effects of the intervention on math and English grades, indicating that physical activity can improve academic performance by increasing cardiorespiratory capacity.

The studies provide consistent evidence that aerobic exercise can positively impact memory and attention in adolescents, as well as other aspects of physical and mental health. Furthermore, they emphasize the importance of implementing school programs that promote physical activity as a means of preventing a sedentary lifestyle and enhancing learning in this age group. A summary of the main findings from the studies reviewed is presented in Table 2.

**Table 2**

*Main findings from the studies.*

| Study | Results |
|---|---|
| Lubans et al. (2020) | Students who performed high-intensity interval training (HIIT) twice a week for 10 weeks significantly improved their cardiorespiratory fitness compared to those who received regular PE, which indicates that HIIT is an efficient strategy for improving cardiovascular health in this age group. |
| Silva et al. (2020) | The study revealed a significant effect on increasing moderate to vigorous physical activity, reducing sedentary behavior, and improving the physical activity/sedentary behavior ratio in the out-of-school segment, but not in the school segment. Multicomponent interventions (i.e., actions targeting both the school community and parents) are usually more effective in changing behavior than single-component interventions. |
| Solberg et al. (2021a) | Students in the intervention group experienced a significant improvement in their math and English grades compared to those in the control group, thereby demonstrating that physical activity can enhance learning. |
| Lima et al. (2020) | Students in the intervention group exhibited a significant improvement in their Portuguese and math grades compared to those in the control group, which demonstrates that PE can positively impact academic performance. |
| Valkenborghs et al. (2022) | HIIT elicited greater activation of the hippocampus compared to CME, which indicates that HIIT may enhance neurogenesis and plasticity in this brain region associated with memory. |

| Study | Results |
|---|---|
| Solberg et al. (2021b) | Aerobic fitness partially mediated the effects of the intervention on math and English grades, thereby indicating that physical activity can improve academic performance by increasing cardiorespiratory capacity. |

Source: Authors (2024).

## Discussion

This review explored the effects of physical fitness and exercise on adolescents' health, as well as their academic and cognitive performance, and found that the practice of physical education enhances adolescents' cognitive skills. Mapping the interventions implemented to enhance academic performance examining the features of each application and their outcomes is beneficial. This systematic review identified evidence suggesting that exercise can (and should) be incorporated into adolescents' routines for several reasons: it enhances cardiorespiratory fitness and yields various secondary benefits, including improved physical conditioning, regulated cortisol levels, better student behavior during reasoning and attention tasks, and increased subjective well-being, suggesting academic advantages to integrating physical activity into the school curriculum (Lubans et al., 2021).

Additionally, it contributes to increased physical activity and reduced sedentary behavior among adolescents during out-of-school hours (Silva et al., 2020). Such evidence demonstrates a partial mediation effect of aerobic fitness on the impact of the intervention, suggesting that the increase in aerobic fitness may be a mechanism through which the intervention enhanced academic performance (Solberg et al., 2021a; Solberg et al., 2021b). Exercise has a beneficial effect on students who initially performed poorly, marking it as a promising strategy to boost the academic outcomes of students who had previously failed in a school year (Lima et al., 2020). Moreover, high-intensity physical education results in enhanced physical fitness and hippocampal metabolism in adolescents, with positive associations between cardiorespiratory fitness, muscular fitness, working memory, and brain-derived neurotrophic factor (BDNF) levels (Valkenborghs et al., 2022).

Review studies have demonstrated the positive effects of physical education on the health of children and adolescents and the influence of physical fitness on cognitive functions and academic performance (Ramires et al., 2023; Aguayo et al., 2022; Heemskerk et al., 2020). The authors found that high levels of activity and physical fitness are associated with higher academic performance and executive function (Aguayo et al., 2022). Evidence was also found on the benefits of physical education in the affective domains (fun, motivation, and autonomy); social domains

(cooperation, problem-solving, and making friends); cognitive domains (memory, attention, concentration, and decision-making) (Ramires et al., 2023); and in reducing screen time (Fernandez-Lazaro y Fernández-Lázaro, 2023; Marciano y Camerini, 2021). These results reinforce the need to develop strategies to promote environments that encourage sports activities.

Lima et al. (2020), Silva et al. (2020), Valkenborghs et al. (2022), Lubans et al. (2021), and Solberg et al. (2021b) approach the subject from various perspectives, methodologies, and contexts, which could potentially lead to divergent results and conclusions. Some of the key differences lie in the type, intensity, duration, frequency, and adherence to aerobic exercise, all of which can positively affect memory and attention in adolescents. Adherence to exercise is crucial for interpreting the results and directly impacts the success of the proposed intervention.

The aforementioned studies also highlight disagreements about whether other factors, such as physical fitness levels, academic performance, sedentary behavior, and the school environment, act as mediators or moderators of the impact of aerobic exercise on adolescents' memory and attention. Solberg et al. (2021a) demonstrate that aerobic physical fitness mediates the impact of a school-based physical activity intervention on adolescents' academic performance, while Solberg et al. (2021b) demonstrates that the intervention also directly impacts academic performance, regardless of physical fitness. Silva et al. (2020) propose that a school intervention aimed at reducing sedentary behavior and increasing physical activity among adolescents can positively impact their physical and mental health.

Although most studies have shown the crucial role of physical exercise in the overall health of children and adolescents, some have shown conflicting results (Barth Vedøy et al., 2021; Haverkamp et al., 2021; Meijer et al., 2020). In a study that sought to explore the longitudinal relationship between physical activity and academic performance among a cohort of adolescents in Norway between 2016 and 2018, the authors found no significant associations between physical activity and academic performance (Haverkamp et al., 2021). Another study that conducted a randomized controlled trial to investigate the effects of an aerobic exercise intervention on children's executive functions showed that physical exercise interventions did not improve children's executive functioning (Meijer et al., 2020).

There are also divergent results regarding the type of physical work performed (Altermann and Gröpel, 2023; Shigeta et al., 2021; Haverkamp et al., 2021). Studies indicate that aerobic endurance plays a fundamental role in the cognitive component (Liu et al., 2023; Shigeta et al., 2021; Cariati et al., 2021; Jiménez Boraita et al., 2021; Ruotsalainen et al., 2020), while another study found that muscular strength was a component that showed the strongest association with the executive function of working memory (Muntaner-Mas et al., 2022). Others point out that speed-agility activities were significantly related to working memory, information processing, and control, but not to academic performance (Haverkamp et al., 2021). When evaluating the acute

effects of specific resistance, strength, and coordination models, the results indicate that both interventions were beneficial for adolescents' attention, while the mode of exercise training was not decisive (Altermann and Gröpel, 2023).

The differences in the generalizability and applicability of the results obtained across various populations, samples, and settings must be emphasized. Lubans et al. (2021) evaluated the effects of a short-term intervention aimed at improving the cardiorespiratory fitness of adolescents in Australia, while Lima et al. (2020) examined the effects of a PE intervention on the academic performance of adolescents in Brazil. These studies may have limitations regarding the generalization of their findings to different sociocultural and educational contexts. Such differences can be viewed as opportunities to broaden the understanding of the subject and to develop effective strategies for promoting cognitive health in adolescents through aerobic exercise.

## Perspective

The studies included in this systematic review corroborate several findings highlighted in the literature regarding the impact of physical fitness and exercise on adolescent health, as well as on academic and cognitive performance. This relationship is particularly evident in terms of how Physical Education (PE) meets the specific needs of adolescents in various fields of application, demonstrating that PE can contribute to improving students' academic performance.

The systematic review mapped the impact of physical fitness and exercise on adolescents' academic and cognitive performance, finding evidence that PE should be incorporated into activities for adolescents aimed at improving their academic and cognitive performance. Physical fitness and exercise play a crucial role in adolescent health, as well as in their mental performance. It is important for adolescents to engage in regular physical activity and adopt a healthy lifestyle to reap benefits in all these areas.

The scientific findings presented in the studies reviewed reveal that physical fitness and exercise play a significant role in the cognitive stimulation of adolescents. Regarding the practical application of these findings, it is suggested to develop physical activity programs that are integrated into the school curriculum, with daily or weekly activities; train teachers and physical educators to implement these activities effectively; establish monitoring systems to assess the impact of physical activities on students' academic performance and mental health; use ongoing assessment tools to adjust and improve programs as needed; involve parents and local communities to support and promote physical activity outside of school; and create awareness campaigns about the benefits of physical activity for adolescents.

As for future studies, it is suggested that research be conducted with diverse samples in terms of geographic location, socioeconomic level, and gender to better understand the variables

that may influence the results; that longitudinal studies be conducted to observe the long-term effects of physical activity on adolescents' academic performance and mental health; that the effects of different types of exercise (aerobic, anaerobic, resistance) be investigated to determine which are most effective in improving academic and cognitive performance; and that the use of technologies, such as fitness apps and active games, be explored to encourage physical activity among adolescents.

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