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The relationship between regular martial arts practice (judo and wrestling) and neurocognitive variables in children and adolescents: a scoping review

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Abstract

This scoping review aims to map existing evidence on the effects of judo and wrestling on cognitive performance in youth. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) was followed, retrieving documents from inception up to March 2025. The search encompassed six electronic databases: Web of Science, SCOPUS, PubMed, Sport Discus, ERIC, and PsycInfo; and other identification methods. Eligible studies included original studies involving judo or Olympic wrestling practices, with or without control groups, acute or chronic, of both sexes, age >6 and <18 years old, from any competitive level. Quantitative assessments of executive functions, cognitive performance, or academic achievement were required for inclusion. A total of 1368 studies were initially identified, and after applying inclusion and exclusion criteria, 10 articles were included in this scoping review, encompassing a combined sample of 683 participants (50% males). As a result, despite the heterogeneous nature of interventions with varying types and characteristics, the studies consistently revealed a positive association between judo or wrestling practice and behavioral and neurocognitive variables. Notwithstanding, it is essential to note that the suboptimal overall quality of the included studies. The findings suggest potential executive function benefits from judo or wrestling in youth. However, results require cautious interpretation due to limited rigorous research. Future studies should examine dose-response relationships considering age, maturation, experience, and include active control groups.

Keywords: Combat sports; martial arts; judo; wrestling; exercise program; children; adolescents; young; cognitive functions; executive functions; review.

La relación entre la práctica regular de artes marciales (judo y lucha olímpica) y las variables neurocognitivas en niños y adolescentes: una revisión de alcance

Resumen

Esta revisión de alcance tiene como objetivo indagar sobre la evidencia existente sobre los efectos del judo y la lucha olímpica en el rendimiento cognitivo de niños y adolescentes. Se siguieron los criterios recomendados por la declaración PRISMA para revisiones de alcance (PRISMA-

A relação entre a prática regular de artes marciais (judô e luta olímpica) e variáveis neurocognitivas em crianças e adolescentes: uma revisão de escopo

Resumo

Esta revisão de escopo tem como objetivo mapear as evidências existentes sobre os efeitos do judô e da luta olímpica no desempenho cognitivo de crianças e adolescentes. Seguiu-se os critérios recomendados pelo *Preferred Reporting Items for Systematic Reviews and*

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ScR), desde el inicio hasta marzo de 2025. La búsqueda se realizó en seis bases de datos electrónicas: Web of Science, SCOPUS, PubMed, Sport Discus, ERIC y PsycInfo, además de otros métodos de identificación. Se consideraron elegibles estudios originales que incluyeran la práctica de judo o lucha olímpica, con o sin grupo de control, ya fueran intervenciones agudas o crónicas, en participantes de ambos sexos, con edades comprendidas entre los 6 y los 18 años, y de cualquier nivel competitivo. Para su inclusión, los estudios debían emplear evaluaciones cuantitativas de funciones ejecutivas, rendimiento cognitivo o rendimiento académico. Se identificaron inicialmente 1368 estudios; tras aplicar los criterios de inclusión y exclusión, se seleccionaron 10 artículos que conforman esta revisión exploratoria, con una muestra combinada de 683 participantes (50 % varones). A pesar de la heterogeneidad de las intervenciones en cuanto a tipo y características, los estudios incluidos mostraron de forma consistente una asociación positiva entre la práctica de judo o lucha y diversas variables conductuales y neurocognitivas. No obstante, cabe destacar la calidad metodológica subóptima de los estudios incluidos. Los hallazgos sugieren posibles beneficios en las funciones ejecutivas derivados de la práctica de judo o lucha en población infantil y adolescente. Sin embargo, los resultados deben interpretarse con cautela debido a la escasa investigación rigurosa disponible. Se recomienda que futuros estudios examinen las relaciones dosis-respuesta, considerando variables como edad, maduración, experiencia y la inclusión de grupos control activos.

Palabras clave: Deportes de combate; artes marciales; judo; lucha; programa de ejercicios; niños; adolescentes; jóvenes; funciones cognitivas; funciones ejecutivas; revisión.

Meta-Analyses for Scoping Reviews (PRISMA-ScR), desde a origem até março de 2025. A busca foi realizada em seis bases de dados eletrónicas: Web of Science, SCOPUS, PubMed, Sport Discus, ERIC e PsycInfo; bem como por outros métodos de identificação. Foram considerados elegíveis os estudos originais que envolvessem práticas de judô ou luta olímpica, com ou sem grupo de controlo, intervenções agudas ou crónicas, com participantes de ambos os sexos, com idades superiores a 6 e inferiores a 18 anos, de qualquer nível competitivo. A inclusão exigiu avaliações quantitativas de funções executivas, desempenho cognitivo ou rendimento académico. Um total de 1368 estudos foi inicialmente identificado, e após a aplicação dos critérios de inclusão e exclusão, 10 artigos foram incluídos na revisão, abrangendo uma amostra combinada de 683 participantes (50% do sexo masculino). Apesar da natureza heterogénea das intervenções, com diferentes tipos e características, os estudos revelaram consistentemente uma associação positiva entre a prática de judô ou luta e variáveis comportamentais e neurocognitivas. No entanto, destaca-se a qualidade metodológica subótima dos estudos incluídos. Os achados sugerem possíveis benefícios das práticas de judô ou luta nas funções executivas de crianças e adolescentes. Contudo, os resultados devem ser interpretados com cautela, dada a escassez de estudos rigorosos. Investigações futuras devem explorar relações dose-resposta, considerando idade, maturação, experiência e incluir grupos de controlo ativos.

Palavras-chave: Desportos de combate; artes marciais; judo; luta livre; programa de exercício; crianças; adolescentes; jovens; funções cognitivas; funções executivas; revisão.

1. Introduction

Over the past decade, several reviews and meta-analyses have consistently indicated a positive association between physical activity (PA) and cognitive function, creative idea generation, as well as academic performance in children and adolescents (Álvarez-Bueno et al., 2017; de Greeff et al., 2018; Donnelly et al., 2016; García-Hermoso et al., 2021; Rominger et al., 2022). It has been suggested that engaging in PA or exercise produces bodily adaptations geared towards improving exercise performance, and these neurobiological changes play a crucial role in promoting positive effects on the brain, ultimately leading to enhanced cognition (Chen & Nakagawa, 2023). In a comprehensive narrative review, emphasis was placed on the state-of-the-art knowledge regarding various neurobiological mechanisms by which PA and exercise enhance cognition (Chen & Nakagawa, 2023). These mechanisms include: 1) the release of growth factors crucial for neuron development, neurogenesis, and angiogenesis, 2) the production of lactate, fuelling the brain and contributing to the synthesis of glutamate and maintenance of long-term potentiation, 3) the release of anti-inflammatory cytokines, mitigating neuroinflammation, 4) an increase in mitochondrial biogenesis and antioxidant enzyme activity, reducing oxidative stress, and 5) the release of neurotransmitters like dopamine and 5-HT, regulating neurogenesis and modulating cognition. Some authors have proposed that PA brings cognitive benefits across diverse domains, encompassing non-executive and executive functions (EFs), as well as metacognition in children and adolescents (Álvarez-Bueno et al., 2017). Moreover, another group of researchers demonstrated that PA not only improves cognitive function but also exerts positive influences on various aspects of academic performance in youth (Muntaner-Mas et al., 2022). Contrastingly, another group of authors, conducting a systematic review of intervention studies while considering the methodological quality of articles, encountered inconclusive evidence regarding the effects of PA on cognitive functions and overall academic performance outcomes (Singh et al., 2019). These inconsistencies may arise from the diverse effects expected due to variations in the selection of exercise parameters such as

intensity, mode, or volume (Chen & Nakagawa, 2023; Singh et al., 2019), as well as the theoretical framework in which studies have been conducted concerning cognitive performance (Colcombe & Kramer, 2003; Kiely, 2014; Singh et al., 2019).

The EFs are integral to learning and cognition and significantly impact academic achievement (Peng & Kievit, 2020). Donnelly et al. (2016) conducted a systematic review on the impact of PA, fitness, or physical education/sport participation on cognition, learning, brain function/structure, academic achievement, or concentration/attention. Their findings reveal that preschool EFs assessments predict achievements in kindergarten mathematics and literacy. Working memory abilities correlate with math and reading scores across age groups and predict academic achievements (mathematics and science) in adolescents. Furthermore, classroom-based PA programs enhance on-task behaviour during instruction, correlating with EFs crucial for self-regulation and inhibiting off-task behaviour, facilitating successful learning. Thus, emphasizing the potential of PA interventions to support the development of cognitive skills and EFs, as well as to improve academic outcomes in children and adolescents (García-Hermoso et al., 2021), skills that exhibit a bidirectional relationship (Peng & Kievit, 2020).

Both short-term and long-term exercise interventions have demonstrated effectiveness in improving cognitive performance among children and adolescents (Donnelly et al., 2016; Leahy et al., 2020; Takacs & Kassai, 2019). A meta-analysis encompassing a population spanning from children to adults, pooling data from 28 interventional studies, indicated that acute exercise interventions exhibited a moderate effect, while chronic interventions showed a large effect on creative performance. Notably, the observed effect was not moderated by the age range of the population (Rominger et al., 2022). While the cognitive benefits of PA and exercise are well-established, maximizing these advantages necessitates careful attention to both the exercise type (endurance or resistance) (Loprinzi et al., 2020; Ludyga et al., 2020) and the prescribed parameters (coordinative demands, intensity, volume, etc.) (Chen & Nakagawa, 2023; Ludyga et al., 2020). Certainly, both endurance and resistance exercise have the potential to influence episodic memory through both similar and distinct mechanisms (Loprinzi et al., 2020). In a recent narrative review by Chen and Nakagawa (2023), which provides an overview of the underlying neurobiological mechanisms, the diverse cognitive effects observed in response to various exercises are suggested to stem from the distinct stimulation of growth factors that modulate brain plasticity. Notably, the review emphasizes that while endurance exercise, particularly at high intensity, consistently influences blood levels of BDNF—a crucial factor linked to neuronal growth and survival—resistance training has been shown to enhance IGF-1 even at low to moderate intensity, facilitating overall growth and development. Moreover, resistance training may contribute to an increase in VEGF (Vascular Endothelial Growth Factor), a growth factor associated with both vascular health and neurogenesis (Chen & Nakagawa, 2023).

Additionally, the cognitive load imposed during exercise has emerged as a critical factor, and several authors have observed that an increased cognitive load leads to more pronounced improvements in cognitive performance (Chen & Nakagawa, 2023; Crova et al., 2014; Tomporowski et al., 2015). In this sense, the role of the exercise type and cognitive load gains further significance in the context of open-skilled sports. In a cross-sectional study involving 113 children (aged 8–13), those regularly participating in open-skilled sports exhibited lower switch costs in a switching task compared to those engaged in closed-skilled sports (Möhring et al., 2022). These authors indicated that children regularly participating in dynamic, unpredictable open-skilled sports may have enhanced EFs, emphasizing the potential impact of sport experiences on cognitive skills (Möhring et al., 2022).

Martial arts and combat sports are open-skilled sports which emphasize physical strength and power, endurance, and cognitive load, making this type of sport a highly promising tool for promoting cognitive performance (Ciaccioni et al., 2024; Sun et al., 2024).Some studies have provided empirical evidence to support that regular martial arts participation could improve cognition (Cho et al., 2017; de Greeff et al., 2018; Lakes et al., 2013). Martial arts, broadly classified as hard or soft, encompass slow, smooth movements emphasizing posture regulation in soft martial arts like tai chi, while hard martial arts prioritize fast, dynamic movements for maximum force generation, relying on physical strength, speed, and endurance (Theeboom & Knop, 1999). It has

been suggested that training in hard martial arts such as judo, taekwondo, and karate, contributes to improved balance, postural control, cognitive function, and psychological health, with studies indicating positive outcomes for middle-aged and older adults, suggesting benefits regardless of the age of initiation (Origua Rios et al., 2018). Grappling sports such as judo and wrestling, given their characteristics, are commonly widely practiced martial arts in children and adolescents likely because of absence of strikes, its educational values (Destani et al., 2014; Pyecha, 1970), and their effects on the psychosocial area (Lindell-Postigo et al., 2023). Moreover, in the realm of combat sports, the reduced impact observed in judo and wrestling enables a heightened frequency of real fight bouts or tasks with an opponent, amplifying the cognitive and emotional challenges during practice sessions. As a result, it is conceivable that the cognitive demands (e.g., attention, memory, decision-making, or problem-solving) and physical demands (e.g., coordination, strength, power, and endurance) remain consistently elevated throughout daily practice, fostering a more substantial stimulus for cognitive and EFs.

Hence, our objective was to investigate the available evidence on the impact of regular judo and wrestling practice on cognitive performance, EFs, and academic achievement in children and adolescents. To achieve this, we opted for a scoping review methodology, as it allows for a comprehensive exploration of the literature without strict criteria regarding study design (cross-sectional and interventional) or quality (randomized and non-randomized) (Munn et al., 2018). Cross-sectional studies can offer insights into the chronic adaptations related to cognitive performance and EFs in children and adolescents engaged in regular judo and wrestling practice. Conversely, interventional studies can provide valuable information about the effects of interventions, particularly among novice practitioners. This comprehensive approach will capture a holistic understanding of the topic in a scoping review. This inclusive approach is fitting for an emerging exploration of the relationship between these combat sports and cognition, EFs, and academic outcomes in the context of young individuals. Additionally, this review aids in assessing the potential value and scope for a subsequent systematic review, wherein the authors will offer a comprehensive identification of gaps in the literature and discuss the implications for future research after discussing the review results.

2. Methods

2.1. Data source

The present scoping review followed the recommendations mentioned in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) (Tricco et al., 2018). The PICOS strategy (Methley et al., 2014) was used to ensure rigor defining of the research question, in which: i) “P” corresponded to young or adolescent participants, regardless of ethnicity or gender; ii) “I” corresponded to any physical judo or wrestling program implemented in this population; iii) “C” (comparison) corresponded to the comparison between the control group versus the experimental group or pre-program to post-program; iv) “O” corresponded to outcomes related to cognitive performance, EFs or academic achievement variables; and, v) “S” (study design) encompassed experimental, quasi-experimental, or cross-sectional studies.

The literature search was carried out across six electronic databases (Web of Science, SCOPUS, PubMed, Sport Discus, ERIC, and PsycInfo) and included pre-print repositories, independently by three blinded authors (M.S.S., X.D.C. and E.C.F.) on March 20, 2025. The search strategy combined keywords related to judo and wrestling (e.g., “judo*”, “wrestl*”) with terms associated with cognitive performance, executive functions, and academic achievement (e.g., “executive function”, “memory”, “academic achieve*”) in youth (e.g., "child”, "juvenile*", "young*", "kid*”) using Boolean connectors. Details of the research strategy used in each database are shown in Appendix 1. Moreover, the articles that passed the title and abstract screening were entered into the Citation Chaser (Haddaway et al., 2021)platform for an exhaustive tracking of backward and forward cites to identify articles not captured by the search strategy (Figure 1), ensuring a thorough search, and minimizing the risk of publication and selection bias. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (https://www.prisma-statement.org/scoping) was followed in detail.

2.2. Eligibility criteria and study selection

The inclusion criteria were: (i) peer-reviewed and preprint studies; (ii) experimental (randomised participants), quasi-experimental (non-randomised participants), and cross-sectional studies; (iii) children and adolescents population from 6 to 18 years; (iv) healthy or with some pathology or disorder; (v) we included studies that quantitatively reported their measurements; and (vi) studies evaluating the effects of judo and Olympic wrestling practice on cognitive performance, EFs and/or academic achievement. Studies were excluded if: (i) while including participants that practice combat sports, the authors did not specify the type of sports, or they did not perform a differentiated sub-group analysis of judo and wrestling interventions; (ii) studies during a competition context; (iii) language differed from English, Spanish, or Portuguese; and (iv) design of the article differed from those specified as inclusion criteria.

Two researchers (M.S.S. and X.D.C.) independently and blindly assessed records obtained from electronic databases for inclusion and removed duplicated studies using Rayyan platform (Ouzzani et al., 2016). Following this, a thorough manual review of the remaining articles was conducted to mitigate potential errors. Subsequently, the same reviewers screened articles by analysing the title and abstract, identifying those meeting the inclusion criteria, and excluding those with characteristics outlined in the exclusion criteria. In the final stage, the same researchers independently conducted a comprehensive examination of the full text to determine the studies' final eligibility (Appendix 2 for a detailed description of articles excluded and reasons). These latter two phases were overseen by a third researcher (E.C.F.), who resolved discrepancies arising from disagreements in individual decisions made by the researchers.

2.3. Data extraction and synthesis of results

The use of Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) facilitated data extraction. Two authors (M.S.S. and X.D.C.) independently and systematically coded each study while being blinded to each other's extraction for the following information: (i) authors and year of publication, (ii) characteristics of participants and sample size, (iii) combat sports experience for cross-sectional studies and intervention details for interventional studies, (iv) comparator for cross-sectional studies and characteristics of control groups for interventional studies, (v) constructs related to cognitive function, EFs, and/or academic achievement, along with the measuring instruments used for obtaining the variables, and (vi) outcomes obtained. A third researcher (E.C.F.) independently verified all entries, and any discrepancies were resolved through discussions between the two authors until a consensus was reached.

In the outcomes column, the results of comparisons between judo or wrestling athletes and comparators in cross-sectional studies were presented in terms of direction of change and significance (Table 1). Due to a lack of sufficient data, the magnitude of changes was not calculated in cross-sectional studies; p-values were reported when available. For interventional studies, main effects over time were indicated by the percentage delta (Post-Pre/Pre*100) for each group in each study separately (Table 2). When available, p-values for group-by-time interaction were reported in the studies. Effect sizes, specifically Cohen's d corrected with Hedges' g for small sample size, were calculated using the online effect size calculator for gain scores and pre-post correlations available at Campbell Collaboration webpage (Wilson, n.d.,https://www.campbellcollaboration.org/research-resources/effect-size-calculator.html), along with their respective 95% confidence intervals ($CI_{95\%}$). Prior to inserting data into the online calculator, within-group correlations, mean change, and standard deviation of changes were calculated following the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2023). If the actual value was not specified, statistical significance was reported as $p < 0.05$. To gauge practical interpretation, the following effect size classification scheme was employed: trivial effect size < 0.2; small effect size, from ≥ 0.2 to < 0.5; medium effect size from ≥ 0.5 to < 0.8; and large effect size ≥ 0.8(Cohen, 1988).

2.4. Risk of bias

As recommended by PRISMA(Page et al., 2021), guidelines, two examiners (M.S.S. and X.D.C.) assessed each study based on the criteria used to rank the risk of bias. The risk of bias in the included cross-sectional studies was reported using The Joanna Briggs Institute Critical Appraisal tool (JBI)

(Hannes & Lockwood, 2011; Ma et al., 2020). For the interventional studies, the risk of bias was assessed by the Revised Cochrane Risk-of-Bias tool for randomised trials (RoB 2) (Sterne et al., 2019). No assessment of the risk of bias was conducted for the only non-randomized trial. In general, a high risk of bias was indicated when positive answers accounted for 49% or less; a moderate risk of bias was deemed when the risk of bias fell between 50% and 69%; and a low risk of bias was identified when positive answers surpassed 70% of the items.

2.5. Reporting of exercise intervention in the interventional studies

The Exercise Consensus Report Template (CERT) tool was used (Hansford et al., 2022) to assess the quality of the exercise intervention report.

3. Results

3.1. Study selection procedure

The electronic search strategy via databases retrieved 771 articles. After removing duplicates, 604 potentially relevant studies remained for screening. After analysing the title and abstract, 577 studies were excluded, and 27 full-text articles were reviewed. Identification via other methods, such as preprint resources, retrieved 597 articles. After removing duplicates (39 articles) and analysing the title and abstract, only 11 articles were selected for full-text review. Finally, 10 of those papers were relevant to this review. The PRISMA flow diagram is shown in Figure 1.

3.2. Study characteristics

The main characteristics and findings of interest from cross-sectional studies are shown in Table 1. Ten studies (four cross-sectional, five interventional, and one both cross-sectional and interventional) were included in the qualitative synthesis with a sample of 683 participants (50% males). Remarkably, a study by Grosu et al. (2015) failed to provide information about the participants' details or sample size. Additionally, none of the studies reported the individual responses of the participants. The age of the participants in the included studies ranged from 8 to 18 years old.

In the cross-sectional studies, the sample sizes ranged from 12 to 42 participants in the experimental groups. Most of the studies focused on adolescents (12 to 18 years) and the range of combat sports experience was from 2 to 9 years, with 2 studies (40%) not providing this information (Grosu et al., 2015; Iadreev et al., 2015). In general, boys were underrepresented (37 %) and one paper did not report both the sample size and the sex of participants (Grosu et al., 2015). Regarding the competition level, one study included participants competing at high level (e.g., Olympic judo Team) (Grosu et al., 2015), whereas 3 studies included sub-elite, regional, and amateur athletes (Li et al., 2021; Lo et al., 2019; Rutkowska & Gierczuk, 2012), and only one study reported no information (Iadreev et al., 2015). Most of the studies (3/5 studies, 60 %) provided no information on the sport combat training load, a study reported training frequency > 3 session /week (Lo et al., 2019), and other study reported a training duration of 20 h/week (Li et al., 2021). Four contributions (80%) focused on outcomes related to EFs (2/4 studies on problem-solving, 1/4 on cognitive flexibility, and 1/4 on attention), while one contribution (20%) addressed outcomes related to brain function. The comparator utilized included a non-combat sports healthy control group (2/5, 40%), athletes (ski and volleyball players) (2/5, 40%), and untrained students (1/5, 20%).

The key characteristics and significant findings of interest from the interventional studies are presented in Table 2. Notably, only interventions involving judo practice were identified in interventional studies. It's noteworthy that participants with no previous experience in any form of combat sports or martial arts, at least in the previous three months, were recruited for these interventions. The reviewed studies comprised varied participant samples, including two studies involving healthy individuals (Lo et al., 2019; Ludyga et al., 2021), two studies with children and adolescents diagnosed with attention-deficit hyperactivity disorder (ADHD) (Ludyga et al., 2022, 2023), one study examining participants with intellectual disabilities (Davis & Byrd, 1975), and one study involving Hispanic immigrant adolescents identified as predelinquent (Fleisher et al., 1995). All the interventional studies were randomised controlled trials, except for those by Lo et al. (2019)

Figure 1. Flowchart of study following the PRISMA (Preferred Reporting Items for Systematic Meta-Analyses) guidelines

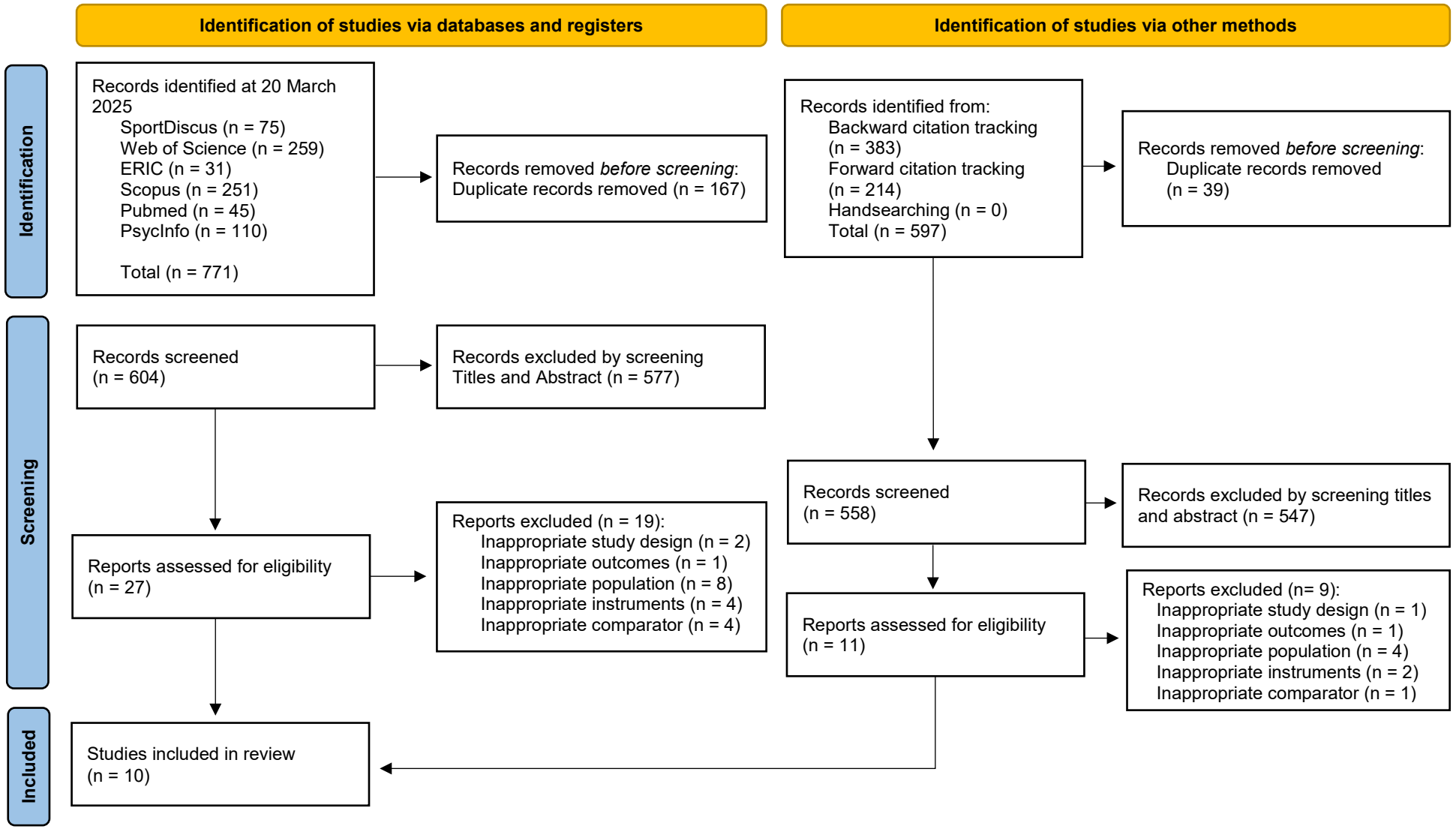


Table 1. *Characteristics of the cross-sectional studies included.*

Study (Author, year)	Participants and Sample Size	Level and Experience	Comparator	Measuring Instruments	Outcomes
Grosu et al. 2015	Romanian (11-15 yr) NR EG: NR judo CG: NR ski	NR Olympic judo team	Ski group of local sports clubs	EFs Attention through questionnaires (not specified)	≈ Concentration and attention (p = 0.052) ≈ Perceptive attention (p = 0.195) ↑ Distributive attention (p < 0.001)
Iadreev et al. 2015	Serbia (12-14 yr) 150 EG: 42 female judocas (0 males) CG: 54 female volleyball players and 54 untrained females (0 males)	NR Shorter training experience	Volleyball players (long-term training) and untrained control group	EFs Problem-solving through the Raven's Standard Progressive Matrices (RSPM): identifying the missing segment required to complete a larger pattern. The difficulty of the items progresses throughout the test.	≈ Abstract reasoning skills (approx. 45/60 points)
Li et al. 2022	China (13-16 yr) 61 EG: 32 (30 males; (18 judo + 14 wrestling) CG: 29 (28 males)	More than 2 yr (20h/week) Competition team	Non-combat sports healthy control group	Brain function through resting-state functional magnetic resonance imaging (Rs-fMRI)	↓ Amplitude of the low-frequency fluctuation in the bilateral cerebellum (p < 0.05, t-value= -6.4411) ↓ Regional homogeneity in the bilateral cerebellum (p < 0.05, t-value= -9.9404) ↑ Functional connectivity within the cerebellar network (p < 0.05, t-value= 4.757)
Lo et al. 2019	China (12-16 yr) 26 EG: 12 judocas (9 males) CG: 14 healthy participants (9 males)	More than 4 yr (at least 3 sessions/week)	Non-combat sports healthy control group	EFs Cognitive flexibility through spatial task-switching test (type: repeat and switch trials)	<u>Switched trials</u> ↓ Error rates (p = 0.001) ≈ Reaction time <u>Repeated trials</u> ≈ Error rates ≈ Reaction time
Rutkowska & Gierczuk 2012	Poland (15-18 yr) 78 EG: 39 wrestlers (19 males) CG: 39 (19 males)	3 to 9 yr Regional wrestlers team	Untrained students' control	EFs Problem-solving through KANH: creative behaviour questionnaire; domains: conformity, algorithmic thinking, nonconformity, heuristic thinking, creative attitude and reproductive attitude	Female wrestlers vs female students ↓ Non-conformity, heuristic thinking, and creative attitude domains (p < 0.05) ↑ Conformity and reproductive attitude domains (p < 0.05) ≈ Algorithmic thinking domains Male wrestlers vs male students No differences

Abbreviations: CG: control group; EG: experimental group; yr: years; NR: not reported; EFs: executive and executive functions.

Table 2. Characteristics of the interventional studies included.

Study (authors, year) *Design*	Participants and sample size	Intervention	Measuring instruments	Outcomes
Davis & Byrd (1975) *Randomised controlled trial, Time x Group*	EE. UU. (13-16 yr) *n* = 16; EG: 8 males; G: 8 males. Boys with mental disabilities (IQ scores 55 to 80)	EG: Supervised: yes. Sport: judo. F: 3 sessions/week. I: NR. Ti: 60 min. Ty: judo traditional. V: NR sessions, 12 w. P: NR. Kodokan. Attrition of the study: NR. Adherence to the study: NR CG: keep their regular activities	Academic performance through Wide Range Achievement Test (WRAT), domains: reading, spelling, and arithmetic	Academic performance No differences in any domains
Fleisher et al. (1995) *Non-randomised study without control group, Time*	EE. UU. (8-12 yr) *n* = 90; EG: 90 (61 males); CG: 0. Predelinquent Hispanic Immigrant	EG: Supervised: yes. Sport: judo. F: 2 sessions/week. I: NR. Ti: 120 min. Ty: judo traditional. V: NR sessions, 1 year. P: NR. Attrition of the study: 27.8%. Adherence to the study: NR	Academic performance through Wide Range Achievement Test (WRAT), domains: reading, spelling, and arithmetic	Academic performance Group-specific pre-post changes: Δ EG reading ≈ ↑ 60%; Δ EG spelling ≈ ↑ 10%; Δ EG arithmetic ≈ ↑ 7%
Lo et al. (2019) *Non-randomised study, Time x Type x Group*	China (12-16 yr) *n* = 29; EG: 14 (11 males); CG: 15 (11 males). Healthy children without experience in judo training	EG: Supervised: yes. Sport: judo. F: 3 sessions/week. I: NR. Ti: 60 min. Ty: physical fitness training, judo technique learning and randori. V: NR sessions, 8 w. P: NR. Sports club. Attrition of the study: NR. Adherence to the study: NR. CG: keep their regular activities	EFs Cognitive flexibility through spatial task-switching test (type: repeat and switch trials)	Switched trials – Errors: Δ EG = ↓ 8.29% and Δ CG = ↑ 0.67% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p = 0.003, d= -0.21 (small), $CI_{95\%}$ [-0.85, 0.43] in time x type x group interactions. Switched trials – Reaction time: No differences Repeated trials - Error and reaction time: No differences
Ludyga et al. (2021) *Randomised controlled trial, Time x Group*	Switzerland (9-13 yr) *n* = 42; EG: 22 (13 males). CG: 20 (10 males). Healthy right-hand children without regular practice of martial arts in the previous 3 months	EG: Supervised: yes. Sport: judo. F: 2 sessions/week. I: moderate intensity (RPE: 13.3 ± 0.9). Ti: 60 min. Ty: physical fitness training, judo technique learning and randori. V: NR sessions, 3 months. P: NR. Local dojo. Attrition of the study: 4.76%. Adherence to the study: 89.7% CG: keep their regular activities	EFs Inhibitory control through Go/NoGo Task: commission and omission trials and electroencephalographic (EEG)	Inhibitory control through Go/NoGo Task: - Commission - Error rate: Δ EG = ↓ 10.3 % and Δ CG = ↓ 3.5% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.017, d= -0.44 (small), $CI_{95\%}$ [-0.98, 0.1] in time x group interactions: - Commission – reaction time: No differences - Omission - Error rate and reaction time: No differences -Brain function (EEG) through N2 amplitude: Δ EG = ↑ 81% and Δ CG = ↓ 222% in Group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.019, d= -0.67 (medium), $CI_{95\%}$ [-1.24, -0.1] in time x group interactions - Brain function (EEG) through P3 amplitude: No differences

Ludyga et al. (2022) *Randomised controlled trial, Time x Group*	Switzerland (8-12 yr) *n* = 63; EG: 31 (23 males), CG: 32 (18 males). Children with ADHD (> 3 months with medication) without regular practice of martial arts in the previous 3 months	EG: Supervised: yes. Sport: judo. F: 2 sessions/week. I: moderate intensity (RPE: 13.3 ± 0.7). Ti: 60 min. Ty: physical fitness training, judo technique learning and randori. V: 24 sessions, 3 months. P: NR. Attrition of the study: 9.52%. Adherence to the study: 81.9% CG: keep their regular activities	EFs Working memory through serial reaction time task and electroencephalographic (EEG)	Working memory through serial reaction time task: - Coefficient between accuracy and reaction time (K-Score): Δ EG = ↑ 18% and Δ CG ≈ 0% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.03, d= 0.43 (small), $CI_{95\%}$ [-0.03, 0.9] in time x group interactions. - Reaction time: No differences - Brain function (EEG) through negativity contralateral delay activity "CDA" waveforms: Δ EG = ↑59% and Δ CG ≈ -32% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.043, d=-0.59 (medium), $CI_{95\%}$ [-1.07, -0.11] in time x group interactions: - Brain function (EEG) through neurocognitive measures (contralateral delay activity "CDA" amplitude): No differences
Ludyga et al. (2023) *Two parallel randomised controlled trial, Study x Time x Group*	Switzerland (8-12 yr) Study 1: 63 (42 males); EG: 31; CG: 32. Children with ADHD (> 3 months with medication) without regular practice of martial arts in the previous 3 months Study 2: 65 (28 males); EG: 32; CG: 33. Children born pre-term (≤32 wk of gestation and IQ score ≥ 85) without regular practice of martial arts in the previous 3 months	EG: Supervised: yes. Sport: judo. F: 2 sessions/week. I: moderate intensity (RPE ≈ 13). Ti: 60 min. Ty: physical fitness training, judo technique learning and randori. V: NR sessions, 3 months. P: NR. Attrition of the study: 7.81%. Adherence to the study: ADHD: 81.3%. Children born pre-term: 82.1% CG: keep their regular activities	EFs Inhibitory control through Go/NoGo Task: commission and omission trials and electroencephalographic (EEG)	Study 1, ADHD Inhibitory control through Go/NoGo Task: - Error rate, reaction time, and brain function: No differences Study 2, children born pre-term Inhibitory control through Go/NoGo Task: - Commission - Error rate: Δ EG = ↓ 31% and Δ CG ≈ 0% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.021, d= -0.47 (small), $CI_{95\%}$ [-0.94, 0.00] in time x group interactions. - Commission – reaction time: No differences - Commission - Error rate and reaction time: No differences - Brain function (EEG) through P3a amplitude: Δ EG = ↑ 54% and Δ CG ≈ 0% in group-specific pre-post changes. $EG_{pre\text{-}post}$ vs $CG_{pre\text{-}post}$: p= 0.021, d= 0.55 (medium), $CI_{95\%}$ [0.07, 1.02] in time x group interactions. - Brain function (EEG) through P3b amplitude and N2 amplitude: No differences

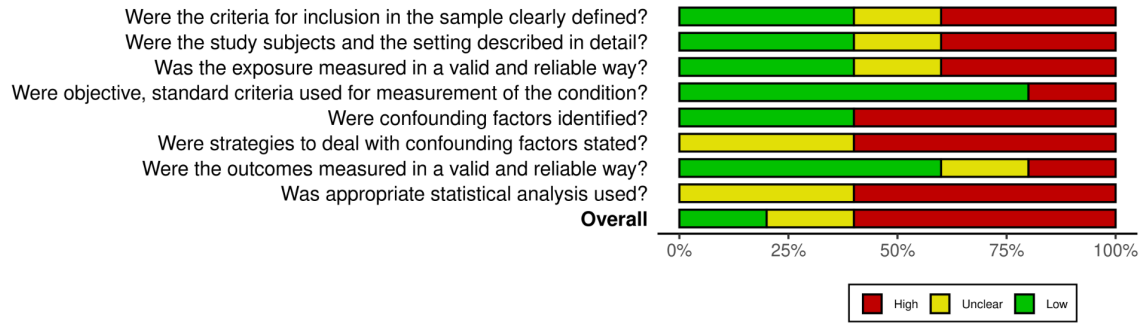
Abbreviations:CG: control group; EG: experimental group; yr: years; EFs: executive and executive functions; NR: not reported; F: frequency; I: intensity; Ti: time; Ty: type; V: volume; P: progression; yr: years, yr; IQ: intelligence quotient; ADHD: attention-deficit hyper- activity disorder; EEG: electroencephalography.

and Fleisher et al. (1995), which utilised a non-randomised controlled design. The interventional studies used a sample of 370 children and adolescents (8 to 16 years, boys: 62%). The duration of interventions varied, ranging from 8 weeks (Lo et al., 2019) to 12 weeks (Davis & Byrd, 1975; Ludyga et al., 2021, 2022, 2023), with the longest intervention extending up to one year (Fleisher et al., 1995). The intervention protocols lasted from 24 (Lo et al., 2019; Ludyga et al., 2021, 2022, 2023) to 36 sessions (Davis & Byrd, 1975) with moderate intensity (RPE ≈ 13) in studies that reported it (Ludyga et al., 2021, 2022, 2023), each lasting 60 minutes, and was conducted over a period of 2 or 3 months. Studies reported adherence was >80% (n=3/5 studies, 60%) and consistently showed low attrition rates (<10%) (n=3/5 studies, 60%) (Ludyga et al., 2021, 2022, 2023). In contrast, Fleisher et al. (1995) employed longer sessions of 120 minutes over one year; however, adherence was not reported, and attrition rates approached 30%. Nevertheless, some crucial intervention details were not reported, impeding replication of the studies. The majority of studies (4/6 studies, 66.66%) centered on EFs outcomes: with a focus on inhibitory control (2/4 studies, 50%), cognitive flexibility (1/4, 25%), and working memory (1/4, 25%). Two studies (n=2/6, 33.33%) investigated outcomes related to academic performance (Davis & Byrd, 1975; Fleisher et al., 1995). The comparator/control groups employed involved participants maintaining their regular activities.

3.3. Risk of bias

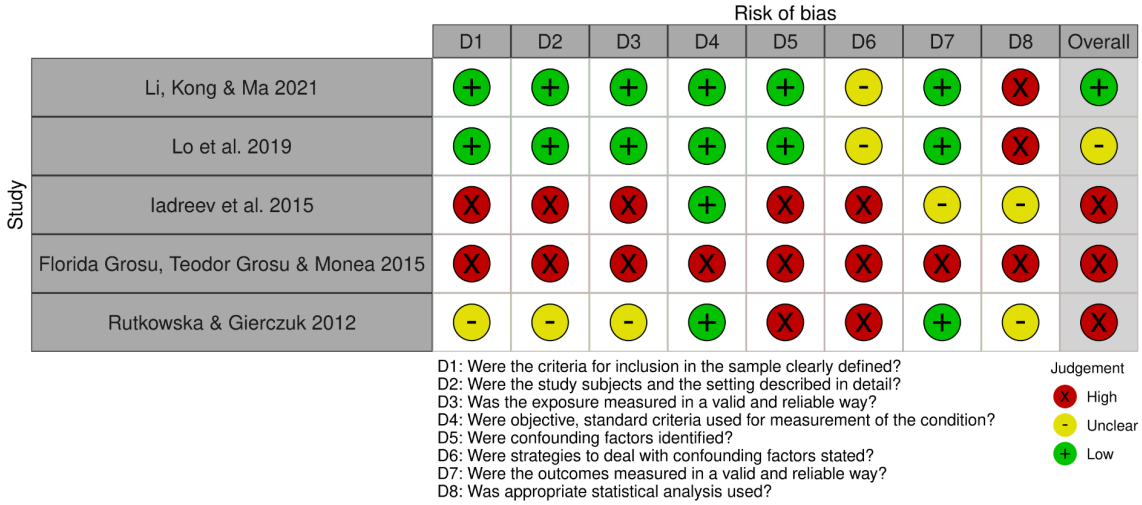
In the cross-sectional studies, Figure 2 and Figure 3 illustrate the risk of bias assessed by the JBI tool. Among these, three studies (n=3/5, 60%) were deemed to carry a high risk of bias based on the overall score (Grosu et al., 2015; Iadreev et al., 2015; Rutkowska & Gierczuk, 2012). Notably, confounding factors, strategies for addressing them, and the appropriateness of the statistical analysis emerged as the primary sources of bias.

Figure 2. Risk of bias graph: judgement about each risk of bias item presented as percentages across all included studies.



Note. Source: Sterne et al. (2019)

Figure 3. Judgments about each risk-of-bias item for each study



Note. Source: Sterne et al. (2019)

In the interventional studies, the risk of bias was assessed using the Rob 2 tool. Among the four randomized studies, three received a classification of low risk in their overall scores (Ludyga et al., 2021, 2022, 2023), whereas one was categorized as having a high risk of bias (Davis & Byrd, 1975). Specifically, the studies by Ludyga et al. demonstrated a low risk of bias in terms of the randomization process and deviations from intended interventions (Ludyga et al., 2021, 2022, 2023).. These studies also exhibited a low risk of bias related to missing outcome data and the selection of reported results. However, all studies were classified as high risk in the domain of outcome measurement bias (Davis & Byrd, 1975; Ludyga et al., 2021, 2022, 2023). Additionally, the non-randomized study by Fleisher et al. (1995), which lacked a control group, exhibited a high risk of bias across nearly all domains, with the exception of the selection of the reported result.

3.4. Reporting of exercise intervention in the training programs

Table 3 summarizes the reporting quality evaluation of intervention protocols based on CERT criteria (Slade et al., 2016). The most consistently reported items across exercise protocols were supervision and clarification regarding whether exercises were generic or individually tailored, with both aspects reported in all studies (100%, n=6). Descriptions of the exercises and rules for determining initial levels were provided in 66.7% of the studies (n=4/6), while adherence reporting was included in 50% of the studies (n=3/6). Notably, details regarding the qualifications of the individual conducting the training were reported in only one study (20%, 1/5). Overall, none of the studies included in this review addressed more than 50% of the total CERT criteria.

Table 3. Completeness reporting of exercise interventions in the training programs.

CERT item	*n*, %	CERT item	*n*, %
Item 1. What (materials)	0 (0%)	Item 8. Exercise replication	0 (0%)
Item 2. Who (provider)	1 (16.7%)	Item 9. Home components	0 (0%)
Item 3. Individually or in a group	1 (16.7%)	Item 10. Non-exercise components	0 (0%)
Item 4. Supervised or unsupervised	6 (100%)	Item 11. Adverse events report	0 (0%)
Item 5. Adherence report	3 (50%)	Item 12. Setting	0 (0%)
Item 6. Motivation strategies	0 (0%)	Item 13. Description of the exercise	5 (83.3%)
Item 7a. Exercise progression	0 (0%)	Item 14a. Exercise generic or tailored?	6 (100%)
Item 7b. Program progression	0 (0%)	Item 14b. Description of the adaptation made in the exercises	0 (0%)
Item 8. Exercise replication	0 (0%)	Item 15. Rules for starting level	5 (83.3%)

Note. Elaborated by the authors (2025), following the recommendations from Slade et al. (2016).

3.5. Summary of evidence

Overall, significant heterogeneity was observed among study groups concerning various crucial study parameters. These parameters encompassed participant characteristics, such as combat sports experience, gender, and group comparator, as well as measures for assessing cognitive performance and EFs (further details available in the Appendix 3). To streamline result synthesis, articles were categorized based on study design, making a distinction between cross-sectional and intervention trials.

The instruments used for evaluating cognitive performance and EFs in cross-sectional studies exhibited significant heterogeneity including questionnaires (Grosu et al., 2015; Iadreev et al., 2015; Rutkowska & Gierczuk, 2012), reaction time tasks (Lo et al., 2019), and brain's neural activity measured by functional magnetic resonance imaging (Li et al., 2021). Most cross-sectional studies (4/5 studies, 80%,) demonstrated that grappler athletes scored better in specific EFs domains, such as cognitive flexibility (Lo et al., 2019) and attention (Grosu et al., 2015), with no discernible differences in problem-solving domains (Iadreev et al., 2015; Rutkowska & Gierczuk, 2012) compared to controls. Additionally, a mixed group of judocas and wrestlers had better brain function, as supported by enhanced cerebellar functional connectivity than controls (Li et al., 2021).

All six interventional studies reported employed only judo-based interventions to explore the effects on cognitive performance, EFs and academic achievement (detailed description in Table 2). More specifically, engaging in judo practice resulted in significant but small enhancements in various EFs variables, including inhibitory control (Ludyga et al., 2021, 2023), cognitive flexibility (Lo et al., 2019), and working memory (Ludyga et al., 2022) compared to control groups. Additionally, significant, and moderate enhancements in brain function in a working memory task (Ludyga et al., 2022) and in inhibitory control tasks (Ludyga et al., 2021, 2023) compared to controls were observed through the evaluation brain's neural activity based on electroencephalography measurements. Regarding academic performance, the findings remain inconclusive. While a judo-based intervention in adolescent males reported no significant effects (Davis & Byrd, 1975), the study by Fleisher et al. (1995) observed a notable improvement from post- to pre-intervention, particularly in relation to reading skills.

4. Discussion

To the best of our knowledge, this is the first review to examine the relationship between judo or wrestling practice and cognitive performance, EFs, and academic achievement in youth. Cross-sectional studies have reported superior cognitive flexibility, attention, and brain function in younger experienced judo and wrestling practitioners compared to non-practitioners. Regular judo practice has been associated with improvements in attention (Grosu et al., 2015), cognitive flexibility (Lo et al., 2019), and greater behavioral conformity (Rutkowska & Gierczuk, 2012). No studies have assessed academic performance using cross-sectional designs or examined the acute effects of single sessions, limiting comparisons with the well-established short-term benefits of PA. Two intervention studies reported improvements in inhibitory control, reducing error rates by 10% to 31%, with small but significant interaction effects (Ludyga et al., 2021, 2023). Cognitive flexibility improved by 8.26% in a spatial task-switching test following regular judo practice (Lo et al., 2019), and working memory gains accompanied by functional brain changes were observed in children with ADHD (Ludyga et al., 2022). Evidence regarding academic outcomes is mixed: no effects were observed in adolescents with intellectual disabilities (Davis & Byrd, 1975), whereas significant improvements were reported in pre-delinquent Hispanic immigrant children (Fleisher et al., 1995).

4.1. Executive functions

These findings align with a systematic review study in adults, indicating enhanced performance among martial arts practitioners in cognitive flexibility and attention tasks (Ciaccioni et al., 2024).The same authors also presented results indicating that individuals practicing martial arts consistently demonstrated enhanced inhibitory control compared to those who were not engaged in athletic activities in adults (Ciaccioni et al., 2024). Concerning working memory assessments, aligning with the outcomes of the current scoping review, the authors noted no disparities in working memory performance between individuals practicing martial arts or combat sports and those who were non-athletes or engaged in other forms of sports practice (Ciaccioni et al., 2024).

Besides, these results are consistent with previous studies in youth demonstrating that regular participation in extracurricular sports improves EFs development (Giordano et al., 2021). Specifically, children's EFs appear particularly sensitive to exercise interventions (Tomporowski & Pesce, 2019). Likewise, organized programs involving open-skilled, such as judo and wrestling, yield greater improvements in children's EFs compared to those engaging in closed-skilled sports (Becker et al., 2018), self-paced sports, or no sports at all (De Waelle et al., 2021). PA programs have demonstrated a positive effect on EFs and attention (de Greeff et al., 2018). Specifically, in a recent meta-analysis, the authors reported that sports interventions had positively affected working memory, inhibitory control, and cognitive flexibility, all of which are components of EFs (Contreras-Osorio et al., 2021). Hence, the mechanisms underlying the effects of PA on children's EFs, suggesting that it results in increased neurotransmitters (e.g., epinephrine, dopamine, and brain-derived neurotrophic factors [BDNF]) (de Greeff et al., 2018). PA enhances angiogenesis and neurogenesis in brain areas supporting memory and learning, thus promoting improved cognitive performance (de Greeff et al., 2018).

4.2. Academic performance

EFs is a strong predictor of children's and adolescents' academic performance(Samuels et al., 2016). Academic performance represents a type of intelligence; yet the study by Davis and Byrd (1975), which examined the relationship between judo practice and academic performance in boys with intellectual disabilities, reported no differences in outcomes compared to the control group after a three-month intervention. In contrast, Fleisher et al. (1995) reported significant improvements in academic performance following a one-year judo intervention in pre-delinquent Hispanic immigrant children. A recent published review highlights the limited and inconclusive evidence concerning the association between the practice of martial arts and combat sports and intelligence in adults (Ciaccioni et al., 2024). These findings align with another specific review focusing on children, indicating that published studies do not strongly support the notion that exercise training universally enhances children's overall intelligence. However, they do suggest that exercise might facilitate specific aspects of cognitive functioning such as EFs (Tomporowski & Pesce, 2019). Consequently, the capacity to formulate definitive conclusions on the relationship between exercise and intelligence is currently impeded by a scarcity of methodologically robust studies.

4.3. Brain function

In terms of brain functional outcomes, as indicated by complex and coordinated cerebral activities, the studies examined brain activity utilizing electroencephalography (EEG; 3/9 studies) and functional magnetic resonance imaging (fMRI; 1/9 studies). Due to variations in cognitive tasks and stimulus types utilized, comparing outcomes between judo and wrestling practitioners and control groups presents challenges in terms of comparability. Evidence suggests a potential positive correlation between engagement in judo and wrestling and cerebellar functional connectivity (Li et al., 2021), alongside alterations in neurocognitive measures compared to control groups (Ludyga et al., 2021, 2022, 2023). A recent systematic review highlighted a convincing positive relationship between changes in brain function and the practice of martial arts or combat sports in adults (Ciaccioni et al., 2024). Largely, exercise in general improves brain functions and prevents decline of cognition across the lifespan (Baek, 2016).

4.4. Quality of Evidence

Three of the five cross-sectional studies (60%) showed a high risk of bias due to poorly described methods limiting replicability (Grosu et al., 2015; Iadreev et al., 2015; Rutkowska & Gierczuk, 2012). Similarly, none of the experimental studies fully met the CERT reporting criteria, addressing only 6 of 16 items. This weakens the ability to establish causal links between martial arts training and cognitive performance or determine effective training doses. Prior research highlights the influence of training type and volume on cognitive outcomes (Herold et al., 2019; Muntaner-Mas et al., 2022). Additionally, control groups received no alternative training, raising the possibility that cognitive gains resulted from engaging in a novel activity or social interaction rather than specific martial arts effects. Sports participation most often involves psychosocial benefits—enhanced social interaction, self-esteem, and the adoption of values like persistence and effort (Morales et al., 2011)—which may contribute to cognitive improvements. Another limitation was the inability to objectively quantify training in control groups. Future studies should incorporate active control groups to better isolate the effects of judo or wrestling. Measurement heterogeneity also complicates interpretation, as cognitive performance was assessed through diverse tools, including reaction time tasks, questionnaires, fMRI, and EEG. Despite this, the variety of methods suggests potential benefits across cognitive domains. Consistent with Souissi et al. (2022), selecting appropriate psychometric tools while considering biological and cultural contexts is recommended. Finally, sex-based comparisons were largely absent, except for Rutkowska and Gierczuk's (2012) study, which found no sex differences in conformity. This suggests that the cognitive impact of judo or wrestling training is likely unaffected by sex, aligning with general findings in combat sports (McCuen et al., 2015).

4.5. Knowledge Gaps in the Literature

Table 4 illustrates the five identified knowledge gaps on the effects of judo or wrestling practice on cognitive performance in youth and the respective implications for future research.

Table 4. Identified knowledge gaps in the literature and recommendations for future studies.

Identified knowledge gaps from scoping review	Implications for future research
Lack of comparative studies that examined judo or wrestling program effects according to age and maturity status	Comparative studies are needed that contrast judo or wrestling program effects according to chronological age and/or maturity status (pre-pubertal vs circa vs post-pubertal)
Lack of comparative studies that examined judo or wrestling program effects according to expertise status	Comparative studies are needed that contrast judo or wrestling program effects according to competition levels (regional vs national vs international) and expertise status (short vs long-training volume)
Lack of interventional studies that examined judo or wrestling program effects compared to control active group	Always include at least one control group that receive additional training to identify the relative contribution of judo or wrestling program to cognitive performance improvement
Inconsistent reporting of cognitive outcomes	Always include at least one quantitatively cognitive measurement (e.g., reaction time, questionnaires, test) and describes methods in detail to allow comparison between studies and to aggregate (meta-analyse) findings across studies in future research
Lack of comparative studies and/or meta-analyses that examined judo or wrestling program dosage effects	Comparative studies and/or future meta-analyses are needed that elucidate the dosage effects of judo or wrestling program

Note. Source: Elaborated by the authors (2025).

4.6. Study Limitations

This scoping review article has some methodological limitations that warrant discussion. First and foremost, the overall number of identified studies (N = 10) and the number of participating individuals is small (N = 683 children and adolescents, 50% males). As a consequence, we did not aggregate a metanalyses findings from the four cross-sectional, five interventional, and one both cross-sectional and interventional study. Instead, we reported single-study outcomes in Table 1 for cross-sectional and in Table 2 for interventional studies and identified five knowledge gaps in the literature (Table 4). Findings from this scoping review may provide new research avenues for well-designed future studies enabling meta-analyses on the topic (Table 4). When designing future research according to age, maturity status, and expertise level, researchers have to keep in mind that these moderators interact. Accordingly, it is important that active comparator groups are present in the future studies, and that multiple experimental groups, each utilizing distinct programs, are established. This approach holds considerable significance for elucidating dosage effects. An often-encountered criticism of meta-analyses is that they synthesize rather heterogeneous study outcomes (i.e., mixing apples and oranges). We tried to overcome this limitation by reporting single-study findings in our scoping review instead of computing a meta-analysis.

5. Conclusions

Judo or wrestling programs promise improvements in EFs, leading to enhanced cognitive performance in children and adolescents. These beneficial effects can be observed on both behavioural (inhibitory control, cognitive flexibility, attention working memory, and emotional intelligence outcomes) and neurocognitive level, including cerebellum functional connectivity, and other variables. Such positive responses can contribute to a decrease in school dropout rates and mitigate the risk of developing mental illnesses. Future research should investigate other changes in maturational levels (prepubertal, pubertal, and post pubertal), expertise status (competition level and volume of practice) and dosage effects in children and adolescents. It is important that future research compares the effects of judo and wrestling with other combat sports, facilitating a comprehensive understanding of the outcomes.

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Appendix 1. Search strategies used in each database.

Database	Search strategy (March 20th, 2025)
PUBMED	(("intellectual*"[Title/Abstract] OR "psychoeducat*"[Title/Abstract] OR "executive function"[Title/Abstract] OR "cogni*"[Title/Abstract] OR "problem solving"[Title/Abstract] OR "memory"[Title/Abstract] OR "intelligen*"[Title/Abstract] OR "neurocogni*"[Title/Abstract] OR "neuroeducat*"[Title/Abstract] OR "neurodynamic function"[Title/Abstract] OR "academic achieve*"[Title/Abstract] OR "acknowled*"[Title/Abstract] OR "comprehensi*"[Title/Abstract] OR "cognizance"[Title/Abstract]) AND ("child*"[Title/Abstract] OR "juvenile*"[Title/Abstract] OR "teen*"[Title/Abstract] OR "young*"[Title/Abstract] OR "youth*"[Title/Abstract] OR "boy*"[Title/Abstract] OR "girl*"[Title/Abstract] OR "kid*"[Title/Abstract] OR "adolescen*"[Title/Abstract] OR "infant*"[Title/Abstract] OR "student*"[Title/Abstract])) AND ("judo*"[Title/Abstract] OR "wrestl*"[Title/Abstract])
SCOPUS	(TITLE-ABS-KEY ("intellectual*" OR "psychoeducat*" OR "executive function" OR "cogni*" OR "problem solving" OR "memory" OR "intelligen*" OR "neurocogni*" OR "neuroeducat*" OR "neurodynamic function" OR "academic achieve*" OR "acknowled*" OR "comprehensi*" OR "cognisance") AND TITLE-ABS-KEY ("child*" OR "juvenile*" OR "teen*" OR "young*" OR "youth*" OR "boy*" OR "girl*" OR "kid*" OR "adolescen*" OR "infant*" OR "student*") AND TITLE-ABS-KEY ("judo*" OR "wrestl*")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "Spanish") OR LIMIT-TO (LANGUAGE , " Portuguese "))
WEB OF SCIENCE	"intellectual*" OR "psychoeducat*" OR "executive function" OR "cogni*" OR "problem solving" OR "memory" OR "intelligen*" OR "neurocogni*" OR "neuroeducat*" OR "neurodynamic function" OR "academic achieve*" OR "acknowled*" OR "comprehensi*" OR "cognisance" (Topic) and "child*" OR "juvenile*" OR "teen*" OR "young*" OR "youth*" OR "boy*" OR "girl*" OR "kid*" OR "adolescen*" OR "infant*" OR "student*" (Topic) and "judo*" OR "wrestl*" (Topic) and Articles or Review Articles (Document Types) and Spanish or English or Portuguese (Languages)
SPORTDISCUSS	("intellectual*" OR "psychoeducat*" OR "executive function" OR "cogni*" OR "problem solving" OR "memory" OR "intelligen*" OR "neurocogni*" OR "neuroeducat*" OR "neurodynamic function" OR "academic achieve*" OR "acknowled*" OR "comprehensi*" OR "cognisance") AND ("child*" OR "juvenile*" OR "teen*" OR "young*" OR "youth*" OR "boy*" OR "girl*" OR "kid*" OR "adolescen*" OR "infant*" OR "student*") AND ("judo*" OR "wrestl*") Idioma: English, Spanish; Tipo de publicación: Academic Journal AND Aplicar palabras relacionadas; Aplicar materias equivalentes on 2025-03-20 13:40 AM"
ERIC	("intellectual*" OR "psychoeducat*" OR "executive function" OR "cogni*" OR "problem solving" OR "memory" OR "intelligen*" OR "neurocogni*" OR "neuroeducat*" OR "neurodynamic function" OR "academic achieve*" OR "acknowled*" OR "comprehensi*" OR "cognisance") AND ("child*" OR "juvenile*" OR "teen*" OR "young*" OR "youth*" OR "boy*" OR "girl*" OR "kid*" OR "adolescen*" OR "infant*" OR "student*") AND ("judo*" OR "wrestl*") Tipo de publicación: Journal Articles AND Aplicar palabras relacionadas; Aplicar materias equivalentes on 2025-03-20 13:40 AM"
APA PsycInfo	("intellectual*" OR "psychoeducat*" OR "executive function" OR "cogni*" OR "problem solving" OR "memory" OR "intelligen*" OR "neurocogni*" OR "neuroeducat*" OR "neurodynamic function" OR "academic achieve*" OR "acknowled*" OR "comprehensi*" OR "cognisance") AND ("child*" OR "juvenile*" OR "teen*" OR "young*" OR "youth*" OR "boy*" OR "girl*" OR "kid*" OR "adolescen*" OR "infant*" OR "student*") AND ("judo*" OR "wrestl*") AND rtype.exact("Peer Reviewed Journal" OR "Journal Article" OR "Peer-Reviewed Status-Unknown" OR "Journal") AND la.exact ("Portuguese" OR "Spanish" OR "English" OR "French")
PREPRINTS PREPRINTS SCIELO PREPRINTS BIORXIV	(full text or abstract or title ""judo" OR “wrestling”" (match whole all)) “judo” OR “wrestling”

Source: elaborated by the authors (2025).

Appendix 2. Excluded studies, with reasons

Wrong outcomes

J.M. Gleser, Physical and psychosocial benefits of modified judo practice for blind, mentally retarded children: a pilot study. https://doi.org/10.2466/pms.74.3.915-925

Wrong populations

R. Fletcher, L. Dowell, Selected personality characteristics of high school athletes and non-athletes. https://doi.org/10.1080/00223980.1971.9916852

R.A. Fabio, G.E. Towey, Cognitive and personality factors in the regular practice of martial arts. https://doi.org/10.23736/S0022-4707.17.07245-0

D. Badau et al., Differences among three measures of reaction time based on hand laterality in individual sports. https://doi.org/10.3390/sports6020045

N. Airoldi et al., Junior High School Athletes Excel in Scholarship. https://doi.org/10.1002/j.2164-4918.1967.tb04774.x

K. D. Lakes, W. T. Hoyt, Promoting self-regulation through school-based martial arts training. https://doi.org/10.1016/j.appdev.2004.04.002

D. Moreau et al., Assessing movement imagery ability: Self-report questionnaires vs. performance-based tests. https://doi.org/10.5964/ejop.v6i4.225

J. F. Sanchez-Lopez Thalía et al., Differences between Judo, Taekwondo and Kung-fu Athletes in Sustained Attention and Impulse Control. http://dx.doi.org/10.4236/psych.2013.47086

J. Sanchez-Lopez et al., Sustained attention in skilled and novice martial arts athletes: A study of event-related potentials and current sources. https://doi.org/10.7717/peerj.1614

H. K. C. Faro et al., Influence of Judo Experience on Neuroelectric Activity During a Selective Attention Task. https://doi.org/10.3389/fpsyg.2019.02838

C. Meneghetti et al., The practice of Judo: how does it relate to different spatial abilities? https://doi.org/10.1080/13875868.2020.1830995

W. T. Tsushima et al., Comparison of neuropsychological test scores of high school athletes in high and low contact sports: A replication study. https://doi.org/10.1080/21622965.2016.1220860

W. T. Tsushima et al., Are There Subconcussive Neuropsychological Effects in Youth Sports? An Exploratory Study of High- and Low-Contact Sports. https://doi.org/10.1080/21622965.2016.1220860

Wrong study design

D. H. Fukuda, et al., Judo for children and adolescents: Benefits of combat sports. https://doi.org/10.1519/SSC.0b013e3182389e74

A. Rogowska, C. Kuśnierz, Coping of Judo Competitors in the Context of Gender, Age, Years of Practice and Skill Level. https://doi.org/10.1080/10413200.2012.694392

K. Sterkowicz-Przybycień et al., Educational judo benefits on the preschool children's behaviour. https://doi.org/10.5604/20815735.1127449

Wrong instruments

W. F. S. Jacini et al., Can exercise shape your brain? Cortical differences associated with judo practice. https://doi.org/10.1016/j.jsams.2008.11.004

W. Li et al., Effects of combat sports on functional network connectivity in adolescents. https://doi.org/10.1007/s00234-021-02713-y

J. Morales et al., Improving motor skills and psychosocial behaviors in children with autism spectrum disorder through an adapted judo program. https://doi.org/10.3389/fpsyg.2022.1067310

B. S. Lockard et al., Short Report on the Impact of Judo on Behaviors and Social Skills of Children With Autism Spectrum Disorder. https://doi.org/10.7759/cureus.41516

Wrong comparator

A. Polevaia-Secareanu et al., Cognitive and Autonomic Properties of Healthy Judokas and Judokas with Autism. https://doi.org/10.13189/saj.2025.130123

P. Drid et al., The differences in motor and cognitive abilities between the more and less successful 12-14 years old judokas. https://archbudo.com/view/abstract/id/10640

J. Sanchez-Lopez et al., Differences in visuo-motor control in skilled vs. novice martial arts athletes during sustained and transient attention tasks: A motor-related cortical potential study. https://doi.org/10.1371/journal.pone.0091112

G. Giordano et al., Sports, executive functions and academic performance: a comparison between martial arts, team sports, and sedentary children. https://doi.org/10.3390/ijerph182211745

Appendix 3: Sports practice and outcomes reported by each study.

Study	Sport	Cognitive performance instruments		
		Rs-fMRI	SRTT	Quest
Li et al., 2021	Judo + wrestling	✓	-	-
Lo et al., 2019	Judo	-	✓	-
Iadreev et al., 2015	Judo	-	-	✓
Grosu et al., 2015	Judo	-	-	✓
Rutkowska & Gierczuk, 2012	Wrestling	-	-	✓
Fleisher et al., 1995	Judo	-	-	✓
Davis & Byrd, 1975	Judo	-	-	✓
Ludyga et al., 2021	Judo	-	✓	-
Ludyga et al., 2022	Judo	-	✓	-
Ludyga et al., 2023	Judo	-	✓	-

Note: Rs-fMRI: resting-state functional MRI; SRTT: serial reaction time task and task variants; Quest: Questionnaires.