MARTIAL ARTS STUDIES

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SCOPING REVIEW OF MARTIAL ARTS INTERVENTION STUDIES FOR ATTENTION-DEFICIT/HYPERACTIVITY DISORDER AND DEVELOPMENTAL COORDINATION DISORDER

ABSTRACT

This study is a scoping review that comprehensively organizes martial arts intervention studies targeting Attention-Deficit/Hyperactivity Disorder (ADHD) and Developmental Coordination Disorder (DCD). Analysis of 17 papers revealed that multiple studies reported improvements in cognitive and socioemotional functioning for ADHD, and in physical fitness components centered on balance for DCD. However, results were inconsistent, and challenges remain regarding the number and quality of studies. Martial arts show potential benefits for physical and psychosocial development, but large-scale, high-quality follow-up studies are still needed.

CONTRIBUTORS

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KEYWORDS

ADHD; DCD; intervention; martial arts; scoping review

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Scoping Review of Martial Arts Intervention Studies for Attention-Deficit/Hyperactivity Disorder and Developmental Coordination Disorder

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INTRODUCTION

Trends in children with neurodevelopmental disorders

As reported in multiple studies, the prevalence of neurodevelopmental disorders is increasing internationally (Danielson et al., 2024; Rah et al., 2020; Russell et al., 2014; Zablotsky et al., 2019; 2023). For example, according to the National Health Interview Survey (NHIS) from 2009 to 2017, the prevalence of neurodevelopmental disorders in U.S. children has increased by 9.5% (Durkin, 2019). In particular, the prevalence of Autism Spectrum Disorder (ASD) in the United States has increased significantly, from 1 in 59 to 1 in 36 (Maenner et al., 2020; 2023). The prevalence of other neurodevelopmental disorders in U.S. children is reported to be highest for Attention-Deficit/Hyperactivity Disorder (ADHD) at 8.5%, followed by Learning Disability (LD) at 6.4% and Intellectual Disability (ID) at 1.4% (Yang et al., 2022).

However, as Francés et al. (2022) demonstrated, the increase may largely reflect improved diagnostics, greater awareness, and broader acceptance of neurodevelopmental disorders.

Symptoms and prevalence of ADHD

ADHD is characterized by inattention, hyperactivity, and impulsivity, and can be a disadvantage in education and employment. The prevalence of ADHD is influenced by age, sex, region, and socioeconomic status, but appears to average about 5% and range from 2-7% (DSM-5). According to a recent national survey in the United States, reports indicate that 11.4% of children aged 3 to 17 have been diagnosed with ADHD (Danielson et al., 2024).

ADHD may also be associated with several comorbidities, including anxiety/mood disorders, learning disabilities, and motor dysfunctions. These complicate the clinical picture of ADHD and exacerbate the primary symptoms. In particular, motor dysfunctions affect 30-50% of children with ADHD and are a serious concern that can severely impact daily life and academic performance (Demers et al., 2013).

Symptoms and prevalence of DCD

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder whose main symptom is a motor dysfunction. The prevalence of DCD varies by country and age, but is thought to average about 5-6% (DSM-5). Symptoms of DCD include clumsiness in gross motor activities (e.g., riding a bicycle) and fine motor activities (e.g., tying a shoelace), and the resulting motor skills deficits and delays in achieving motor developmental milestones. These symptoms begin in early childhood and persist into adulthood in 30-70% of cases (Biotteau et al., 2019). In addition, as with ADHD, there is a risk of secondary psychological symptoms such as anxiety and depression occurring in DCD (Meachon et al., 2022).

Comorbidity of ADHD and DCD

In Scandinavian countries, ADHD and DCD comorbid symptoms are called attention, motor control, and perception disorders (DAMP) (Cairney, 2014). The prevalence of DAMP in school-aged children is estimated to be about 5% (especially, 1.5% of the cases were clinically serious) and is diagnosed more often in boys than girls (Gillberg, 2003). The impact of this disorder on daily and leisure activities is significant, and children with DAMP often avoid team sports and other activities that require motor control. In addition, follow-up studies have reported that children with DAMP have a higher incidence of mental disorders and drug abuse, from adolescence through adulthood. The above points to the importance of early detection and early intervention when ADHD, DCD, or both are suspected to co-occur.

Furthermore, ADHD and DCD frequently co-occur with a wide range of other conditions, including ASD, LD, anxiety disorders, and depression (Bonti et al., 2024). However, most existing intervention studies have not adequately controlled for the potential effects of these comorbid conditions and medications (Lalonde et al., 2025). To more accurately identify the effects of martial arts and other exercise interventions on neurodevelopmental disorders, a broader range of comorbid conditions should be systematically evaluated and controlled.

Treatment interventions for ADHD

Currently, ADHD is treated using both pharmacological and non-pharmacological therapies (Catalá-López et al., 2017). Methylphenidate is mainly used in pharmacological therapy, and its effectiveness against the core symptoms of ADHD has been established (Mechler et al., 2022). However, there is a risk that pharmacological therapy may exacerbate motor dysfunction, pointing to the need for careful monitoring (Stämpfli et al., 2021). On the other hand, non-pharmacological therapies such as behavioral therapy, environmental adjustment, and exercise therapy are being used. In particular, various interventions are being used in exercise therapy (Xie et al., 2021; Zang, 2019), including aerobic exercise (Yang et al., 2024), exergames (Ji et al., 2023), neuromotor feedback (Enriquez-Geppert et al., 2019), perceptual training (Kouhbanani & Rothenberger, 2021), swimming and aquatic exercise (Chang et al., 2014), and martial arts. These interventions have been reported to be effective not only for motor function but also for cognitive and socio-emotional function. Therefore, exercise therapy is attracting attention because it has comprehensive effects despite having no side effects.

Treatment interventions for DCD

The main treatment for DCD is non-pharmacological therapy, and evidence is accumulating for treatments using the Cognitive Oriented to daily Occupational Performance (CO-OP) approach, behavioral observation and motor imagery (AOMI), and neurofeedback approaches (Ilana et al., 2017; Smits-Engelsman et al., 2018). Because the core symptom of DCD is a motor

dysfunction, interventions involving some types of exercise are common. In these exercise-based interventions, it is hoped that not only exercise skills can be acquired, but also that quality of life will improve and participation in sports activities will be promoted.

Exercise interventions for other neurodevelopmental disorders

More exercise intervention studies have been conducted in ASD than in other neurodevelopmental disorders, using aerobic exercise, swimming, and martial arts (Healy et al., 2018; Monteiro et al., 2022). For example, several reviews of swimming and water exercise intervention studies for ASD and ADHD have shown benefits not only in physical aspects such as muscle strength and swimming ability, but also in socioemotional aspects (Aleksandrovic et al., 2015; Hosokawa et al., 2024a). Several reviews of martial arts interventions studies for ASD have also shown moderate to strong effects on core symptoms (Hosokawa et al., 2024b; Zou et al., 2017). However, to our knowledge, no study has comprehensively reviewed martial arts intervention studies for ADHD and DCD. Therefore, it is important to conduct a comprehensive survey of ongoing unorganized exercise intervention studies in order to develop more effective treatments and to expand treatment options.

Purpose and research questions in this study

Therefore, this study was conducted as a scoping review to identify the outcomes and issues in martial arts intervention studies for ADHD and DCD.

The main research questions in this study are as follows: (i) When, where, and what interventions were made? (e.g., events, time, frequency, and duration of the intervention). (ii) What research gaps currently exist? (e.g., availability of neurological assessment to elucidate the effect mechanism of martial arts intervention, diversity of outcomes affecting core symptoms of ADHD and DCD). (iii) Is there sufficient quality and quantity of evidence to ensure the validity of the meta-analysis? (e.g., number of articles included in the analysis, study quality assessment score, etc.).

METHODS

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) to collect, select and evaluate articles (Tricco et al., 2018).

Collection of articles

The search included English-language articles on martial arts intervention studies for ADHD and DCD. The search engines used were PubMed, Science Direct, and EBSCO essentials, and the operators were: *("ADHD" OR "attention deficit hyperactivity disorder" OR "DCD" OR "developmental coordination movement disorder") AND "martial arts"*. Then, in order to avoid omissions, a citation search from the literature and an additional search using Google Scholar were conducted.

Additional searches were performed using the following search terms: "Judo", "Jiu-jitsu", "Karate", "Kata", "Tai Chi*", "Taiji Quan", "Taekwon*", "Taekwondo", "Aiki*", "Kendo", "Naginata", "Shorinji", "Shaolin", "Kung fu", "Sumo", "Japanese wrestling", "Kyudo", "Japanese archery", "Iai", "Mixed Martial Arts", "MMA"

The articles were retrieved on February 1, 2024, and the collected articles were managed in the Mendeley Reference Manager.

Selection of articles

In order to comprehensively discuss martial arts intervention studies for ADHD or DCD, the following three eligibility criteria were used in this study: (1) the study must be conducted with ADHD or DCD, (2) the study must involve a martial arts-related intervention, and (3) the study must show at least one quantitative outcome regarding improvement of core symptoms of ADHD or DCD and physical, cognitive and socio-emotional functioning. In this study, in order to improve the accuracy of the screening process, two authors screened the titles, abstracts, and main text using the above criteria.

Study quality assessment

In this study, the PEDro scale, consisting of 11 items, was applied to assess study quality only in articles employing Randomized Controlled Trial (RCT) (Maher et al., 2003). The first item addresses external validity (eligibility criteria) and is not included in the total score. The remaining ten items cover key aspects of internal validity and statistical reporting. Two researchers independently read the articles and evaluated them according to a checklist. The study quality is classified on four levels: excellent (9-10 points), good (6-8 points), fair (4-5 points) and poor (less than 4 points).

Integration of studies

For selected articles, the following items were extracted and summarized: study areas and publication date, sample size and participant profile (age, sex and comorbidity), study design and quality, protocol and effectiveness of intervention. In the included studies, both sex and gender were used to describe participants. However, as most studies reported categories such as male/female or boy/girl these were interpreted as referring to biological sex. Therefore, for consistency, this review uniformly reports participant characteristics as sex.

RESULTS AND DISCUSSION

Collection and article selection

A total of 176 articles (ADHD=152, DCD=24) were included in the database search results. In addition, 11 articles (ADHD=9, DCD=2) were added by additional search and citation search. Of the above articles, a total of 150 articles were removed; 10 were removed due

to duplication (ADHD=6, DCD=4) and 140 were removed due to screening by title, abstract, and full text (ADHD=123, DCD=17). Therefore, 37 articles (ADHD=32, DCD=5) were screened by the eligibility criteria and 20 (ADHD=20, DCD=0) were removed. Thus, finally 17 articles (ADHD=12, DCD=5) were included in the study analysis (Figure 1). The query *("DAMP" OR "deficits in attention, motor control, and perception") AND ("martial arts")* was also searched, but no papers were accepted.

As this study was conducted as a scoping review, we did not exclude studies that may have involved overlapping participant samples (e.g., multiple publications by Kadri and Kadri et al., or by Fong et al.). While this approach is consistent with the exploratory and comprehensive purpose of a scoping review, it also means that the duplication of participants cannot be ruled out. Such duplication does not invalidate the present synthesis, but it does represent an important consideration for subsequent meta-analyses or other secondary analyses, in which overlapping samples could influence estimates of variance and effect size.

The next and subsequent sections describe the characteristics of the reviewed articles. A summary of each article is shown in Table 1 and 2.

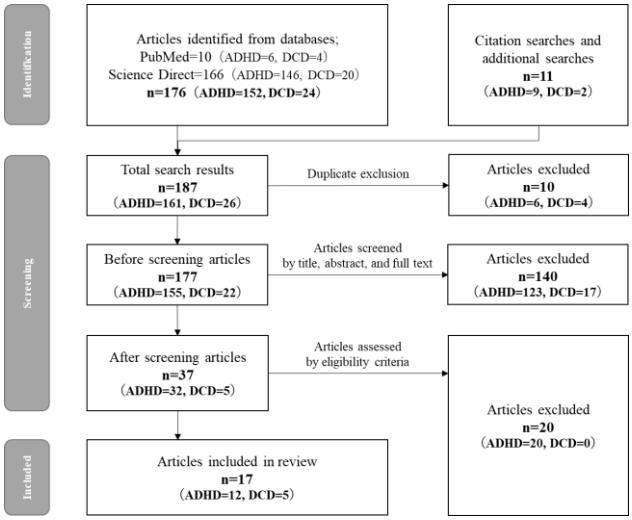

Figure 1: PRISMA-ScR flow chart of the inclusion process.

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Table 1. List of martial arts intervention studies for ADHD.

Authors & Year Country *Study design* *(Study quality)*	**Group** N (males) - Exclusions (%) *Age*	**Intervention style** Time, Frequency, Duration *Adherence rate, Follow-up assessment*	**Outcome measured** Sub scales	**Category**
Clark et al. (2020) Baltimore, USA *Pre-Post*	**MIG** 34(28) – 5(14.7) *10.2±1.3*	**Mindful Movement Treatment (Based on Tai Chi)** 60 minutes *2 times per week *8 weeks *NA, No follow-up*	**Physical and Neurological Examination for Subtle Signs (PANESS)** - gaits-stations, total timed, total overflow, total score **Conners 3** - inattentive type, hyperactive/impulsive type, executive function, ODD, emotional lability **Clinical Global Impression- Severity (CGI-S)** **Developmental Neuropsychological Assessment (NEPSY)**	**Phy** **Cog**
Convers et al. (2020) Wisconsin, USA *RCT* *Feasibility Trial* *(6pt, good)*	**MIG** 9(4) – 0(0.0) *18-23* **COG (active)** 5(1) – 1(20.0) *18-23*	**Tai Chi training program** 60 minutes *2 times per week *7 weeks *NA, No follow-up*	**Postural stability** **Conners' Adult ADHD Rating Scales - Self report: Long version (CAARS-S:L)** - DSM IV inattentive, DSM IV hyperactive/ impulsive **Cognitive function tests**	**Phy** **Cog**

	COG (inactive) 7(2) – 1(14.3) *18-23*		- flanker test, dimensional change card sort test **Graduate Record Exam (GRE)** **Five Facet Mindfulness Questionnaire (FFMQ)** **Pittsburgh Sleep Quality Index (PSQI)** **RAND 36-Item Short Form Health Survey 1.0. (SF-36)**	**Soc** **QoL**
Haydicky et al. (2012) Toronto, Canada *non-RCT* *Wait-list design*	**MIG** n=39(NA) – 11(28.2) <includes 14 people with ADHD and LD> *13.8±1.6* **CON** n=39(NA) – 7(18.0) <includes 14 people with ADHD and LD> *14.1±1.1*	**Integra Mindfulness Martial Arts** 90 minutes *1 time per week *20 weeks *NA, No follow-up*	**Behavior Rating Inventory of Executive Function (BRIEF)** - behavior regulation, monitor **Child Behavior Checklist (CBCL)** - externalizing, social problems, rule breaking, ADHD problems, oppositional defiant, conduct problems **Youth Self-Report (YSR)** - externalizing, social problems, ADHD problems, oppositional defiant, conduct problems	**Cog** **Soc**
Hernandez-Reif et al. (2001) Baltimore, USA *Pre-Post*	**MIG** 13(11) – NA *14.5±NA*	**Tai Chi training program** 30 minutes *2 times per week *5 weeks *NA, 2 weeks after intervention*	**Conners Teacher Rating Scale Revised (CTRS-R)** - anxiety, asocial behavior, conduct, dreaming, emotion, hyperactivity	**Soc**
Kadri et al. (2019) Tunisia *RCT* *(4pt, fair)*	**MIG** 20(18) – NA *14.5±3.5* **COG** 20(18) – NA *14.2±3.0*	**Taekwondo training program** 50 minutes *2 times per week *1.5 years *NA, No follow-up*	**Stroop Color-Word Test** - color block test, color-word interference test, word test, interference, error **Ruff 2 and 7 tests** - automatic detection trials, controlled search trials, total speed trials	**Cog**
Kadri (2021) Tunisia *RCT* *(3pt, poor)*	**MIG** 25(20) – NA *9.1±3.27* **COG** 25(20) – NA *9.5±3.57*	**Poomsae Movement Taekwondo Training Program (PMTTP)** 50 minutes *3 times per week *1.5 years *100%, No follow-up*	**Number of Digits (WAIS-IV)** - forward, reverse **Stroop trial (4 colors)** - reading, color denomination, interference, flexibility **Ruff 2 and 7 tests** - automatic detection trials, controlled search trials	**Cog**

Kadri & Azaiez (2021a) Tunisia *RCT* *(3pt, poor)*	**MIG** 20(18) – NA *14.5±3.5* **COG** 20(18) – NA *14.2±3.0*	**Taekwondo training program** 50 minutes *2 times per week *1.5 years *NA, No follow-up*	**Cooper Smith's self-esteem** - general self-esteem, social self-esteem, familial self-esteem, familial self-esteem, school self esteem	**Soc**
Kadri & Azaiez (2021b) Tunisia *RCT* *(5pt, fair)*	**MIG** 20(18) – NA *14.5±3.5* **COG** 20(18) – NA *14.2±3.0*	**Taekwondo training program** 50 minutes *2 times per week *1.5 years *NA, No follow-up*	**Intensive Care Psychological Assessment Tool (IPAT) Anxiety Scale** - manifest anxiety, veiled anxiety	**Soc**
Ludyga et al. (2022) Switzerland, Germany *RCT* *Wait-list design* *(5pt, fair)*	**MIG** n=31(18) – 2(6.4) *10.0±1.2* **COG** n=32(23) – 4(12.5) *10.8±1.2*	**Judo training program** 60 minutes *2 times per week *12 weeks *81.9±10.9, No follow-up*	**Movement Assessment Battery for Children, Second Edition (MABC-2) overall score** **Change Detection Task** - reaction time, K-score **Electroencephalography (EEG)** - CDA low load, CDA high load	**Phy** **Cog** **Neu**
Ludyga et al. (2023) Switzerland, Germany *RCT* *Wait-list design* *(8pt, good)*	**MIG** n=31(NA) – 1(3.2) *10.0±1.2* **CON** n=32(NA) – 5(15.6) *10.8±1.2*	**Judo training program** 60 minutes *2 times per week *12 weeks *82.1±11.6%, No follow-up*	**MABC-2 overall score** **Physical Work Capacity (PWC) 170** **Go/No Go task** - go reaction time, omission error rate, commission error rate **EEG** - N2 amplitude, P3a amplitude, P3b amplitude	**Phy** **Cog** **Neu**
Milligan et al. (2019) Toronto, Canada *non-RCT* *Wait-list design*	**MIG** n=48(41) – 8(16.7) <includes 41 people with ADHD and LD> *13.1±1.7* **CON** n=38(31) – 8(21.1) <includes 22 people with ADHD and LD>	**Integra Mindfulness Martial Arts** 90 minutes *1 time per week *20 weeks *90% or more, 3 months after intervention*	**Flanker Task** - congruent, incongruent **Selective Auditory Attention Task (SAAT)** **Conners 3-Parent-Inattention Subscale** **Habitual Activity Estimation Scale (HAES)** **EEG** - P3 amplitude, P3 latency	**Cog** **Soc** **Neu**

	12.8±1.2			
Rodrigues et al. (2019) Porto, Portugal *Pre-Post*	**MIG** 4(3) – NA *6-10 years old*	**TaijiQuan (TJQ) and Qi Gong (QG) practice** 20 minutes *1 time per week *30 weeks *NA, No follow-up*	**Achenbach Teacher's Report Form (TRF)** **Structured interview to the children on satisfaction**	**Soc**

Abbreviations: MIG = Martial Arts Intervention Group, COG = Control Group, Phy = Physical functions, Cog = Cognitive functions, Soc = Socio-emotional functions, Neu = Neurological functions, QoL = Quality of life

Table 2. List of martial arts intervention studies for DCD.

Authors & Year Country *Study design* *(Study quality)*	**Group** N (males) - Exclusions (%) *Age*	**Intervention style** Time, Frequency, Duration *Adherence rate, Follow-up assessment*	**Outcome measured** Sub scales	**Category**
Fong et al. (2012) Hong Kong, China *RCT* *(6pt, good)*	**MIG** 21(17) – 5(23.8) *7.7±1.3* **COG (DCD)** 23(18) – 10(43.5) *7.4±1.2* **COG (TD)** 18(14) – 8(44.4) *7.2±1.0*	**Taekwondo training program** 60 minutes *1 time per week * 12 weeks at university 60 minutes *6 times per week * 12 weeks at home *at university=90.9%, at home=95.2%,* *No follow-up*	**Sensory Organization Test (SOT)** - somatosensory ratio, visual ratio*, vestibular ratio*, composite score* **Unilateral Stance Test (UST)** - COP sway velocity	**Phy**
Fong et al. (2013) Hong Kong, China *RCT* *(6pt, good)*	**MIG** 21(17) – 5(23.8) *7.7±1.3* **COG (DCD)** 23(18) – 10(43.5) *7.4±1.2* **COG (TD)** 18(14) – 8(44.4) *7.2±1.0*	**Taekwondo training program** 60 minutes *1 time per week * 12 weeks at university 60 minutes *6 times per week * 12 weeks at home *at university=90.9%, at home=95.2%,* *No follow-up*	**Knee extensor and flexor muscle strength with an isokinetic machine** - low, moderate and high movement velocities **Unilateral Stance Test (UST) with a computerized dynamic posturography (CDP) machine (Static balance control)** - COP sway velocity **Motor Control Test (MCT) with a computerized dynamic posturography (CDP) machine (Reactive balance control)**	**Phy**

Fong et al. (2022) Hong Kong, China *RCT* *(6pt, good)*	**MIG (TC-MPT)** 30(25) – 8(26.7) *9.5±1.1* **MIG (TC)** 30(26) – 8(26.7) *9.9±1.2* **MIG (MPT)** 30(25) – 7(23.3) *9.8±1.0* **COG** 31(25) – 10(32.3) *9.7±1.0*	**Tai chi (TC) muscle power training (MPT) program** 90 minutes *1 time per week * 12 weeks at university 90 minutes *2 times per week * 12 weeks at home *TC-MPT=60 %, TC=61%, MPT=83%,* *No follow-up*	**Limits of stability test with a BioSway™** - limits of stability (LOS) completion time, dynamic limits of stability (DLOS) score **MABC-2** - total score, total percentile rank **Knee extensor and flexor muscle strength with Lafayette Manual Muscle Test System** - peak force, time to peak force **Number of falls** - in past 3 months, in past 12 months	**Phy**
Ghadiri et al. (2022) Tehran, Iran *non-RCT*	**high-SES group** 9(0) – 1(11.1) *12.5±0.5* low-SES group 8(0) – 0(0.0) *12.4±0.5*	**Karate training program** 75 minutes *3 times per week *8 weeks *NA, No follow-up*	**SES questionnaire** **Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOTMP-SF2)** - fine motor precision*, fine motor integration*, manual dexterity*, upper limb coordination*, bilateral coordination*, balance*, strength*, speed*, agility*	**Phy**
Ma et al. (2018) Hong Kong, China *RCT* *(6pt, good)*	**MIG** 51(45) – 15(29.4) *7.4±1.2* **COG** 94(76) – 25(26.6) *7.5±1.2*	**Taekwondo training program** 60 minutes *1 time per week * 12 weeks at university 60 minutes *7 times per week * 12 weeks at home *75%, 3 months after intervention*	**Delay in skeletal development*** **Movement Assessment Battery for Children (MABC)** **Eye–Hand Coordination (EHC) scores with a force-sensing resistor** - Accuracy, reaction time, movement time* **modified Clinical Test of Sensory Integration of Balance (mCTSIB)**	**Phy**

Abbreviations: MIG=Martial Arts Intervention Group, COG=Control Group, TD=Typical Development, SES= Socio-economic Status, Phy = Physical functions.

Study areas and publication date

Countries and areas

Intervention studies for ADHD were conducted in North America (five studies, 41.7%: three in the United States and two in Canada), in Africa (four studies, 33.3%, all in Tunisia), and in Europe (three studies, 25.0%: two in Germany and Switzerland, and one in Portugal). In contrast, intervention studies for DCD were conducted exclusively in Asia (five studies, 100.0%: four in China and one in Iran). Overall, the analyzed intervention studies were conducted in North America (five studies, 29.4%), Asia (five studies, 29.4%), Africa (four studies, 23.5%), and Europe (three studies, 17.6%).

The study areas are globally distributed, but areas are unevenly distributed by type of disability and intervention. One reason for this may have to do with the origins, history, and population of the martial arts. A second reason may be the limited medical resources and underdeveloped educational systems in these

regions, which hinders conducting intervention studies. In certain areas of the Republic of South Africa, the comorbidity of ADHD and DCD is as high as 74% (Dawson et al., 2020), and future intervention programs will need to be developed and implemented while taking into account social and cultural factors in these research gaps.

Publication Dates

Intervention studies for ADHD have been published in 10 (83.3%) articles since 2019. Also, intervention studies for DCD have been published in three (60.0%) articles since 2018. Overall, analyzed intervention studies were published after 2018 in 13 (76.5%) articles, between 2012-2013 in three (17.6%) articles, and in 2000 in one (5.9%) article.

Martial arts intervention studies for ASD have been published in 13 (59.1%) articles since 2019 (Hosokawa et al., 2024b). In light of this fact, it can be seen that martial arts intervention studies for neurodevelopmental disorders have increased rapidly in recent years. But the number of studies actually conducted is more limited because it includes cases such as Kadri et al. (2019), Kadri and Azaiez (2021a, 2021b) and Fong et al. (2012, 2013), in which studies with the same participants are published separately. Therefore, the number of studies may not be sufficient to integrate intervention effects through meta-analysis.

Sample size and participant profile

Sample size

The sample sizes in the ADHD intervention studies ranged from 4 to 86 participants, with a mean of 44.3 ± 25.1; in the DCD intervention studies, samples ranged from 17 to 145 participants, with a mean of 81.4 ± 51.3. Exclusion rates, including dropouts, in the ADHD intervention studies ranged from 9.5 to 23.1% participants, with a mean of 14.2 ± 5.7%; in the DCD intervention studies, exclusion rates ranged from 5.9 to 37.1% participants, with a mean of 27.0 ± 12.8%.

On average, sample sizes were larger than that of the martial arts intervention studies for ASD (Hosokawa et al., 2024b). Many of the articles reviewed recruited participants in cooperation with medical and health institutions, which may be helpful when conducting other intervention studies.

Age and sex

The age of participants in the ADHD intervention studies ranged from 6-23 years, with a mean of 12.5 ± 2.1%; in the DCD intervention studies, ages ranged from 6-13 years, with a mean of 8.8 ± 1.9%. The sex ratios in the ADHD intervention study ranged 33.3-90.0% for males and 10.0-67.7% for females, with a mean of 77.4 ± 17.3% for males and 22.6 ± 17.3% for females; in the DCD intervention studies the ratio ranged 79.0-83.4% for males and 16.6-21.0% for females, with a mean of 81.2 ± 2.6% for males and 18.8 ± 2.5% for females.

Most of the articles reviewed were focused on the school-age and adolescent period. This is probably related to the fact that the symptoms of ADHD and DCD are usually detected by the school-age period, and that early intervention is important (Missiuna et al., 2008; Pastor et al., 2015). Given that the symptoms of movement disorders have a high probability of persisting into adulthood (Biotteau et al., 2019), it is desirable to conduct intervention studies focusing on adulthood and beyond.

Comorbidity

Regarding comorbidities, intervention studies for ADHD have reported oppositional defiant disorder (ODD) and conduct disorder (CD) (Clark et al., 2020; Rodrigues et al., 2019) and Learning Disabilities (LD) (Haydicky et al., 2012; Milligan et al., 2019); and intervention studies for DCD have reported ADHD, dyslexia, and ASD (Fong et al., 2012, 2013, 2022; Ma et al., 2018).

ADHD and DCD are known to be comorbid in 50-75% of cases (Montes-Montes et al., 2021; Pranjić et al., 2023). However, only Fong et al. (2012, 2013) and Ma et al. (2018) clearly stated the comorbidity of ADHD and DCD in the articles reviewed. In addition, only Ludyga et al. (2022; 2023) measured the participants' motor skills using the M-ABC2, a screening test for DCD. For this reason, the DCD symptoms comorbid with ADHD may have been overlooked in many studies. Considering the secondary impact of motor disorders, it is important to confirm the symptoms of DCD in participants, especially in exercise intervention studies.

Study design and quality

Study design

In the intervention studies for ADHD, the study designs were seven RCT (58.3%), three pre-post designs without a control group (25.0%), and two non-RCT with a control group (16.7%); in the intervention studies for DCD were four RCT (80.0%), one pre-post design without a control group (25.0%). The wait-list design was employed in four (33.3%) intervention studies for ADHD. Follow-up assessments after the intervention period were conducted in two (16.7%) intervention studies for ADHD and one (20.0%) intervention study for DCD.

Compared to martial arts intervention studies for ASD (Hosokawa et al., 2024b), many of the studies had larger sample sizes and control groups. Many studies also employed a wait-list design for ethical considerations. Most of the articles reviewed are recent, and the study design may have been refined with reference to other interventions. However, on the PEDro scale, most studies were rated as moderate (fair to good) and none were rated as excellent. Therefore, there is still room for improvement in study design.

Table 3. Analysis of study quality using the PEDro scale.

ADHD	②*3	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	Score	Quality
Convers et al. (2020)	0	1	1	1	0	0	1	0	1	1	6	good
Kadri et al. (2019) *1	1	0	1	0	0	0	0	0	1	1	4	fair
Kadri (2021)	0	0	1	0	0	0	0	0	1	1	3	poor
Kadri & Azaiez (2021a) *1	Not assessed											
Kadri & Azaiez (2021b) *1												
Ludyga et al. (2022)	1	1	1	1	0	0	1	0	1	1	7	good
Ludyga et al. (2023)	1	1	1	1	0	0	1	0	1	1	7	good
DCD	**②**	**③**	**④**	**⑤**	**⑥**	**⑦**	**⑧**	**⑨**	**⑩**	**⑪**	**Score**	**Quality**
Fong et al. (2012)	1	1	1*2	1	0	0	0	1	1	1	6	good
Fong et al. (2013)	1	1	1*2	1	0	0	0	1	1	1	6	good
Fong et al. (2022)	1	0	1	0	0	0	0	1	1	1	5	fair
Ma et al. (2018)	1	0	1	1	0	0	0	0	1	1	5	fair

＊1：Caution should be exercised because these studies may be a series of studies with the same subjects.
＊2：The lottery randomization used in this study has recently been associated with the risk of arbitrariness.
＊3：Evaluation criteria for each item; ② random allocation, ③ concealed allocation, ④ baseline comparability, ⑤. blinding of participants, ⑥ blinding of therapists, ⑦ blinding of assessors, ⑧ adequate follow-up, ⑨ intention-to-treat analysis, ⑩ between-group statistical comparisons, ⑪ reporting of point estimates and variability.

Study quality

The mean score for the study quality evaluation on the PEDro scale (Maher et al., 2003) in the intervention studies for ADHD was 5.4 ± 1.8, with four articles assessed as medium quality (Good~Fair) and one article assessed as low quality (Poor); in the DCD intervention studies, the mean score for the study quality evaluation was 5.5 ± 0.6, with four articles assessed as medium quality (Good~Fair). As shown in table 3, on the PEDro scale, most studies were rated as moderate (fair to good) and none were rated as excellent.

In particular, few studies met the three conditions for blinding (item 5: Blind assessors; item 6: Blind subjects; item 7: Blind therapists). Blinding may be difficult to fully implement in exercise intervention studies, but there is still room for improvement in study design.

Protocol and effectiveness of intervention

Type of intervention

Four types of martial arts were used in the ADHD intervention studies: four (33.3%) employed taekwondo, another four (33.3%) tai chi, two (16.7%) used mindfulness martial arts, and two (16.7%) employed judo; three types of martial arts were used in the DCD intervention study: three (60.0%) employed taekwondo, one (20.0%) used Tai Chi, and another one (20.0%) karate.

The types of interventions applied in the articles reviewed overlapped with those used in martial arts interventions for ASD (Hosokawa et al., 2024b). However, while karate was often used in interventions for ASD (Bahrami et al., 2012; 2016), taekwondo was often used in interventions for ADHD and DCD. On the other hand, traditional Chinese martial arts, including Tai Chi, were often used in interventions for both ASD and ADHD (Sarabzadeh et al., 2019; Tabeshian et al., 2022). The slow motion of Tai Chi may be beneficial for normalizing the attention deficit (hyperfocus or inattention) of ASD and ADHD.

Time, frequency and duration of intervention

The time, frequency and duration of interventions in the ADHD intervention studies ranged from 20–90 minutes, 1–2 times per week, for 5–78 weeks; and in the DCD intervention studies from 60–90 minutes, 1–7 times per week, for 8–12 weeks.

Systematic reviews have shown that exercise interventions can improve core symptoms of ADHD when conducted for 30–60 minutes, 1–2 times per week, over a period of 9–12 weeks (Vysniauske et al., 2020). Similarly, evidence suggests that at least 10–12 weeks of exercise interventions are required to achieve improvements in core symptoms of DCD (Ilana et al., 2017; Zaragas et al., 2023). Therefore, although most of the reviewed studies met these criteria, it should be noted that longer-term interventions are considered necessary to adequately evaluate the

effectiveness and safety of martial arts and to elucidate their underlying mechanisms (Lee et al., 2025).

On the other hand, only three studies (ADHD=2, DCD=1) conducted follow-up assessments. Follow-up assessments are important for determining the long-term and delayed effects of exercise intervention. Consequently, it is desirable to ensure a sufficient intervention period and to conduct follow-up assessments as much as possible (Dastamooz et al., 2023).

In addition, only two studies appropriately managed the exercise intensity during the intervention (Ludyga et al., 2022; 2023). Excessively high exercise intensity may increase the risk of side effects and dropouts (Schmitz et al., 2017). Thus, it is desirable to manage exercise intensity in interventions using the Report of Perceived Exertion (RPE) and heart rate monitors. In fact, exercise intervention studies targeting DCD employ Borg's RPE, which ranges from 6 (no exertion at all) to 20 (maximal exertion), to monitor exercise intensity and ensure participant safety (Bonney et al., 2018).

Effectiveness of interventions

Effectiveness of interventions for ADHD

All intervention studies for ADHD measured and assessed core symptoms. In addition, the measurement and assessment of core symptoms was broadly divided into three categories: comprehensive assessment of ADHD symptoms, assessment focusing on cognitive functions such as attention and executive functions, and assessment focusing on socio-emotional functions such as behavioral problems and anxiety.

Comprehensive assessments of ADHD symptoms primarily used Conners revised and derived versions, and most studies showed significant improvements in inattention, hyperactivity, and impulsivity (Clark et al., 2020; Hernandez-Reif et al., 2001; Milligan et al., 2019). Assessments focused on cognitive functions used the Flanker Test, Card Sorting Test, Stroop Test, and go/no go tasks, and showed significant improvements in executive functions such as attentional control, working memory, and cognitive flexibility (Kadri et al., 2019; Kadri, 2021; Ludyga et al., 2022; 2023). However, some studies showed no improvement (Converse et al., 2020; Haydicky et al., 2012). Assessments focused on socio-emotional function used the Child Behavior Checklist (CBCL) as well as the Cooper Smith's self-esteem and Intensive Care Psychological Assessment Tool (IPAT) Anxiety Scale, and showed significant improvements in behavioral aspects such as rule breaking and conduction problems (Haydicky et al., 2012), and in emotional aspects such as self-esteem and anxiety (Kadri & Azaiez, 2021a; 2021b). Physical functions, including motor control, skills, and fitness, were measured as a secondary outcome, but only some showed significant improvement (Clark et al., 2020; Ludyga et al., 2022; 2023). A few studies used Electroencephalography (EEG) as a neurological test which evidenced significant changes in specific conditions (Ludyga et al., 2022; 2023; Milligan et al., 2019). Assessment with EEG and fMRI is important to explore the neurological mechanisms of intervention effects and is expected to be actively used in the future.

Effectiveness of interventions for DCD

All intervention studies for DCD also measured and assessed core symptoms related to physical functions such as musculoskeletal development, balance, and motor skills. The results for balance were mixed, with tests in static conditions such as UST showing significant improvement (Fong et al., 2012, 2013), but tests in dynamic conditions such as MCT and LOS showing no significant improvement(Fong et al., 2013; 2022; Ma et al., 2018). Similarly, results for muscle strength were mixed, with significant improvement under specific conditions using the dynamometer (Fong et al., 2013; 2022). On the other hand, results for skeletal development displayed significant improvement using the ultrasonography (Ma et al., 2018). The results for gross motor skills were mixed, while fine motor skills showed significant improvement under specific conditions (Ghadiri et al., 2022; Ma et al., 2018). Considering the possibility of comorbidities such as ADHD and the influence of physical function on secondary disorders such as anxiety, it is necessary to assess the intervention effects more multidimensionally. No neurological tests were performed in the intervention studies for DCD. More studies using EEG and other methods are required to clarify the neurological mechanisms of intervention effects.

Study limitations and outlook

This scoping review was exploratory in nature, and as such it is subject to several important limitations that should be acknowledged. These limitations not only concern the interpretation of the present findings but also highlight directions for future research on martial arts interventions for neurodevelopmental disorders.

First, in recent years, studies on martial arts interventions for ADHD and DCD have been increasing. However, rigorous and high-quality research designs remain lacking. As a result, a meta-analysis could not be conducted in the present study, and the integrated effects of martial arts interventions could not be calculated sufficiently. For the advancement of this field, it will be essential not only to increase the number of intervention studies but also to improve their methodological quality.

Second, in this review, the effects of martial arts interventions were broadly categorized into three domains – physical, cognitive, and socio-emotional functioning – based on prior research. In other fields, however, psychological outcomes are often assessed using frameworks that distinguish between cognitive, affective, and behavioral dimensions. Employing such more detailed frameworks for evaluating intervention effects may enhance the interdisciplinary relevance of martial arts studies and improve the comparability of findings across diverse contexts.

Finally, the reviewed papers employed various martial arts intervention styles, all showing promising outcomes. However,

given the exploratory nature of this review, it remains unclear whether the reported benefits stem from elements unique to martial arts or from general effects of physical exercise. Furthermore, existing research often emphasizes the "style," which risks obscuring the activity characteristics that produce the observed outcomes. Therefore, future studies should focus on martial arts-specific elements (e.g., exercise intensity, repetition frequency, practice structure, movement characteristics) and, through comparison with other exercise forms, identify the activity features most relevant to therapeutic effects.

CONCLUSION

This study was conducted as a scoping review to identify the outcomes and issues in martial arts intervention studies for ADHD and DCD. As a result, the following findings were obtained.

1. Compared to other martial arts intervention studies for neurodevelopmental disorders (ASD), the number of intervention studies was small, but the study quality was relatively high. The types of martial arts used in the interventions were similar.
2. The time, frequency, and duration of the interventions were comparable to other exercise interventions for ADHD and DCD, but fewer studies conducted follow-up assessments.
3. Most of the ADHD studies showed significant improvement in the comprehensive assessment of core symptoms. On the other hand, results were mixed for individual assessment of cognitive and socio-emotional functioning.
4. DCD studies also showed mixed results on assessments of balance, musculoskeletal development, and motor skills.

Taken together, these findings suggest that martial arts interventions may offer promising benefits for children with ADHD and DCD, particularly in relation to core symptoms and motor functioning. At the same time, the heterogeneity of outcomes and the limited number of studies underscore the need for caution in interpreting the current evidence. There are still not enough studies to calculate a reliable effect size through meta-analysis. Future research should therefore focus on conducting larger-scale, high-quality trials with standardized outcome measures and long-term follow-ups.

Declaration of competing interests

The authors affirm that they had no competing interests relevant to the work underpinning this manuscript.

Declaration of artificial intelligence use

The authors affirm that no artificial intelligence applications were used in the preparation of this manuscript.

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