INPLASY

INPLASY202610036

doi: 10.37766/inplasy2026.1.0036

Received: 12 January 2026

Published: 12 January 2026

Corresponding author:
Ge Ling

2337304770@qq.com

Author Affiliation:
Capital University of Physical Education and Sports.

Comparative effects of different exercise modalities on executive function in children with attention-deficit/ hyperactivity disorder: a systematic review and network meta-analysis

Ling, G.

ADMINISTRATIVE INFORMATION

Support - No financial support or sponsorship has been received for this systematic review protocol. This review is being conducted as an independent academic research project without external funding.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - The authors declare no conflicts of interest, financial or non-financial, related to this systematic review. None of the authors have competing interests that might unduly influence judgments made in this review.

INPLASY registration number: INPLASY202610036

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 12 January 2026 and was last updated on 12 January 2026.

INTRODUCTION

Review question / Objective The aim of this systematic review and network meta-analysis is to compare the effectiveness of different exercise modalities on executive function outcomes in children and adolescents with attention-deficit/hyperactivity disorder to better inform evidence-based non-pharmacological interventions. To this end, the proposed systematic review will address the following research question: Which exercise modality is most effective for improving executive function domains including working memory, inhibitory control, and cognitive flexibility in children and adolescents with ADHD when compared to other exercise interventions and control conditions? Secondary questions include determining whether treatment effects vary by age group, exercise supervision level, intervention duration, or specific executive function domain measured.

Condition being studied Attention-deficit/ hyperactivity disorder affects approximately 5-7% of children worldwide and is characterized by persistent patterns of inattention, hyperactivity, and impulsivity that significantly impact academic, social, and behavioural functioning. Executive function deficits, including impaired working memory, inhibitory control, and cognitive flexibility, represent core neurocognitive features of ADHD that contribute substantially to functional impairment. While pharmacological interventions remain the primary evidence-based treatment, growing interest exists in non-pharmacological approaches, particularly exercise interventions, which show promise for improving both ADHD

symptoms and underlying executive function deficits.

Recent systematic reviews have demonstrated that exercise interventions can improve executive function in children with ADHD, with effect sizes ranging from moderate to large across different domains. However, existing reviews primarily focus on comparing exercise to control conditions rather than comparing different types of exercise interventions directly. This creates a critical gap in understanding which specific exercise modalities may be most beneficial for improving executive function outcomes. Current evidence includes studies of aerobic exercise, resistance training, coordinative activities, mind-body interventions such as yoga and tai chi, cognitively engaging exercises like table tennis, and high-intensity interval training approaches.

The heterogeneity in exercise interventions studied makes it challenging for clinicians, educators, and families to make informed decisions about which type of physical activity program would be most beneficial for a specific child with ADHD. Network meta-analysis provides a powerful analytical approach to address this question by combining direct and indirect evidence to estimate the relative effectiveness of multiple interventions simultaneously. This approach will enable ranking of different exercise modalities and provide robust evidence to guide clinical practice guidelines and school-based intervention programs. Furthermore, understanding whether treatment effects vary by participant characteristics such as age, baseline severity, or intervention characteristics such as supervision level and duration will provide crucial information for personalizing exercise interventions for children with ADHD. This systematic review addresses identified gaps in current clinical practice guidelines, which provide limited specific guidance on exercise interventions despite growing evidence of their efficacy.

METHODS

Participant or population The target population includes children and adolescents aged 6 to 18 years with a clinical diagnosis of attention-deficit/hyperactivity disorder established using standardized diagnostic criteria including DSM-IV, DSM-5, or ICD-10/11 criteria. Participants may represent any ADHD presentation including predominantly inattentive, predominantly hyperactive-impulsive, or combined presentation. Studies including participants with comorbid conditions such as learning disabilities, anxiety disorders, or oppositional defiant disorder will be eligible provided that ADHD represents the primary diagnosis.

Studies will be excluded if they include participants with intellectual disability, autism spectrum disorder, or other neurodevelopmental conditions as primary diagnoses, as executive function profiles and treatment responses may differ substantially in these populations. Studies including mixed populations of participants with and without ADHD will be included only if results are reported separately for the ADHD subgroup or if at least 80% of participants have confirmed ADHD diagnoses.

Participants may be receiving concurrent pharmacological treatment for ADHD provided that medication status is stable during the intervention period or is appropriately controlled in the study design. Studies will not be restricted based on setting, geographical location, or socioeconomic status to enhance generalizability of findings.

Intervention Exercise interventions of interest include structured physical activity programs designed to improve fitness, motor skills, or mind-body awareness that are delivered over multiple sessions with specified frequency, intensity, and duration parameters. Eligible intervention categories include aerobic exercise programs such as running, cycling, or swimming; resistance or strength training involving weights, resistance bands, or bodyweight exercises; coordinative training focusing on motor skill development, balance, and coordination; mind-body interventions including yoga, tai chi, qigong, or martial arts; cognitively engaging physical activities such as exergaming, table tennis, or dance; high-intensity interval training protocols; and multimodal programs combining different exercise types.

Interventions must be structured with clear protocols regarding frequency, duration, and intensity rather than general recommendations for increased physical activity. Single-session acute exercise studies will be excluded in favour of chronic training interventions delivered over multiple weeks to assess sustained effects on executive function. Interventions may be delivered in various settings including schools, clinical facilities, community centres, or home environments and may involve individual or group formats with varying levels of supervision.

Comparator Eligible comparators include other structured exercise interventions, attention control conditions, wait-list control groups, treatment as usual, or no intervention conditions. Studies comparing different exercise modalities head-to-head will be particularly valuable for network meta-analysis. Control conditions that provide attention and social interaction equivalent to exercise

interventions will be preferred over passive controls to minimize non-specific effects.
Studies using active control conditions such as sedentary activities, educational programs, or standard physical education classes will be included. Comparisons with pharmacological interventions alone will be excluded unless combined with behavioural or educational components, as the focus of this review is on non-pharmacological intervention approaches.

Study designs to be included This review will include randomized controlled trials and controlled clinical trials with concurrent control groups that evaluate exercise interventions in children and adolescents with ADHD. Randomized controlled trials will be prioritized as they provide the highest quality evidence for intervention effectiveness. Controlled clinical trials using quasi-randomization or systematic allocation methods will be included if they otherwise meet eligibility criteria and provide adequate control for selection bias.Crossover studies will be eligible provided that adequate washout periods are include.

Eligibility criteria Inclusion criteria: Studies will be included if they meet all of the following criteria: participants are children or adolescents aged 6-18 years with clinically diagnosed ADHD using standardized criteria; interventions involve structured exercise programs delivered over multiple sessions; study design is a randomized controlled trial or controlled clinical trial with concurrent controls; outcomes include validated measures of executive function domains; and studies provide sufficient statistical information to calculate effect sizes and standard errors.
Exclusion criteria: Studies will be excluded if participants include adults over 18 years of age; primary diagnoses include intellectual disability, autism spectrum disorder, or other neurodevelopmental conditions; interventions consist of single exercise sessions or unstructured physical activity recommendations; study designs are observational without concurrent control groups; outcomes focus solely on ADHD symptoms without executive function measurement; studies are published before 2010; studies are published in languages other than English; or insufficient statistical information is provided for meta-analysis inclusion.
Language restrictions will be imposed, with only studies published in English included in this review. Publication date restrictions will be applied, limiting inclusion to studies published from 2010 onwards to focus on contemporary exercise intervention approaches and executive function assessment methods. Studies will not be excluded based on geographical location, setting, or sample size provided they meet other eligibility criteria.

Information sources Electronic database searches will be conducted in MEDLINE via PubMed, Embase, Scopus, Web of Science Core Collection, SPORTDiscus, PsycINFO, and Cochrane Central Register of Controlled Trials from 2010 through 2025. These databases were selected to provide comprehensive coverage of medical, psychological, and exercise science literature relevant to the research question.
Additional sources will include grey literature databases such as ProQuest Dissertations and Theses Global, clinical trial registries including ClinicalTrials.gov and WHO International Clinical Trials Registry Platform, and conference proceedings from organizations such as the International Society for Physical Activity and Health, American College of Sports Medicine, and World Federation of ADHD. Reference lists of included studies and relevant systematic reviews will be manually searched to identify additional eligible studies through forward and backward citation tracking.
Subject matter experts in pediatric ADHD and exercise science will be contacted to identify unpublished or ongoing studies that may meet inclusion criteria. Authors of included studies may be contacted to request additional data or clarify methodological details as needed for the analysis.

Main outcome(s) The primary outcomes are executive function measures assessed using validated neuropsychological tests or standardized rating scales. Executive function domains of interest include working memory measured by tasks such as the Digit Span, Spatial Span, or n-back tasks; inhibitory control assessed using measures such as the Stroop Test, Go/No-Go tasks, or Stop Signal Task; and cognitive flexibility evaluated using tasks such as the Wisconsin Card Sorting Test, Trail Making Test, or Task Switching paradigms.
Both performance-based neuropsychological measures and behavioral rating scales such as the Behavior Rating Inventory of Executive Function will be included as primary outcomes. Timing of outcome assessment must occur immediately post-intervention or within four weeks of intervention completion to capture proximal effects of exercise training. Studies must provide sufficient statistical information including means, standard deviations, and sample sizes or effect sizes with confidence intervals to be included in quantitative synthesis.

Additional outcome(s) Secondary outcomes include ADHD symptom severity measured using standardized rating scales such as the ADHD Rating Scale, Conners' Rating Scales, or Vanderbilt Assessment Scales; academic performance indicators including standardized achievement test scores or teacher ratings of academic functioning; behavioral outcomes such as on-task behavior, classroom behavior ratings, or social skills assessments; physical fitness measures including cardiovascular fitness, strength, or motor skills; and longer-term follow-up assessments of executive function or ADHD symptoms conducted more than four weeks post-intervention.

Quality of life measures, parent and teacher satisfaction with interventions, and adverse events or safety outcomes will also be extracted when reported. These secondary outcomes will provide important context for interpreting executive function findings and understanding the broader impact of exercise interventions on functioning in children with ADHD.

Data management Study selection will be conducted independently by two reviewers using standardized eligibility criteria with disagreements resolved through discussion or consultation with a third reviewer when necessary. Screening will be conducted in two phases including initial title and abstract screening followed by full-text review of potentially eligible studies.

Data extraction will be performed independently by two reviewers using standardized forms developed specifically for this review and piloted on a sample of included studies. Extracted data will include study characteristics, participant demographics and clinical characteristics, intervention details, comparison conditions, outcome measures and assessment timing, and statistical results. Authors will be contacted to request missing data or clarify methodological details when necessary.

Data will be managed using EPPI-Reviewer software for systematic review management and Zotero for reference management. Statistical analyses will be conducted using R software with the netmeta package for network meta-analysis and validated using MetaInsight web-based software for sensitivity analyses. All data extraction forms and statistical analysis code will be made publicly available to enhance transparency and reproducibility.

Quality assessment / Risk of bias analysis Methodological quality of included studies will be assessed independently by two reviewers using the revised Cochrane Risk of Bias tool for randomized trials (RoB 2) with domain-specific considerations for exercise intervention studies. Assessment domains include bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of outcomes, and bias in selection of reported results.

Particular attention will be paid to challenges inherent in exercise intervention research including difficulty blinding participants and intervention providers, potential for performance bias related to expectation effects, and selective outcome reporting especially given the multiple executive function measures commonly used in this population. Assessment of outcome measurement bias will consider whether assessors were blinded to group allocation and whether objective versus subjective outcome measures were used.

Overall quality of evidence for network meta-analysis will be evaluated using the GRADE approach adapted for network meta-analysis, considering study limitations, inconsistency, indirectness, imprecision, and publication bias. Confidence in network meta-analysis results will be assessed for each treatment comparison considering both direct and indirect evidence contributing to effect estimates.

Strategy of data synthesis A network meta-analysis will be conducted using a frequentist approach implemented in R using the netmeta package, with sensitivity analyses conducted using MetaInsight web-based software. The analysis will synthesize both direct evidence from head-to-head comparisons and indirect evidence through common comparators to estimate relative effects of all exercise interventions.

Standardized mean differences will be calculated as the primary effect measure for continuous executive function outcomes, with random-effects models used to account for expected heterogeneity between studies. Network geometry will be examined through network plots showing all treatment comparisons and their connections.

Statistical heterogeneity will be assessed using I-squared statistics and tau-squared estimates. Network inconsistency will be evaluated using design-by-treatment interaction models and net heat plots to identify potential sources of inconsistency within the network. Treatment rankings will be generated using P-scores as frequentist analogues to surface under the cumulative ranking curves.

Pairwise meta-analyses will be conducted for treatment comparisons with sufficient direct evidence to complement network meta-analysis results. Missing data will be handled according to intention-to-treat principles when possible, with

sensitivity analyses exploring the impact of different missing data assumptions on results.

Subgroup analysis Pre-specified subgroup analyses will examine potential effect modifiers including participant age groups comparing children aged 6-12 years versus adolescents aged 13-18 years, given developmental differences in executive function maturation and exercise capacity; intervention supervision level comparing supervised versus unsupervised exercise programs; intervention duration comparing short-term interventions under 8 weeks versus longer programs of 8 weeks or more; and baseline ADHD medication status comparing participants receiving stable pharmacotherapy versus those not receiving medication.
Additional subgroup analyses will explore differences by specific executive function domain measured, intervention setting such as school versus clinical environments, and study quality ratings. Subgroup analyses will be conducted only when sufficient studies are available in each subgroup to provide meaningful estimates and will be interpreted cautiously given the observational nature of these comparisons.

Sensitivity analysis Multiple sensitivity analyses will be conducted to assess the robustness of primary findings. These will include restricting analyses to studies with high methodological quality defined by low risk of bias ratings; excluding studies with high dropout rates exceeding 20% to assess the impact of missing data; comparing fixed-effects versus random-effects models to evaluate the influence of between-study heterogeneity assumptions; and excluding outlying studies with effect sizes exceeding three standard deviations from the pooled estimate.
Additional sensitivity analyses will examine the impact of different outcome measurement approaches by separating performance-based neuropsychological tests from behavioural rating scales, and restricting analyses to studies using blinded outcome assessment when feasible. Network meta-analysis results will be compared with pairwise meta-analysis results for treatment comparisons with adequate direct evidence to assess consistency between approaches.

Language restriction Language restrictions will be imposed on the literature search, with only studies published in English included in this systematic review. This decision was made to ensure feasibility of the review.

Country(ies) involved China.

Keywords ADHD; attention-deficit hyperactivity disorder; executive function; exercise; physical activity; children; adolescents; network meta-analysis; systematic review.

Contributions of each author
Author 1 - Ge Ling.
Email: 2337304770@qq.com