# INPLASY

## The Impact of Physic and Motor Skills in Children with Autism: A Systematic Review and Meta-Analysis of Randomizedal Exercise Interventions on Social, Behavioral, Controlled Trials

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## ADMINISTRATIVE INFORMATION

**Support -** None.

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

**Conflicts of interest -** None declared.

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**Amendments -** This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 14 January 2025 and was last updated on 14 January 2025.

## INTRODUCTION

Review question / Objective To systematically evaluate and meta-analyze the impact of physical exercise interventions on various domains, including flexibility, cognitive control, social skills, behavioral problems, motor skills, and coordination in children with Autism Spectrum Disorder (ASD), to provide scientific guidance for effective clinical exercise interventions. PICOS Framework: P (Population): Children diagnosed with Autism Spectrum Disorder (ASD). I (Intervention): Physical exercise interventions, including various forms like aerobic exercise, strength training, ball sports, and martial arts. C (Comparison): No exercise intervention or other standard treatments without physical activity. O (Outcome): Improvement in flexibility, cognitive control, social skills, behavioral problems, motor skills, and coordination, assessed through validated autism-related measures. S (Study Design): Randomized Controlled Trials (RCTs).

Rationale The study is driven by several key considerations and gaps in current knowledge: Prevalence and Impact of ASD:

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition that affects approximately 1 in 100 children, with a rising prevalence worldwide.

ASD is characterized by impairments in social interaction, communication, repetitive behaviors, and often includes motor and cognitive challenges. These deficits lead to significant social, economic, and psychological burdens on individuals, families, and healthcare systems.

Limitations of Existing Interventions:

Current pharmacological treatments for ASD target comorbid symptoms (e.g., ADHD, depression) rather than the core symptoms of autism. They often result in side effects, such as weight gain and sedation, which limit their long-term use.

Non-pharmacological treatments like behavioral therapy, speech therapy, and psychosocial interventions require significant time, financial

resources, and early intervention, which are not always accessible or feasible.

Potential of Physical Exercise:

Physical exercise has gained attention as a non-invasive, cost-effective intervention that can improve multiple domains of functioning in children with ASD.

Studies suggest that various forms of physical activity, such as swimming, ball sports, and martial arts, can enhance motor skills, social interactions, and emotional regulation while reducing behavioral problems.

Gaps in Existing Evidence:

Previous research has produced inconsistent results regarding the efficacy of exercise interventions for ASD. Some studies report significant benefits, while others find limited or no impact, especially in certain domains like social skills and cognitive flexibility.

Existing systematic reviews often have methodological limitations, such as including non-randomized trials, focusing on a narrow set of outcomes, or lacking detailed subgroup analyses.

Need for Comprehensive Analysis:

There is a lack of systematic reviews and meta-analyses that holistically evaluate the effects of different types of exercise interventions across multiple domains (e.g., cognitive, motor, behavioral) in children with ASD.

By synthesizing evidence from Randomized Controlled Trials (RCTs) and conducting subgroup analyses, this study aims to address these gaps, provide more reliable conclusions, and guide the development of personalized exercise interventions for children with ASD.

**Condition being studied** Social Communication and Interaction:

Difficulties in understanding and engaging in social interactions.

Challenges with verbal and non-verbal communication, such as limited speech, lack of eye contact, and difficulty interpreting social cues.

Repetitive Behaviors and Restricted Interests:

Engagement in repetitive actions or routines.

Intense focus on specific interests, often to the exclusion of other activities.

Motor and Cognitive Impairments:

Delayed development of motor skills, such as balance and coordination.

Deficits in cognitive flexibility, working memory, and executive functions.

Associated Challenges:

Sensory processing issues, where individuals may be overly sensitive to or unaware of environmental stimuli.

Comorbid conditions, such as anxiety, ADHD, sleep disturbances, and obesity.

ASD is highly heterogeneous, with symptoms ranging from mild to severe, and affects approximately 1 in 100 children globally, as per the World Health Organization (WHO). Despite extensive research, the exact causes of ASD remain unclear, although genetic, environmental, and metabolic factors are believed to contribute.

ASD poses significant challenges to individuals and families, including a high disability rate, limited independence, and barriers to social integration. Interventions aim to improve the quality of life by targeting core symptoms and associated deficits, though a definitive cure remains elusive.

## METHODS

**Search strategy** This study conducted a comprehensive literature search across five major electronic databases to ensure the inclusion of authoritative and relevant studies: PubMed, EMBASE, Cochrane Library, EBSCOhost, and Web of Science. The search timeframe covered studies from the inception of these databases until February 15, 2024, to provide the latest and most comprehensive results. The search was limited to publications in English to maintain consistency and accuracy.

The search terms were developed using MeSH headings and included two primary categories: exercise-related terms and autism-related terms. Exercise-related terms included keywords such as "Exercises," "Physical Activity," "Activities, Physical," "Acute Exercise," "Isometric Exercise," "Aerobic Exercise," and "Exercise Training." Autism-related terms included "Autistic Disorder," "Autism," "Infantile Autism," and "Kanner's Syndrome."

The search strategy was structured using the PICOS framework:

P (Population): Children diagnosed with Autism Spectrum Disorder (ASD).

I (Intervention): Any form of physical exercise intervention (e.g., aerobic exercises, strength training, coordination training).

C (Comparison): No exercise intervention or other standard treatments without physical activity.

O (Outcome): Improvement in ASD-related indicators such as social communication, motor skills, flexibility, behavioral problems, and cognitive control.

S (Study Design): Randomized Controlled Trials (RCTs) or quasi-experimental studies.

**Participant or population** Children diagnosed with Autism Spectrum Disorder (ASD).

**Intervention** Any form of physical exercise intervention (e.g., aerobic exercises, strength training, coordination training).

**Comparator** No exercise intervention or other standard treatments without physical activity.

**Study designs to be included** Randomized Controlled Trials (RCTs).

**Eligibility criteria** Additional Inclusion Criteria:
Homogeneity of Study Population: Only studies involving children formally diagnosed with Autism Spectrum Disorder (ASD) using standardized diagnostic tools (e.g., ADOS-2, DSM-5) were included to ensure the comparability of results.
Outcome Reporting: The study must report at least one quantifiable autism-related outcome measure, such as the Social Communication Questionnaire (SCQ), Childhood Autism Rating Scale (CARS), Autism Behavior Checklist (ABC), Social Responsiveness Scale (SRS), or Autism Diagnostic Observation Schedule (ADOS).
Intervention Characteristics: The intervention had to include specific exercise components (e.g., aerobic, strength, coordination training), ensuring clear identification of physical activity's role.
Additional Exclusion Criteria:
Non-English Publications: Studies not published in English were excluded to maintain consistency and avoid translation biases.
Non-Original Research: Reviews, conference abstracts, commentaries, and case reports were excluded, as they do not provide primary data suitable for meta-analysis.
Incomplete Data: Studies that did not provide sufficient statistical data (e.g., means, standard deviations, or effect sizes) required for meta-analysis were excluded to ensure the precision of quantitative assessments.
Population Mismatch: Studies involving adults, non-ASD populations, or mixed populations (without subgroup analysis for ASD) were excluded, as they did not meet the study's target demographic.
Control Group Absence: Studies lacking a control group for comparison or using poorly defined control conditions were excluded to ensure methodological rigor.
Duration of Intervention: Studies with intervention durations too short to produce measurable effects (e.g., less than two weeks) were excluded.

**Information sources** This study employed a comprehensive approach to identify relevant research, utilizing multiple information sources to ensure completeness and minimize potential biases. The primary sources included five major electronic databases: PubMed, EMBASE, Cochrane Library, EBSCOhost, and Web of Science. In addition to database searches, reference tracking was employed. The reference lists of included articles were systematically reviewed to identify any additional studies that might have been missed during the initial search process. This step often uncovers older or less accessible studies that are still relevant to the research question.
When eligible studies presented incomplete or unclear data, the study team proactively contacted authors to request missing information or clarification. This step aimed to enhance data accuracy and ensure the robustness of the analyses.

**Main outcome(s)** The primary outcomes of this systematic review assess the effects of exercise interventions on developmental and behavioral domains in children with Autism Spectrum Disorder (ASD), including flexibility, cognitive control, motor skills, coordination, social skills, and behavioral problems. These outcomes were evaluated using Standardized Mean Difference (SMD) and 95% Confidence Intervals (CI), with assessments typically conducted after 8 to 12 weeks of interventions.
For flexibility and cognitive control, the focus was on improvements in working memory, planning, and physical flexibility, particularly through martial arts or coordination training. Outcomes for motor skills and coordination aimed to quantify changes in gross motor abilities and precision, with interventions like ball sports and balance training showing potential benefits.
Social skills outcomes evaluated whether interactive activities, such as team sports, could enhance communication and interpersonal interactions. Similarly, behavioral problems were assessed in terms of reductions in impulsivity, aggression, and self-injurious behaviors, with aerobic and strength training interventions playing a key role in emotional regulation.
These structured assessments and outcome measures provide insights into the potential of exercise interventions to improve critical developmental areas in children with ASD.

**Additional outcome(s)** None.

**Data management** After literature screening, two independent researchers (SKZ and YAW) extracted data from the included studies. Data extraction used standardized forms designed by the Cochrane Handbook to ensure systematic and consistent data collection. Researchers read the full texts and filled out the data extraction forms,

recording all relevant information. If discrepancies arose during data extraction, a third party (SJM) made the final decision to ensure data accuracy and consistency. The extracted data covered various aspects of the studies, including authors, publication years, study designs, sample sizes, types of interventions, intervention durations, and primary outcome measures. These measures included social communication abilities, flexibility, cognitive control, motor skills, coordination, and behavioral issues. By thoroughly documenting these data points, we could comprehensively assess the impact of exercise interventions on children with ASD.

**Quality assessment / Risk of bias analysis** To assess the quality of the included studies, this study used the Physiotherapy Evidence Database (PEDro) scale. The PEDro scale is a validated quality assessment tool widely used in evaluating the quality of randomized controlled trials in the field of physical therapy, with high reliability and validity. The quality assessment included multiple dimensions: random allocation, blinding, baseline comparability, intervention descriptions, reliability of outcome measures, and completeness of follow-up. Each study was scored based on these dimensions, with higher scores indicating higher quality. Through quality assessment, we could determine the risk of bias in the included studies, ensuring the reliability and scientific validity of the meta-analysis results.

**Strategy of data synthesis** In this study, effect sizes were calculated using standardized mean differences (SMD) to measure the impact of exercise interventions on children with ASD. The use of SMD allows comparison of results across different studies employing various measurement tools, ensuring comparability. The 95% confidence interval (CI) for each effect size was also calculated to provide a precise range for the effect size. By calculating SMD and 95% CI, we could quantify the overall effect of exercise interventions across different studies and assess their statistical significance.

To evaluate heterogeneity among the included studies, we used the $I^2$ statistic. The $I^2$ value quantifies the proportion of total variation due to heterogeneity. An $I^2$ value exceeding 50% indicates moderate to high heterogeneity. In such cases, we used a random effects model for analysis to account for variability among studies. If the $I^2$ value was below 50%, indicating low heterogeneity, we used a fixed effects model for analysis. This approach allowed us to accurately assess the impact of exercise interventions on children with ASD while considering differences among studies.

**Subgroup analysis** To gain a deeper understanding of the impact of exercise interventions on different subgroups, we conducted multiple subgroup analyses. Participants were grouped by grade level (preschool children, lower grade students, middle grade students, and upper grade students) to evaluate differences in responses to exercise interventions among different grade levels. Interventions were also grouped by type (aerobic exercise, strength training, coordination training, ball sports, physical training, martial arts, etc.) to identify the effects of different types of exercise interventions. Participants were further grouped by severity of autism (mild, moderate, and severe) to assess responses to interventions among different levels of autism severity. Interventions were also grouped by duration (short-term <8 weeks, mid-term 8-12 weeks, long-term >12 weeks) to determine the impact of intervention duration on outcomes. Through these subgroup analyses, we identified differences in effects under specific conditions, providing more targeted intervention strategies.

**Sensitivity analysis** To verify the robustness of the results, we conducted sensitivity analysis on all included studies. The specific method involved sequentially excluding each study and re-analyzing the data to observe changes in effect sizes. This process aimed to assess the impact of individual studies on the overall results and detect the robustness of the findings. By using this exclusion method, if the effect sizes and conclusions remained consistent, it indicated high robustness and reliability of the study results. This method helped validate the consistency of research conclusions under different conditions, ensuring the final conclusions' credibility.

**Language restriction** English.

**Country(ies) involved** China; Poland.

**Other relevant information** None.

**Keywords** Autism; Motor Skills; Children; Social Skills; Exercise Intervention; Physical Activity.

**Dissemination plans** The findings of this systematic review and meta-analysis are intended to be disseminated through publication in a peer-reviewed journal.

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