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The Effects of Functional Exercise on Physical Fitness in Children and Adolescents with Autism Spectrum Disorder: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

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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 3 September 2026 and was last updated on 3 September 2026.

INTRODUCTION

Review question / Objective What are the effects of functional exercise on body composition, cardiorespiratory capacity, neuromuscular capacity, and flexibility in children and adolescents with autism spectrum disorder?

Rationale Evidence supporting the benefits of exercise for individuals with autism spectrum disorder has been available for more than two decades. Despite this, exercise participation remains significantly lower than among typically developing peers. The substantial clinical heterogeneity of the autism spectrum disorder population has contributed to the lack of consensus regarding the most effective exercise protocols for maximising the established benefits of exercise. Nevertheless, a major limitation of the current literature is that studies often combine the outcomes of different types of exercise interventions, each requiring a distinct motor skill repertoire. This limitation makes it difficult to determine the specific effects of each type of exercise intervention on autism spectrum disorder symptoms. Furthermore, the key components of exercise prescription (frequency, intensity, time, type, volume, and progression) have been insufficiently investigated in the literature. Consequently, current international guidelines remain inconsistent and do not provide exercise recommendations specifically tailored to individuals with autism spectrum disorder. In this context, the challenge may lie less in the search for the "ideal" intervention and more in the development of personalised programs in real-world settings. Overly complex, intensive, or costly interventions may limit implementation and long-term adherence, perpetuating the gap between scientific evidence and practice.

Condition being studied According to the American Psychiatric Association, autism spectrum disorder is a complex category of neurobiological developmental disorders that are typically diagnosed in childhood and categorised

into two dimensions: difficulties in verbal and non-verbal communication and social interaction, and the presence of repetitive and stereotyped behaviours. Although motor impairment is not included in the diagnostic criteria for autism spectrum disorder, recent evidence indicates that more than 87% of children with autism spectrum disorder present with motor impairments. Furthermore, these difficulties tend to persist into adolescence, negatively affecting performance in activities of daily living. Interventions aimed at alleviating the symptoms of autism spectrum disorder include both pharmacological and non-pharmacological approaches. Although pharmacological interventions may contribute to symptom management, their use is associated with adverse health effects. In contrast, non-pharmacological interventions encompass a range of therapeutic modalities and require time, financial resources, specialised professionals, and sustained psychological engagement throughout the therapeutic process. These requirements may compromise the consistency of the procedures and, consequently, limit the achievement of clinically significant outcomes. Physical exercise has received increasing attention from families, researchers, and healthcare professionals as a non-pharmacological adjunctive therapy. In this context, functional exercise interventions designed to improve physical fitness and functional performance in activities of daily living may represent a promising approach to addressing the heterogeneity that characterises autism spectrum disorder.

METHODS

Search strategy Search strategy was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The review utilised the PICOs strategy which entailed the following components (i) 'P'(Population): children and adolescents with autism spectrum disorder; (ii) 'I'(Intervention): functional exercise programs; (iii) 'C'(Comparator): control group; (iv) 'O'(Outcomes): physical fitness; (v) 'S'(Study Design): experimental studies. The search was conducted in the following databases: US National Library of Medicine National Institutes of Health (pubMED), Scopus, SPORTDiscus and Web of Science with access made between 1 May 2026 to 1 June 2026. The search strategy combined key Medical Subject Heading and search indexed descriptors to refine the data: ((((adolescent* OR child* OR kid OR preschool* OR "school-age*" OR teen* OR youth*) AND (exercis* OR intervention* OR "physical activit*" OR "physical exercis*" OR program* OR training) AND (ASD OR autism OR "autism spectrum disorder" OR autistic* OR "autistic spectrum disorder*") AND ("aerobic" OR body mass index OR cardiovascular OR "cardiorespiratory" OR endurance OR flexibility OR muscle OR muscular OR neuromuscular OR power OR resistance OR running OR "strength")))).

Participant or population Children and adolescents with autism spectrum disorder will be included. Participants older than 21 years and/or those with another type of disability (e.g., multiple disabilities) and/or serious chronic diseases (e.g., cardiovascular disease or insulin-dependent) will be excluded.

Intervention We will evaluate interventions involving functional exercise. It is based on movements performed during activities of daily living, which can be adapted to different levels of functional ability. The frequency, intensity, duration, type, volume, and/or progression may vary between exercises. Sports will not be included.

Comparator The control group usually refers to physically inactive participants.

Study designs to be included Experimental and quasi-experimental studies, including randomised controlled trials, non-randomised controlled trials, and pre-post test designs.

Eligibility criteria The inclusion criteria used to select studies for this Systematic Review and Meta-Analysis were: (i) Studies published between 2000-2026; (ii) Studies published in peer-reviewed journals in English; (iii) Studies with samples made up exclusively of children (3–12 years) and adolescents (13–18 years) diagnosed with autism spectrum disorder (Autistic Disorder, Asperger's Syndrome or Unspecified Developmental Disorder), at different levels (Mild, Moderate and/or Severe); (iv) Studies with no restrictions on gender, ethnicity or number of participants; (v) Studies with a control group; (vi) The intervention group have adopted a functional exercise program for at least four weeks; (vii) Studies using physical exercise as a structured intervention tool (frequency, intensity, duration, type, volume and/or progression); (viii) Studies that assessed physical fitness (body composition, cardiorespiratory capacity, neuromuscular capacity and/or flexibility) using validated protocols; (ix) The study must provide quantitative statistical information necessary to allow the calculation of effect sizes. The exclusion criteria were as follows: (i) Studies not published in English; (ii) Review article, editorial, commentary, observational, a case study, conference abstracts, policy documents, book chapters, research

proposals, and articles where the full text was unavailable; (iii) Do not include a control group; (iv) Studies that did not describe the guidelines for prescribing a functional exercise program; (v) Studies that included complementary therapeutic interventions or sports; (vi) Online interventions, without face-to-face supervision; (vii) Studies in which physical fitness levels were not objectively assessed.

Information sources US National Library of Medicine National Institutes of Health (PubMED), Scopus, SPORTDiscus, and Web of Science.

Main outcome(s) Meta-analyses were separately conducted for each main outcome (body composition, cardiorespiratory capacity, neuromuscular capacity, and flexibility) using Comprehensive Meta-Analysis Software version 4.0. Meta-analyses were performed using random effects, assuming the heterogeneity among studies. The data extracted from the different studies for effect size calculations included: (i) the pre-mean and post-mean values of the outcome measurements in each group; (ii) the paired p for change in each group; (iii) the number of participants for whom the outcome was assessed in each group; (iv) the number of tails used for p-values; (v) the assumed pre–post correlation; (vi) the effect direction; and (vii) standardise by change score standard deviation. We performed a meta-analysis using forest plots, and the statistical significance of the results was set at $p \leq .05$. Heterogeneity was tested using: (i) Cochran's Q statistic (Q), in which a p-value <.05 or a large Q statistic relative to its degree of freedom represents evidence of heterogeneity in intervention effects; (ii) I-squared (I^2), which ranges from 0 to 100% and in which values of 25%, 50%, and 75% reflect low, moderate, and high observed heterogeneity, respectively; (iii) Tau-squared (τ^2), which defines the variance of the true effect size between studies, with $\tau^2 \geq 1$ representing substantial heterogeneity; and (iv) Tau (τ) statistic, which refers to the estimated standard deviation of the underlying effects across studies. Publication bias was estimated through visual inspection of funnel plots, as well as using Egger's intercept test.

Data management Word; EndNote 2025.3; Comprehensive Meta Analysis 4.0.

Quality assessment / Risk of bias analysis The methodological quality assessment of the studies was performed using the TESTEX scale, designed specifically for exercise intervention studies. The TESTEX scale evaluates 12 criteria, including: (i) eligibility criteria specified; (ii) randomisation specified; (iii) allocation concealment; (iv) groups similar at baseline; (v) blinding of the assessor (for at least one key outcome); (vi) outcome measures assessed in at least 85% of participants; (vii) intention-to-treat analysis; (viii) between-group statistical comparisons reported; (ix) point measures and measures of variability for all reported outcome measures; (x) activity monitoring in control groups; (xi) relative exercise intensity remained constant; and (xii) exercise volume and energy expenditure, with a maximum score of 15. Studies were categorised as high quality (≥10), adequate quality (6–9), or low quality (≤5).

Strategy of data synthesis Data obtained from the search were imported into Endnote program. The imported references were screened to determine whether the articles from the initial search were relevant for the study: (i) all duplicates were removed; (ii) articles whose title and abstract did not provide enough information on the topic were removed; (iii) articles whose full texts did not meet the inclusion criteria were removed; (iv) methodologic quality assessment from each study was checked using the tool for the assessment of study quality and reporting in exercise – TESTEX.

Subgroup analysis Subgroup analyses were conducted to evaluate the components of physical fitness.

Sensitivity analysis We did not perform sensitivity analysis.

Language restriction Only studies published in the English language are included.

Country(ies) involved Portugal.

Keywords autism; exercise; health-related fitness; body composition; cardiorespiratory fitness; strength; flexibility; meta-analysis.

Contributions of each author

Author 1 - Sofia Ataíde - Conceptualization; Methodology; Software; Formal Analysis; Writing-Original Draft.
Author 2 - Maria Campos - Methodology; Resources; Supervision; Visualization; Writing-Review and Editing; Validation.
Author 3 - Miguel Castelo-Branco - Supervision; Visualization; Validation.
Author 4 - José Ferreira - Conceptualization; Methodology; Resources; Supervision; Visualization; Writing-Review and Editing; Validation.