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Effects of School-Based Physical Activity Interventions on Brain Development in Childhood: A Meta-Analysis

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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 3 December 2024 and was last updated on 3 December 2024.

INTRODUCTION

Review question / Objective To meta-analyze the eligible (quasi-)experimental studies examining the effects of school-based PA interventions on brain development in school-aged children under 18 years old, and to examine potential moderating factors influencing intervention effectiveness.

Condition being studied Schools are regarded as an optimal setting to carry out physical activity (PA) interventions aimed at fostering children's intellectual competence and learning ability, as physical exercise is positively related to brain development. This meta-analysis aims to systematically review and quantify the effects of school-based PA interventions on brain structure and function in school-aged children.

METHODS

Search strategy A comprehensive electronic literature search performing in six databases (Web of Science, ProQuest Dissertations and Theses, PsycINFO, MEDLINE, ERIC and Google Scholar) for literature from inception to June 2024. The search scope includes terms linked to PA, comprising “physical activity”, “physical education”, “exercise”, “fitness” and “sports”. In addition, we adopted search terms related to interventions (i.e., “intervention”, “training”, “program”, and “curriculum”), school settings (i.e., “school-based”, “school”, and “afterschool”), outcomes (i.e., “brain”, “brain structure”, “brain function”, “brain development”, and “brain health”), and sample (i.e., “child”, “children”, “young children”, “kid”, “infant”, “toddler”, “pupil”, “preadolescent”, “teenagers”, “adolescents”, “youth”, “Juvenile”, and “student”). We utilized

Boolean operators "AND" to connect search terms in different categories and "OR" to link search terms within each category. Furthermore, the reference lists of the eligible research were manually searched for potentially relevant research.

Participant or population School-aged children under 18 years old, including healthy children and obese children.

Intervention Physical activity interventions were implemented in school settings (e.g., classrooms, school playgrounds, school gyms and afterschool settings).

Comparator Wait-list control group or control group.

Study designs to be included Research using quasi-experimental designs (e.g., non-randomized studies of the effects of interventions) or experimental designs (e.g., randomized controlled trials) with control condition.

Eligibility criteria (1) Research used an quasi-experimental design (e.g., non-randomized studies of the effects of interventions) or experimental design (e.g., randomized controlled trials) with control condition; (2) Participants were school-aged children under 18 years old; (3) Physical activity interventions were implemented in school settings (e.g., classrooms, school playgrounds, school gyms and afterschool settings); (4) The effects of school-based physical activity interventions on brain development were examined; (5) Articles were written in English.

Information sources A comprehensive electronic literature search performing in six databases (Web of Science, ProQuest Dissertations and Theses, PsycINFO, MEDLINE, ERIC and Google Scholar) for literature from inception to June 2024. And manual searching in the reference lists of the eligible research.

Main outcome(s) (1) The average effect size of school-based physical activity interventions on brain development in school-aged children under 18 years old; (2) the moderating effects of several study and physical activity intervention descriptors, containing brain outcome category, age, sample type, duration, dose and frequency.

Quality assessment / Risk of bias analysis The risk of bias was independently evaluated by the first and second authors using the RoB 2 tools (Sterne et al., 2019) and ROBINS-I (Sterne et al., 2016). RoB 2 tool including five bias domains was used for randomized controlled trials. ROBINS-I assessment was used for non-randomized studies of the effects of interventions. The funnel plot analysis (Pigott & Polanin, 2020), the trim-and-fill procedure (Duval & Tweedie, 2000) and Egger's regression analysis (Egger et al., 1997) were used to assess the publication bias in this meta-analysis.

Strategy of data synthesis Comprehensive Meta-Analysis Software V3 (Borenstein et al., 2013) was utilized to conduct data analysis. Meta-analytic effect sizes were computed using Hedges's g to prevent overestimation bias that may exist when the sample sizes in the included studies were small (Cooper et al., 2009). Random effects models were employed to calculate meta-analytic data, as the magnitude of the effects may be affected by some variables (e.g., characteristics of studies and interventions). The 95% confidence interval limits for all effect sizes were reported, which are significant ($p < 0.05$) if the confidence intervals doesn't contain zero. Additionally, Q-statistics and I2 value were used to examine the homogeneity of effects (Huedo-Medina et al., 2006). A statistically significant Q ($p < 0.05$) reveals that the moderating factors may lead to the variance of effects.

Subgroup analysis The moderating effects of several study and PA intervention descriptors were further examined, containing brain outcome category (brain structure and brain function), age (children aged 12-18 years old and children younger than 12 years old), sample type (healthy children and obese children), duration (less than four months, four to eight months, and more than eight months), dose (less than 150 min/week, 150 to 300 min/week, and more than 300 min/week) and frequency (1-2 days/week, 3-4 days/week, and 5 days/week).

Sensitivity analysis The trim and fill method is an iterative non-parametric method based on the symmetry of a funnel plot that estimates an adjusted pooled effect. Previous research (Duval & Tweedie, 2000; Peters et al., 2007) suggested that the trim and fill method can be used as a form of sensitivity analysis. In this study, the trim and fill method were used for sensitivity analysis.

Country(ies) involved China.

Keywords school-based physical activity, brain structure, brain function, meta-analysis, intervention.

Contributions of each author

Author 1 - Sheng Quan - SQ designed the research, extracted the data and drafted the manuscript.
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