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24-hour movement behaviours and executive function in children and adolescents: a systematic review and meta-analysis

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ADMINISTRATIVE INFORMATION

Support - No support.

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 17 June 2026 and was last updated on 17 June 2026.

INTRODUCTION

Review question / Objective In children and adolescents aged 18 years or younger (including preschoolers), what is the association of 24-hour movement behaviours (sleep, sedentary behaviour, light physical activity, and moderate-to-vigorous physical activity—analysed compositionally or as adherence to 24-hour movement guidelines) with executive function (inhibitory control, working memory, and cognitive flexibility), and do these associations differ by executive-function measurement (performance-based task vs parent-rated scale), region, age stage, or study design? 24-hour movement behaviours and executive function in children and adolescents: a systematic review and meta-analysis.

Rationale Across a fixed 24-hour day, sleep, sedentary behaviour, light physical activity and moderate-to-vigorous physical activity form a closed composition: increasing one behaviour necessarily reduces the others, so they should be

analysed jointly rather than in isolation. Executive function develops rapidly in early childhood and predicts school readiness, academic achievement and later health, making it an important and modifiable target. Primary studies applying compositional data analysis or 24-hour movement-guideline frameworks to children's executive function have increased rapidly but report inconsistent findings, and a recent compositional meta-analysis addressed broad cognition rather than executive function specifically. A dedicated quantitative synthesis focused on executive function—harmonising heterogeneous effect sizes to a common metric and examining measurement and contextual moderators—is therefore warranted.

Condition being studied Cognitive development in early life—specifically executive function (inhibitory control, working memory, and cognitive flexibility)—in generally healthy, typically developing children and adolescents, in relation to 24-hour movement behaviours (sleep, sedentary behaviour, and physical activity) characterised

compositionally or as adherence to 24-hour movement guidelines. This is a developmental health domain (not a disease) relevant to school readiness and academic and psychosocial outcomes; clinical groups such as ADHD are considered only in sensitivity analyses.

METHODS

Search strategy Collection, Scopus, Embase, APA PsycINFO, SPORTDiscus. Databases (Chinese): CNKI, Wanfang, VIP, SinoMed (CBM). Grey literature: dissertations (CNKI/ProQuest, sensitivity analysis only) and preprints (medRxiv, OSF); reference lists of relevant reviews/meta-analyses were screened (snowballing). No start-date limit (up to the search date); languages restricted to English and Chinese.

Terms combined four concept blocks with AND, each expanded with OR and truncation (*): (A) 24-hour movement/compositional: "24-hour movement", "movement behavio*", compositional, isotemporal, "time-use"; (B) behaviours: "physical activity", MVPA, sedentary, "screen time", sleep, accelerometr*; (C) executive function: "executive function*", inhibit*, "working memory", "cognitive flexibilit*", "self-regulation"; (D) children/adolescents: child*, preschool*, kindergarten, toddler*, adolescen*, youth, p?ediatric. Subject headings (MeSH/Emtree/thesaurus) were added per database; Chinese databases used corresponding Chinese terms.

Example (PubMed): ("24-hour movement"[tiab] OR "movement behavior*" [tiab] OR compositional [tiab] OR isotemporal [tiab] OR "physical activity" [tiab] OR sedentary [tiab] OR "screen time" [tiab] OR sleep [tiab]) AND ("Executive Function" [Mesh] OR "executive function*" [tiab] OR inhibit* [tiab] OR "working memory" [tiab] OR "cognitive flexibilit*" [tiab]) AND ("Child" [Mesh] OR "Adolescent" [Mesh] OR child* [tiab] OR preschool* [tiab] OR adolescen* [tiab]) AND (English [lang] OR Chinese [lang]).

Participant or population Children and adolescents aged 18 years or younger, including preschoolers; generally healthy/typically developing populations. No restriction on sex or socioeconomic status. Clinical populations (e.g., ADHD) are eligible only for pre-specified sensitivity analyses.

Intervention 24-hour movement behaviours: individual components (sleep, sedentary behaviour, light physical activity, moderate-to-vigorous physical activity) measured by accelerometer or

validated report; the overall 24-hour composition (compositional data analysis / isotemporal substitution); and/or adherence to 24-hour movement guidelines (number of recommendations met). This is an observational exposure, not an experimental intervention.

Comparator As an observational review, no separate control group is required. Comparisons are made within the 24-hour composition through relative time reallocation between behaviours, or between different levels of guideline adherence/exposure (e.g., more vs fewer guidelines met).

Study designs to be included Peer-reviewed observational studies: cross-sectional and longitudinal/cohort (baseline associations eligible). Excluded: reviews, methodological or theoretical papers, and studies without extractable or convertible effect sizes after author contact.

Eligibility criteria Inclusion: age ≤ 18 years (including preschoolers); reports a 24-hour movement behaviour exposure (component, composition, or guideline adherence) and an executive-function outcome with an extractable or convertible effect size; English or Chinese; peer-reviewed observational design. Exclusion: adult/university/older samples; outcomes limited to non-EF domains (physical fitness, BMI, academic achievement, motor skills, mental health); reviews, methodological or purely theoretical papers; no extractable effect size after author contact; dissertations (retained for grey-literature sensitivity analysis only). Broad cognition/IQ outcomes are flagged as boundary outcomes and examined in a cognition sensitivity analysis.

Information sources Electronic databases: PubMed/MEDLINE, Web of Science Core Collection, Scopus, Embase, APA PsycINFO, SPORTDiscus (English); CNKI, Wanfang, VIP, SinoMed/CBM (Chinese). Grey literature: dissertations via CNKI and ProQuest (sensitivity analysis only) and preprints (medRxiv, OSF). Additional sources: backward and forward citation tracking (snowballing) of included studies and relevant reviews/meta-analyses; contact with study authors for missing data. Searches were limited to English- and Chinese-language records with no start-date restriction up to the search date.

Main outcome(s) Executive function—inhibitory control, working memory, cognitive flexibility, or a composite/latent EF index—measured by performance-based tasks (e.g., Go/No-Go, Flanker, Stop-signal, N-back, Wisconsin Card Sorting Test, NEPSY-II, Early Years Toolbox) or

validated rating scales (e.g., BRIEF-P). Effect measure: heterogeneous effect sizes (compositional IIR coefficients, isotemporal reallocation estimates, zero-order correlations, standardized regression coefficients, guideline-adherence coefficients/OR) harmonised to a common partial correlation r and pooled via random-effects (DerSimonian–Laird) meta-analysis on Fisher's z .

Additional outcome(s) Direction of isotemporal substitution effects by behaviour (MVPA, sleep, sedentary behaviour, light physical activity); dose–response association between the number of 24-hour movement guidelines met and executive function/cognition. Broad cognitive ability/IQ outcomes are treated as boundary outcomes and examined separately in a cognition sensitivity analysis.

Data management Records from all databases were imported into reference-management software (EndNote/NoteExpress) for automatic de-duplication, followed by manual verification (by DOI and title+author+year). Title/abstract and full-text screening were tracked in a shared spreadsheet. Data were extracted into a piloted structured spreadsheet (study/year, country, design, sample size, age, exposure measurement, sleep measurement, EF instrument and scoring direction, analysis method, point estimates, uncertainty, p -values) and stored together with the analysis scripts to ensure reproducibility.

Quality assessment / Risk of bias analysis Two reviewers independently appraise each study; disagreements are resolved by a third reviewer. Cross-sectional studies are assessed with the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies (8 items); longitudinal/cohort studies with the JBI cohort checklist or the Newcastle–Ottawa Scale. Each item is rated yes/no/unclear and summarised per study and across studies (traffic-light plot). Certainty of evidence is summarised using GRADE.

Strategy of data synthesis Random-effects (DerSimonian–Laird) meta-analysis of partial correlations transformed to Fisher's z ; pooled r is reported with 95% confidence intervals, Cochran's Q , I^2 , τ^2 , and a 95% prediction interval. Two a-priori pools are analysed: MVPA–executive function and guideline adherence. Isotemporal-substitution results (heterogeneous time units) are synthesised narratively by direction. Small-study effects are assessed with Egger's test (pools with $k \geq 10$) and funnel plots. Robustness is examined with leave-one-out analysis and grey-literature inclusion.

Analyses use custom scripts; two-sided $p < 0.05$ is significant.

Subgroup analysis Pre-specified subgroups: executive-function measurement (performance-based task vs parent-rated BRIEF-P); region (China vs non-China); age stage (preschool vs school-age/adolescent); and study design (cross-sectional vs longitudinal). Meta-regression will be used if the number of studies permits. Potential confounding between measurement method and region is acknowledged and discussed.

Sensitivity analysis Leave-one-out analysis to assess the influence of each individual study; inclusion of grey literature (a questionnaire-based dissertation) to test robustness of the pooled estimate; a cognition sensitivity analysis incorporating boundary outcomes (broad cognitive ability/IQ); and handling of overlapping or related samples (including only one report per shared cohort, e.g., ABCD; verifying non-overlap of same-research-group samples). Heterogeneity sources are further examined by excluding outlying studies identified from their contribution to Q .

Language restriction English and Chinese only.

Country(ies) involved China; Malaysia.

Other relevant information This is a retrospective registration: at the time of registration, searches, screening, data extraction, risk-of-bias assessment and data synthesis had been completed, and the review is being prepared for submission. No external funding.

Keywords 24-hour movement behaviours; executive function; physical activity; sedentary behaviour; sleep; compositional data analysis; isotemporal substitution; children; meta-analysis.

Dissemination plans Findings will be disseminated through peer-reviewed publication— one English-language SCI/SSCI journal and one Chinese core (CSSCI/Peking-core) journal—and through conference presentations.

Contributions of each author

Author 1 - Hanchen Shao- Shao conceived and designed the study, developed the protocol, performed the literature search, study screening, data extraction and statistical analysis, and drafted the manuscript. Shao is the guarantor of the review.

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Author 2 - Mohd Radzani Bin Abdul Razak- Abdul Razak provided methodological supervision,

advised on study design and analysis, served as the third reviewer and arbiter for disagreements, and critically revised the manuscript.

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Author 3 - Lan Luo - Luo independently performed study screening and data extraction, cross-checked the extracted data against source reports, and contributed to manuscript revision.

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Author 4 - Jianjing Jin - Jin conducted the risk-of-bias assessment and data verification, contributed to data interpretation, and revised the manuscript.

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