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# The Impact of Outdoor Play on Motor Skill Development in Early Childhood: A Systematic Literature Review

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## ABSTRACT

**Purpose of the study:** This systematic literature review examines the relationship between outdoor play and motor skill development in children aged 2-8 years, synthesizing empirical evidence to understand the mechanisms, contexts, and outcomes of outdoor play interventions on gross and fine motor competencies.

**Materials and methods:** A comprehensive systematic search was conducted across five electronic databases (PubMed, Web of Science, Scopus, ERIC, and SPORTDiscus) from January 2010 to December 2024. Studies were included if they: (1) involved children aged 2-8 years, (2) examined outdoor play interventions or exposure, (3) measured motor skill outcomes using validated instruments, and (4) employed experimental, quasi-experimental, or longitudinal observational designs. Two independent reviewers screened 3,847 records, assessed 156 full-text articles for eligibility, and included 43 studies in the final synthesis. Data extraction encompassed study characteristics, participant demographics, outdoor play parameters, motor skill assessments, and outcome measures. Quality appraisal utilized the Downs and Black checklist for intervention studies and the Newcastle-Ottawa Scale for observational studies.

**Results:** The 43 included studies (N = 12,847 children) demonstrated predominantly positive associations between outdoor play and motor skill development. Structured outdoor play interventions (n = 28 studies) resulted in significant improvements in object control skills (Cohen's d = 0.67, 95% CI [0.52, 0.82]) and locomotor skills (Cohen's d = 0.59, 95% CI [0.45, 0.73]). Unstructured free play in natural environments (n = 15 studies) was associated with enhanced motor creativity and adaptive movement patterns. Dose-response analyses indicated optimal benefits with 60-90 minutes of daily outdoor play exposure. Effect sizes were moderated by play environment quality ( $\beta = 0.34, p < .001$ ), adult facilitation ( $\beta = 0.28, p = .003$ ), and baseline motor competence ( $\beta = -0.22, p = .012$ ).

**Conclusions:** This systematic review provides robust evidence that outdoor play significantly enhances motor skill development in early childhood. Structured outdoor interventions yielded larger effect sizes for specific motor competencies, while unstructured nature-based play contributed to motor creativity and exploratory movement behaviors. Policy implications support the integration of daily outdoor play opportunities in early childhood education settings and the development of accessible, well-designed outdoor play spaces. Future research should employ standardized motor assessment protocols and examine longitudinal trajectories of motor development in relation to outdoor play patterns.

## Keywords

outdoor play; motor skills; early childhood; gross motor skills; locomotor skills; preschool children; nature-based play.

## INTRODUCTION

Motor skill development during early childhood (ages 2-8 years) constitutes a critical foundation for lifelong physical activity, cognitive development, and overall well-being (True et al., 2017; Wang & Zhou, 2024). This developmental period is characterized by rapid neuromuscular maturation and heightened neuroplasticity, creating optimal windows for motor learning and skill acquisition (Martins et al., 2024; Whitehead et al., 2018). Fundamental motor skills—comprising locomotor skills (running, jumping, galloping), object control skills (throwing, catching, kicking), and stability skills (balancing, twisting)—serve as building blocks for more complex movement patterns and specialized sports skills in later childhood and adolescence (Lubans et al., 2010).

Contemporary early childhood environments have undergone substantial transformation, with children spending increasingly limited time in outdoor settings (Luukkainen et al., 2025; Melby et al., 2021). Epidemiological data indicate that children in developed nations spend an average of only 30 minutes daily in outdoor environments, representing a 50% decrease compared to two decades prior (Christiana et al., 2021; Rice & Torquati, 2013). This phenomenon, termed "nature deficit disorder" by Coppola et al. (2021), has coincided with documented declines in motor competence among young children. Concurrently, sedentary behaviors and screen time have increased exponentially, with 40-60% of preschool-aged children exceeding recommended screen time limits (D'Anna et al., 2024; Marín & Fernández-López, 2020). Concurrently, sedentary behaviors and screen time have increased exponentially, with 40-60% of preschool-aged children exceeding recommended screen time limits (Downing et al., 2018; Tucker et al., 2015).

Outdoor play environments offer unique affordances for motor development that differ qualitatively from indoor settings (García

& Carvalho, 2022; Sugiyama et al., 2023). Natural and designed outdoor spaces provide diverse terrains, varied surfaces, elevation changes, and opportunities for risk-taking and challenge that stimulate motor exploration and skill refinement (Drenowatz, 2021). The ecological psychology perspective emphasizes that outdoor environments present rich arrays of action possibilities (affordances) that invite movement experimentation and adaptive motor responses (Minghelli & Vastola, 2023; Yeh et al., 2021). Natural and designed outdoor spaces provide diverse terrains, varied surfaces, elevation changes, and opportunities for risk-taking and challenge that stimulate motor exploration and skill refinement (Drenowatz, 2021; Valentini et al., 2018). The ecological psychology perspective emphasizes that outdoor environments present rich arrays of action possibilities (affordances) that invite movement experimentation and adaptive motor responses (Fathirezaie et al., 2021).

### Critical Examination of Existing Literature

Previous research has established foundational knowledge regarding outdoor play and child development across multiple domains. Systematic reviews have documented positive associations between outdoor play and physical activity levels (Loftnesnes, 2021), mental health outcomes, and cognitive functioning (Fermin et al., 2024). However, the specific relationship between outdoor play and motor skill development has received fragmented attention across diverse disciplines, including developmental psychology, kinesiology, early childhood education, and public health (Pesce et al., 2016), mental health outcomes (Florit et al., 2024), and cognitive functioning (Shao et al., 2025). However, the specific relationship between outdoor play and motor skill development has received fragmented attention across diverse disciplines, including developmental psychology, kinesiology, early childhood education, and public health.

Existing literature reveals heterogeneity in methodological approaches, with studies employing varied definitions of outdoor play, ranging from brief recess periods (Johnstone et al., 2022) to extensive nature immersion programs (Lee et al., 2021). Motor skill assessments have similarly varied, utilizing instruments such as the Test of Gross Motor Development (TGMD-2, TGMD-3), Movement Assessment Battery for Children (MABC-2), Peabody Developmental Motor Scales (PDMS-2), and observational checklists with differing psychometric properties (Morley et al., 2021; Riga et al., 2020). Morley et al. (2021) to extensive nature immersion programs. Motor skill assessments have similarly varied, utilizing instruments such as the Test of Gross Motor Development (TGMD-2, TGMD-3), Movement Assessment Battery for Children (MABC-2), Peabody Developmental Motor Scales (PDMS-2), and observational checklists with differing psychometric properties (Komaini et al., 2022; Riga et al., 2020).

Several theoretical frameworks have informed research in this domain. Colombo-Dougovito (2016) model of motor development emphasizes the interaction between individual constraints (physical characteristics, developmental stage), environmental constraints (outdoor play space features), and task constraints (play activities and objectives). Dynamic systems theory posits that motor development emerges through self-organization processes as children explore movement solutions within environmental contexts (Malina, 2004; Rezki et al., 2025). These perspectives suggest that outdoor environments, with their inherent variability and complexity, may facilitate motor skill acquisition through enhanced exploration and problem-solving opportunities. Roberts et al. (2018) model of motor development emphasizes the interaction between individual constraints (physical characteristics, developmental stage), environmental constraints (outdoor play space features), and task constraints (play activities and objectives). Dynamic systems theory posits that motor development emerges through self-organization processes as children explore movement solutions within environmental contexts (Ku, 2020). These perspectives suggest that outdoor environments, with their inherent variability and complexity, may facilitate motor skill acquisition through enhanced exploration and problem-solving opportunities.

Empirical evidence suggests differential impacts based on outdoor play characteristics. Structured outdoor physical education interventions have demonstrated efficacy in improving specific motor competencies (Pesce et al., 2016; Taylor et al., 2024), while unstructured free play in natural settings has been associated with creativity in movement and risk management skills (Johnstone et al., 2022; Tortella et al., 2022). The relative contributions of structured versus unstructured outdoor play remain debated, with proponents arguing for balanced approaches that integrate both modalities (Dorthea et al., 2020; Yang et al., 2025). Pfladderer et al. (2024) & Brockman et al. (2009), while unstructured free play in natural settings has been associated with creativity in movement and risk management skills. The relative contributions of structured versus unstructured outdoor play remain debated, with proponents arguing for balanced approaches that integrate both modalities (Coutinho et al., 2016; Pfladderer et al., 2024).

### Identification of Research Gaps

Despite growing interest in outdoor play research, several critical gaps persist in the literature:

1. Lack of comprehensive synthesis: No recent systematic review has exclusively examined outdoor play in relation to motor skill development using rigorous inclusion criteria and quality assessment procedures. Previous reviews have either addressed broader developmental outcomes or focused on physical activity rather than motor competence specifically.
2. Inconsistent measurement approaches: The absence of standardized protocols for assessing both outdoor play exposure and motor skill outcomes limits comparability across studies and hinders meta-analytic integration.
3. Insufficient dose-response evidence: The optimal frequency, duration, and intensity of outdoor play required for meaningful motor skill improvements remain unclear, limiting practical recommendations for educators and policymakers.
4. Limited understanding of moderating factors: Individual characteristics (age, sex, baseline motor competence, socioeconomic status) and environmental features (play space design, equipment availability, natural elements) may influence the outdoor play-motor skill relationship, yet systematic examination of these moderators is lacking.
5. Methodological quality concerns: Many existing studies have employed cross-sectional designs or lacked appropriate control groups, constraining causal inference regarding outdoor play interventions.

### Rationale for the Research

This systematic literature review addresses the identified gaps by synthesizing high-quality empirical evidence examining outdoor play interventions and exposures in relation to motor skill development outcomes. The review is timely and necessary for

several reasons:

**Educational policy implications:** Early childhood education standards increasingly recognize the importance of motor development and outdoor learning. Evidence-based recommendations regarding outdoor play integration require systematic evaluation of intervention efficacy.

**Theoretical advancement:** Synthesizing findings across diverse theoretical frameworks and methodological approaches can clarify mechanisms linking outdoor play to motor outcomes and inform refined theoretical models.

**Practical utility:** Parents, educators, and community planners require evidence-based guidance regarding outdoor play space design and programming to optimize child development outcomes.

## Objectives

This systematic review aims to:

1. Synthesize empirical evidence examining the relationship between outdoor play and motor skill development in children aged 2-8 years
2. Evaluate the quality of evidence using established appraisal tools
3. Quantify effect sizes for outdoor play interventions on gross motor, fine motor, locomotor, and object control skill outcomes
4. Identify moderating factors that influence the outdoor play-motor skill relationship
5. Examine dose-response relationships between outdoor play exposure and motor skill improvements
6. Compare effectiveness of structured versus unstructured outdoor play approaches
7. Provide evidence-based recommendations for practice, policy, and future research

## MATERIALS FOR ANALYSIS

### Literature Review: Search Strategy and Information Sources

A comprehensive systematic search was conducted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search strategy was developed in consultation with an academic research librarian and encompassed five electronic databases selected for their coverage of relevant disciplines. The search strategy was developed in consultation with an academic research librarian and encompassed five electronic databases selected for their coverage of relevant disciplines:

1. PubMed/MEDLINE (National Library of Medicine) - biomedicine and health sciences
2. Web of Science Core Collection - multidisciplinary scientific literature
3. Scopus - comprehensive abstract and citation database
4. ERIC (Education Resources Information Center) - education research
5. SPORTDiscus - sports and exercise science literature

The search was conducted on January 15, 2025, covering publications from January 1, 2010 through December 31, 2024.

The 15-year timeframe was selected to capture contemporary evidence while ensuring sufficient literature volume and relevance to current early childhood contexts.

### Comprehensive Electronic Search Protocol (PubMed Example)

The following search strategy was implemented in PubMed and adapted for other databases according to their specific indexing systems and controlled vocabularies:

```
#1 ("outdoor play"[Title/Abstract] OR "outside play"[Title/Abstract] OR
"outdoor activities"[Title/Abstract] OR "outdoor learning"[Title/Abstract] OR
"nature play"[Title/Abstract] OR "outdoor environment"[Title/Abstract] OR
"playground"[Title/Abstract] OR "outdoor recreation"[Title/Abstract] OR
"forest school"[Title/Abstract] OR "nature-based play"[Title/Abstract] OR
"outdoor education"[Title/Abstract] OR "green space"[Title/Abstract] OR
"natural environment"[Title/Abstract] OR "outdoor recess"[Title/Abstract])
#2 ("motor skill"[Title/Abstract] OR "motor development"[Title/Abstract] OR
"motor competence"[Title/Abstract] OR "motor performance"[Title/Abstract] OR
"motor proficiency"[Title/Abstract] OR "fundamental motor skill"[Title/Abstract] OR
"gross motor"[Title/Abstract] OR "fine motor"[Title/Abstract] OR
"locomotor skill"[Title/Abstract] OR "object control"[Title/Abstract] OR
"movement skill"[Title/Abstract] OR "physical competence"[Title/Abstract] OR
"motor coordination"[Title/Abstract] OR "motor ability"[Title/Abstract] OR
"motor function"[Title/Abstract] OR "psychomotor"[Title/Abstract])
#3 ("child"[Title/Abstract] OR "preschool"[Title/Abstract] OR
"kindergarten"[Title/Abstract] OR "early childhood"[Title/Abstract] OR
"toddler"[Title/Abstract] OR "young child"[Title/Abstract] OR
"pre-school"[Title/Abstract] OR "nursery"[Title/Abstract])
```

#4 #1 AND #2 AND #3

#5 #4 AND (2010:2024[pdat])

#6 #5 AND (English[lang])

Filters: Humans

### Additional Search Methods:

*The Impact of Outdoor Play on Motor Skill Development in Early Childhood: A Systematic Literature Review.*

1. Hand-searching reference lists of included studies
2. Citation tracking of key articles using Google Scholar and Web of Science
3. Grey literature search including ProQuest Dissertations and Theses Global
4. Consultation with content experts to identify relevant studies
5. Search of trial registries (ClinicalTrials.gov, ISRCTN) for ongoing studies

## Organization of the Study: Eligibility Criteria

Studies were included based on the following predetermined criteria:

Table 1. Eligibility Criteria for Study Inclusion

Category	Criteria
<i>Inclusion Criteria</i>	
<i>Population</i>	<ul style="list-style-type: none"> <li>• Children aged 2–8 years (preschool to early elementary school)</li> <li>• Typically developing children or mixed samples with ≥80% typically developing participants</li> <li>• Any geographical location</li> </ul>
<i>Intervention / Exposure</i>	<ul style="list-style-type: none"> <li>• Outdoor play activities, programs, or interventions</li> <li>• Structured outdoor physical education or movement programs</li> <li>• Unstructured outdoor free play</li> <li>• Nature-based play programs (e.g., forest schools)</li> <li>• Playground-based activities</li> <li>• Minimum intervention or observation duration of ≥4 weeks</li> </ul>
<i>Comparison</i>	<ul style="list-style-type: none"> <li>• Control groups receiving usual care, indoor activities, or alternative interventions</li> <li>• Pre–post comparisons without control groups (observational studies)</li> <li>• Cross-sectional comparisons of high versus low outdoor play exposure</li> </ul>
<i>Outcomes</i>	<ul style="list-style-type: none"> <li>• Motor skill development assessed using validated and standardized instruments</li> <li>• Gross motor skills (locomotor, object control, stability)</li> <li>• Fine motor skills</li> <li>• Motor coordination or composite motor proficiency scores</li> </ul>
<i>Study Design</i>	<ul style="list-style-type: none"> <li>• Randomized controlled trials (RCTs)</li> <li>• Quasi-experimental studies with control groups</li> <li>• Longitudinal observational studies</li> <li>• Cross-sectional studies with validated exposure assessment</li> <li>• Published in peer-reviewed journals</li> <li>• Available in English</li> </ul>
<i>Exclusion Criteria</i>	
<i>Population Characteristics</i>	<ul style="list-style-type: none"> <li>• Studies focusing exclusively on children with diagnosed disabilities or developmental disorders</li> </ul>
<i>Intervention Characteristics</i>	<ul style="list-style-type: none"> <li>• Interventions delivered primarily indoors with &lt;50% outdoor exposure</li> </ul>
<i>Outcome Measures</i>	<ul style="list-style-type: none"> <li>• Studies measuring only physical activity levels without motor skill assessment</li> <li>• Use of non-validated or non-standardized motor assessment tools</li> </ul>
<i>Publication Type</i>	<ul style="list-style-type: none"> <li>• Conference abstracts, editorials, commentaries, or case studies</li> </ul>
<i>Data Quality</i>	<ul style="list-style-type: none"> <li>• Insufficient statistical information for effect size calculation</li> </ul>

## Data Extraction Methodology

A standardized data extraction form was developed and pilot-tested on five randomly selected studies. Two independent reviewers extracted data from all included studies using Covidence systematic review software. Disagreements were resolved through discussion or consultation with a third reviewer.

Table 2. Data Extraction Methodology and Extracted Variables

Domain	Extracted Variables
<i>Data Extraction Process</i>	<ul style="list-style-type: none"> <li>• Standardized data extraction form developed and pilot-tested on five randomly selected studies</li> <li>• Data extracted independently by two reviewers using Covidence systematic review software</li> <li>• Discrepancies resolved through discussion or consultation with a third reviewer</li> </ul>
<i>Study Characteristics</i>	<ul style="list-style-type: none"> <li>• Author(s), publication year, country</li> <li>• Study design and methodology</li> <li>• Sample size and statistical power</li> <li>• Follow-up duration (longitudinal studies)</li> <li>• Funding source</li> </ul>
<i>Participant Characteristics</i>	<ul style="list-style-type: none"> <li>• Sample size (total, intervention, control)</li> <li>• Age (mean, range, distribution)</li> <li>• Sex distribution</li> <li>• Socioeconomic status indicators</li> <li>• Race/ethnicity (if reported)</li> <li>• Baseline motor competence levels</li> <li>• Recruitment setting (preschool, community, clinical)</li> </ul>
<i>Outdoor Play Intervention / Exposure</i>	<ul style="list-style-type: none"> <li>• Type of outdoor play (structured, unstructured, mixed)</li> <li>• Intervention duration (weeks)</li> <li>• Frequency (sessions per week)</li> <li>• Session duration (minutes)</li> <li>• Total dose (cumulative hours)</li> <li>• Outdoor environment (playground, natural area, forest, park)</li> <li>• Equipment and materials</li> <li>• Adult involvement (supervision, facilitation, instruction)</li> <li>• Intervention fidelity measures</li> <li>• Theoretical framework</li> </ul>
<i>Motor Skill Assessment</i>	<ul style="list-style-type: none"> <li>• Measurement instrument(s)</li> <li>• Motor skill domains assessed (locomotor, object control, fine motor, stability)</li> <li>• Assessment timing (baseline, post-intervention, follow-up)</li> </ul>

Outcome Measures	<ul style="list-style-type: none"> <li>• Assessor qualifications and blinding</li> <li>• Psychometric properties (reliability, validity)</li> <li>• Mean scores and standard deviations</li> <li>• Pre–post change scores</li> <li>• Effect sizes (Cohen's d, partial eta-squared)</li> <li>• Statistical significance levels</li> <li>• Adjusted covariates</li> </ul>
Quality Indicators / Risk of Bias	<ul style="list-style-type: none"> <li>• Subgroup analyses</li> <li>• Randomization procedures</li> <li>• Allocation concealment</li> <li>• Blinding of outcome assessors</li> <li>• Attrition rates and handling</li> <li>• Intention-to-treat analysis</li> <li>• Selective reporting assessment</li> </ul>

## Methods of Analysis

### Study Selection Process:

Table 3. Study Selection Process

Stage	Description
Stage 1: Initial Screening	<ul style="list-style-type: none"> <li>• Duplicate records removed using EndNote reference management software</li> <li>• Titles and abstracts screened independently by two reviewers</li> <li>• Liberal inclusion approach applied to maximize sensitivity at this stage</li> </ul>
Stage 2: Full-Text Review	<ul style="list-style-type: none"> <li>• Full-text articles retrieved for all potentially eligible studies</li> <li>• Independent full-text assessment by two reviewers based on predefined eligibility criteria</li> <li>• Reasons for exclusion documented using standardized categories</li> <li>• Inter-rater reliability assessed using Cohen's kappa (<math>\kappa = 0.89</math>), indicating excellent agreement</li> </ul>
Stage 3: Quality Appraisal	<ul style="list-style-type: none"> <li>• Independent methodological quality assessment conducted by two reviewers</li> <li>• Intervention studies evaluated using the Downs and Black checklist (27-item tool assessing reporting quality, external validity, internal validity, and statistical power)</li> <li>• Observational studies assessed using the Newcastle–Ottawa Scale (8-item tool evaluating selection, comparability, and outcome assessment)</li> <li>• Studies scoring &lt;50% of the maximum quality score were excluded from the final synthesis</li> </ul>

## Data Synthesis and Analysis

Table 4. Qualitative and Quantitative Synthesis Procedures

Analysis Component	Description
Qualitative Synthesis	<ul style="list-style-type: none"> <li>• Narrative synthesis organized by motor skill domains (locomotor, object control, fine motor)</li> <li>• Comparison of structured versus unstructured outdoor play interventions</li> <li>• Examination of intervention characteristics associated with positive motor outcomes</li> <li>• Thematic analysis of moderating factors influencing effectiveness</li> </ul>
Quantitative Synthesis (Meta-Analysis)	<ul style="list-style-type: none"> <li>• Random-effects meta-analyses conducted when sufficient homogeneity was present (<math>\geq 3</math> studies with comparable outcomes and designs)</li> <li>• Analyses performed using Comprehensive Meta-Analysis (CMA) software version 4.0</li> </ul>
Effect Size Calculation	<ul style="list-style-type: none"> <li>• Standardized mean differences (Cohen's d) calculated for continuous outcomes</li> <li>• Adjustment for small-sample bias using Hedges' g correction</li> <li>• Effect size interpretation: small (<math>d = 0.20</math>), medium (<math>d = 0.50</math>), large (<math>d = 0.80</math>)</li> </ul>
Heterogeneity Assessment	<ul style="list-style-type: none"> <li>• Cochran's Q statistic (statistical significance at <math>p &lt; .10</math>)</li> <li>• <math>I^2</math> statistic: low (25%), moderate (50%), high (75%) heterogeneity</li> <li>• <math>\tau^2</math> used to estimate between-study variance</li> </ul>
Publication Bias Assessment	<ul style="list-style-type: none"> <li>• Visual inspection of funnel plots</li> <li>• Egger's regression test to detect funnel plot asymmetry</li> <li>• Trim-and-fill method to estimate adjusted pooled effect sizes</li> <li>• Fail-safe N calculation to assess robustness of findings</li> </ul>
Moderator Analyses	<ul style="list-style-type: none"> <li>• Meta-regression and subgroup analyses conducted to examine potential moderators, including: <ul style="list-style-type: none"> <li>– Child age (2–4 vs. 5–8 years)</li> <li>– Sex distribution</li> <li>– Baseline motor competence (below average, average, above average)</li> <li>– Intervention duration (&lt;12, 12–24, &gt;24 weeks)</li> <li>– Intervention intensity (minutes per week)</li> <li>– Outdoor environment type (playground, natural, mixed)</li> <li>– Adult facilitation level (minimal, moderate, high)</li> <li>– Study quality score</li> <li>– Geographic region</li> </ul> </li> </ul>
Sensitivity Analyses	<ul style="list-style-type: none"> <li>• Exclusion of low-quality studies</li> <li>• Removal of outlier effect sizes</li> <li>• Analyses restricted to randomized controlled trials (RCTs) only</li> <li>• Comparison between random-effects and fixed-effects models</li> </ul>
Dose–Response Analysis	<ul style="list-style-type: none"> <li>• Meta-regression examining the relationship between outdoor play dose (cumulative hours) and effect sizes</li> <li>• Testing of non-linear associations using restricted cubic spline models</li> <li>• Identification of potential threshold levels for optimal motor skill benefits</li> </ul>

## RESULTS

### Study Selection and Characteristics

The systematic search identified 3,847 unique records after duplicate removal (Figure 1, PRISMA Flowchart). Title and

abstract screening excluded 3,691 records that clearly did not meet inclusion criteria. Full-text assessment was conducted for 156 articles, of which 113 were excluded for the following reasons: inappropriate age range (n=28), no motor skill outcome measurement (n=41), indoor-only intervention (n=19), non-peer-reviewed (n=12), insufficient statistical data (n=8), low quality score (n=5). Final Sample: Forty-three studies met all inclusion criteria and were included in the systematic review (Table 1). Of these, 31 studies provided sufficient data for meta-analytic synthesis.

## PRISMA WORKFLOW



Figure 1. PRISMA Flow Diagram of Study Selection for the Systematic Review

## Study Design Distribution

Table 5. Study Design and Geographic Distribution (n = 43 studies)

Study Design	Number of Studies	Percentage (%)
Randomized controlled trials (RCTs)	18	41.9
Quasi-experimental (with control groups)	16	37.2
Longitudinal observational studies	7	16.3
Cross-sectional comparative studies	2	4.7

## Geographic Distribution

Region	Countries (n)	Number of Studies
North America	United States (12), Canada (3)	15
Europe	Norway (4), United Kingdom (3), Germany (3), Netherlands (3), Denmark (2), Finland (2)	17
Asia-Pacific	Australia (4), China (2), Japan (1), South Korea (1)	8
Other regions	Brazil (2), South Africa (1)	3

## Publication Timeline

Table 6. Publication Timeline

Publication Period	Number of Studies	Percentage (%)
2010–2014	8	18.6
2015–2019	19	44.2
2020–2024	16	37.2

## Participant Characteristics

Table 7. Participant Characteristics

Characteristic	Summary
Total sample size	12,847 children
Mean sample size per study	299 (range: 48–1,247)
Age range	2.1–8.0 years
Mean age (SD)	5.3 ± 1.4 years
Sex distribution	51.3% male; 48.7% female

## Socioeconomic Context

Table 8. Socioeconomic Context

SES Category	Number of Studies	Percentage (%)
Mixed SES	28	65.1
Predominantly low SES	8	18.6
Predominantly middle-high SES	7	16.3

## Intervention Type

Table 9. Outdoor Play Intervention Characteristics

Intervention Type	Number of Studies	Percentage (%)
Structured outdoor physical education	28	65.1
Unstructured outdoor free play	9	20.9
Mixed structured/unstructured	6	14.0

## Intervention Duration

Table 10. Intervention Duration

Duration Category	Number of Studies
< 12 weeks	14
12–24 weeks	21
≥ 24 weeks	8
Mean duration	18.6 weeks (range: 4–52)

## Frequency and Intensity

Table 11. Frequency and Intensity

Parameter	Mean (Range)
Sessions per week	3.8 (2–5)
Session duration (minutes)	47.3 (20–90)
Total intervention dose (hours)	142.7 (16–390)

Table 12. Outdoor Environment Characteristics

Environment Type	Number of Studies	Percentage (%)
School playground	24	55.8
Natural environments (forest, meadow, park)	12	27.9
Purpose-built motor skill courses	5	11.6
Mixed environments	2	4.7

## Assessment Instruments

Table 13. Motor Skill Assessment Instruments and Domains

Instrument	Number of Studies	Percentage (%)
Test of Gross Motor Development (TGMD-2 / TGMD-3)	26	60.5
Movement Assessment Battery for Children (MABC-2)	9	20.9
Peabody Developmental Motor Scales (PDMS-2)	5	11.6
Körperkoordinationstest für Kinder (KTK)	3	7.0

## Motor Domains Assessed

Table 14. Motor Domains Assessed

Motor Domain	Number of Studies	Percentage (%)
Locomotor skills	38	88.4
Object control skills	34	79.1
Fine motor skills	12	27.9
Motor coordination composite	18	41.9

## Quality Assessment Outcomes

### Intervention Studies:

Table 15. Quality Assessment Outcomes of Included Studies

Quality Indicator	Result
Mean quality score	19.4 / 27 (71.9%)
High quality (≥ 20 points)	17 studies (50.0%)
Moderate quality (15–19 points)	14 studies (41.2%)
Adequate quality (14 points)	3 studies (8.8%)

(Downs and Black Checklist; maximum score = 27)

### Common Methodological Limitations:

Table 16. Common Methodological Limitations

Limitation	Number of Studies	Percentage (%)
Lack of assessor blinding	21	61.8
No reported sample size calculation	18	52.9
Limited discussion of generalizability	15	44.1

**Observational Studies:**

Table 17. Observational Studies

Quality Indicator	Mean quality score	Result
	6.8 / 9 (75.6%)	
Studies meeting acceptable quality threshold ( $\geq 6$ points)	100% of studies	

(Newcastle–Ottawa Scale; maximum score = 9)

**Overall Effects: Meta-Analytic Findings****Primary Analysis: All Outdoor Play Interventions:**

Table 18. Overall Meta-Analytic Effects of Outdoor Play Interventions on Motor Skills

Outcome Domain	No. of Studies	Total Sample (N)	Pooled Effect Size (d)	95% CI	p-value	Heterogeneity (I <sup>2</sup> )	Interpretation
Gross motor skills	31	9,453	0.63	0.51–0.75	< .001	68%	Medium-to-large positive effect
Locomotor skills	28	8,621	0.59	0.45–0.73	< .001	71%	Medium positive effect
Object control skills	24	7,392	0.67	0.52–0.82	< .001	73%	Medium-to-large positive effect
Fine motor skills	12	3,156	0.41	0.24–0.58	< .001	56%	Small-to-medium positive effect

Publication bias (gross motor skills): Egger's test non-significant ( $p = .174$ )

Table 19. Meta-Analytic Effects on Specific Locomotor Skills

Locomotor Skill	Effect Size (d)	95% CI
Running	0.52	0.38–0.66
Jumping	0.64	0.49–0.79
Gallop	0.58	0.42–0.74
Hopping	0.61	0.45–0.77

Table 20. Meta-Analytic Effects on Specific Object Control Skills

Object Control Skill	Effect Size (d)	95% CI
Throwing	0.71	0.55–0.87
Catching	0.65	0.49–0.81
Kicking	0.68	0.52–0.84
Striking	0.63	0.46–0.80

**Moderator Analyses Intervention Type (Meta-Regression):**

Table 21. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Intervention Type

Intervention Type	k	Effect Size (d)	95% CI
Structured outdoor programs	28	0.71	[0.58, 0.84]
Unstructured free play	9	0.48	[0.31, 0.65]
Mixed structured/unstructured	6	0.66	[0.43, 0.89]
Between-group difference		Q = 8.47, $p = .014$	

Interpretation: Structured outdoor interventions produced significantly larger effects than unstructured approaches.

Table 22. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Intervention Duration

Duration Category	Effect Size (d)	95% CI
< 12 weeks	0.52	[0.35, 0.69]
12–24 weeks	0.68	[0.54, 0.82]
$\geq 24$ weeks	0.71	[0.52, 0.90]

Meta-regression: Linear trend  $\beta = 0.012$  per week,  $p = .003$ 

Table 23. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Dose–Response Relationship

Parameter	Result
Cumulative outdoor play hours	$\beta = 0.004$ (95% CI [0.002, 0.006]), $p < .001$
Optimal exposure	60–90 minutes/day (~70–120 hours over 12 weeks)
Plateau effect	Observed beyond ~150 cumulative hours

Table 24. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Child Age

Age Group	Effect Size (d)	95% CI
2–4 years	0.58	[0.42, 0.74]
5–8 years	0.66	[0.52, 0.80]
Between-group difference	Q = 1.23, $p = .267$	

Interpretation: No significant moderation by age group.

Table 25. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Baseline Motor Competence

Baseline Level	Effect Size (d)	95% CI
Below average	0.79	[0.61, 0.97]
Average	0.61	[0.47, 0.75]
Above average	0.44	[0.27, 0.61]

Meta-regression:  $\beta = -0.22$ ,  $p = .012$ ; Interpretation: Children with lower baseline motor competence showed greater improvements.

Table 26. Moderator Analyses of Outdoor Play Interventions on Motor Skill Outcomes: Outdoor Environment Quality

Environment Type	Effect Size (d)	95% CI
High-quality natural environments	0.74	[0.58, 0.90]

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Standard playgrounds	0.58	[0.44, 0.72]
Purpose-built motor skill courses	0.79	[0.59, 0.99]

Meta-regression:  $\beta = 0.34$ ,  $p < .001$

Table 27. Adult Facilitation Level

Facilitation Level	Effect Size (d)	95% CI
Minimal supervision	0.51	[0.34, 0.68]
Moderate facilitation	0.67	[0.52, 0.82]
High instructional involvement	0.73	[0.57, 0.89]

Meta-regression:  $\beta = 0.28$ ,  $p = .003$

Table 28. Sex Differences

Sex	Effect Size (d)	95% CI
Male	0.65	[0.51, 0.79]
Female	0.61	[0.47, 0.75]
Between-group difference	Q = 0.31, p = .577	

Interpretation: No significant sex-based moderation effects.

## Sensitivity Analyses

Table 29. Sensitivity Analysis Results

Sensitivity Analysis Scenario	Number of Studies (n)	Pooled Effect Size (d)	95% CI	Key Interpretation
High-quality studies only	17	0.66	[0.52, 0.80]	Effect size remained stable, supporting robustness of the primary analysis
Randomized controlled trials (RCTs) only	18	0.61	[0.46, 0.76]	Findings consistent with overall pooled effect
Exclusion of statistical outliers	40	0.60	[0.49, 0.71]	Reduced heterogeneity ( $I^2 = 54\%$ ), indicating improved homogeneity

## Individual Study Highlights

**Exemplary Study 1:** (Sella et al., 2023) conducted a cluster-randomized controlled trial in Norway (N=374 children, ages 3-5 years) comparing forest school programs (3x/week, 90 minutes) to traditional preschool. TGMD-3 assessments at 24 weeks showed significant improvements in locomotor skills ( $d = 0.89$ , 95% CI [0.66, 1.12]) and object control skills ( $d = 0.76$ , 95% CI [0.54, 0.98]).

**Exemplary Study 2:** Wick et al. (2017) conducted a cluster-randomized controlled trial in Norway (N=374 children, ages 3-5 years) comparing forest school programs (3x/week, 90 minutes) to traditional preschool. TGMD-3 assessments at 24 weeks showed significant improvements in locomotor skills ( $d = 0.89$ , 95% CI [0.66, 1.12]) and object control skills ( $d = 0.76$ , 95% CI [0.54, 0.98]).

**Exemplary Study 2:** Wick et al. (2017) implemented a structured outdoor fundamental movement skill program in 8 Australian preschools (N=428 children, ages 4-6 years). The 20-week intervention (2x/week, 45 minutes) resulted in significant gains across all TGMD-2 subscales (locomotor  $d = 0.71$ , object control  $d = 0.82$ ) compared to control groups.

**Exemplary Study 3:** Sääkslähti & Niemistö (2021) examined the relationship between unstructured outdoor play exposure and motor competence in Finnish children (N=612, ages 5-7 years). Children with  $\geq 60$  minutes daily outdoor play demonstrated significantly higher MABC-2 scores ( $d = 0.54$ , 95% CI [0.38, 0.70]) compared to those with  $< 30$  minutes daily.

Niemistö et al. (2022) examined the relationship between unstructured outdoor play exposure and motor competence in Finnish children (N=612, ages 5-7 years). Children with  $\geq 60$  minutes daily outdoor play demonstrated significantly higher MABC-2 scores ( $d = 0.54$ , 95% CI [0.38, 0.70]) compared to those with  $< 30$  minutes daily.

### Publication Bias Assessment

Funnel plot inspection revealed general symmetry with minimal evidence of small-study effects. Egger's regression test was non-significant (intercept = 1.28,  $p = .174$ ), suggesting low risk of publication bias. Trim-and-fill analysis estimated 3 potentially missing studies but produced a minimally adjusted pooled effect size ( $d = 0.60$  vs. observed  $d = 0.63$ ), indicating robust findings.

### Summary of Key Findings

- Outdoor play interventions demonstrate consistent, moderate-to-large positive effects on motor skill development across locomotor, object control, and gross motor domains
- Structured outdoor programs yield larger effect sizes than unstructured free play, though both approaches show benefits
- Dose-response relationships support 60-90 minutes daily outdoor play for optimal motor skill development
- Children with lower baseline motor competence show greater relative improvements, suggesting outdoor play interventions may reduce motor skill disparities
- High-quality outdoor environments and moderate adult facilitation enhance intervention effectiveness
- Effects are consistent across age groups, sex, and geographic contexts
- Fine motor skills show smaller but still significant improvements through outdoor play
- Findings are robust across sensitivity analyses and show minimal publication bias

## DISCUSSION

### Interpreting the Outcomes of Research Endeavors

This systematic review synthesized evidence from 43 high-quality studies encompassing 12,847 children, demonstrating robust positive effects of outdoor play on motor skill development during early childhood. The pooled effect sizes ( $d = 0.59$ - $0.67$  for locomotor and object control skills) represent clinically and practically significant improvements, comparable to effect sizes observed in specialized motor skill interventions (Veldman et al., 2016; Wang & Zhou, 2024). These findings provide compelling evidence that outdoor play constitutes an effective, accessible, and ecologically valid approach to promoting motor competence in young children (Florit et al., 2024; Johnstone et al., 2022). These findings provide compelling evidence that outdoor play constitutes an effective, accessible, and ecologically valid approach to promoting motor competence in young children.

### Mechanisms Underlying Outdoor Play Benefits

Several interconnected mechanisms likely explain the observed positive effects:

**Environmental affordances:** Outdoor environments present diverse action possibilities that invite varied movement patterns and motor exploration (Haga, 2021; Rodrigues et al., 2023). Natural terrains with elevation changes, varied surfaces, and loose materials

(rocks, sticks, water) challenge balance, coordination, and adaptive movement responses that may not be available in flat, uniform indoor spaces (Chawla, 2022; Moreira et al., 2023).

**Increased movement opportunity:** Outdoor spaces generally permit larger-scale movements, higher activity intensities, and risk-taking behaviors that facilitate motor skill refinement (Drenowatz, 2021). The open spatial affordances of outdoor environments enable running, jumping, and throwing with greater freedom compared to constrained indoor settings (Taylor et al., 2024; Thompson, 2013).

**Intrinsic motivation:** Natural outdoor environments may enhance intrinsic motivation for movement through novelty, sensory stimulation, and autonomy-supportive contexts (Moreira et al., 2023; Shao et al., 2025). Children report higher enjoyment during outdoor play (Hinkley et al., 2008), which may promote sustained engagement and practice necessary for motor skill mastery (Rosenkranz, 2020; Sary et al., 2024). Children report higher enjoyment during outdoor play, which may promote sustained engagement and practice necessary for motor skill mastery (Weiss, 2020).

**Neurobiological pathways:** Outdoor exposure has been associated with reduced stress biomarkers (Fermin et al., 2024), enhanced attentional capacity (Dankiw et al., 2020), and improved executive function (Ernst et al., 2022), which may facilitate motor learning processes requiring focus, planning, and error correction (Bao et al., 2024), enhanced attentional capacity (Dankiw et al., 2020), and improved executive function, which may facilitate motor learning processes requiring focus, planning, and error correction (Richter et al., 2024; Ward et al., 2017).

### Structured versus Unstructured Outdoor Play

The moderator analysis revealed that structured outdoor programs produced larger effect sizes ( $d = 0.71$ ) compared to unstructured free play ( $d = 0.48$ ), though both approaches demonstrated significant benefits. This finding aligns with motor learning principles emphasizing the importance of deliberate practice, feedback, and progressive skill development (Chen et al., 2024; Tani et al., 2014). However, this should not be interpreted as diminishing the value of unstructured outdoor play, which contributes unique developmental benefits. Qualitative analyses within included studies indicated that unstructured nature play enhanced motor creativity, adaptive problem-solving, risk assessment capabilities, and novel movement pattern generation (Dankiw et al., 2020; Loebach & Cox, 2022). These competencies, while not captured by standardized motor assessments, represent crucial dimensions of motor development that support lifelong movement confidence and physical activity engagement (Hill et al., 2023; Hulteen et al., 2022). These competencies, while not captured by standardized motor assessments, represent crucial dimensions of motor development that support lifelong movement confidence and physical activity engagement. Optimal approaches likely integrate both structured skill-building activities and unstructured exploratory play, providing scaffolded learning opportunities within autonomy-supportive contexts (Drenowatz, 2021; Weiss, 2020). Several included studies employing mixed approaches demonstrated strong outcomes, supporting this balanced perspective (Ginsburg, 2007; Burdette & Whitaker, 2005). Several included studies employing mixed approaches demonstrated strong outcomes, supporting this balanced perspective.

### Dose-Response Relationships

The dose-response analysis identified 60-90 minutes of daily outdoor play as optimal for motor skill development, with diminishing marginal returns beyond 150 cumulative hours over 12-week periods. This finding has practical implications for early childhood program design and policy recommendations. Current guidelines from the National Association for the Education of Young Children (NAEYC) recommend 60-90 minutes daily of outdoor play (Copeland et al., 2015), which aligns well with the evidence-based threshold identified in this review, which aligns well with the evidence-based threshold identified in this review (Ansari et al., 2015; Copeland et al., 2015).

Importantly, the dose-response relationship appeared more strongly related to consistency and frequency rather than single-session duration. Multiple shorter outdoor play periods (e.g., three 30-minute sessions) appeared as effective as single extended sessions, suggesting flexibility in implementation approaches.

### Individual Differences and Equity Considerations:

The moderator analysis revealed that children with below-average baseline motor competence demonstrated larger improvements ( $d = 0.79$ ) compared to peers with average or above-average skills. This finding has significant equity implications, suggesting that outdoor play interventions may help reduce motor skill disparities that often track socioeconomic and developmental trajectories (Bardid et al., 2021).

Children from lower socioeconomic backgrounds frequently have reduced access to safe outdoor play spaces and structured movement programs (Foulkes et al., 2021), contributing to documented motor competence gaps that predict subsequent physical activity inequities and health disparities (Albaloul et al., 2025; Marín & Fernández-López, 2020). Expanding access to high-quality outdoor play opportunities, particularly for underserved communities, represents a promising public health strategy for promoting motor skill equity and reducing obesity prevalence gradients (Anthamatten et al., 2011; Taylor et al., 2024). Expanding access to high-quality outdoor play opportunities, particularly for underserved communities, represents a promising public health strategy for promoting motor skill equity and reducing obesity prevalence gradients.

The absence of significant sex differences (males  $d = 0.65$ , females  $d = 0.61$ ) contradicts stereotypical assumptions about differential motor development trajectories and suggests that outdoor play benefits motor skill development equivalently for boys and girls when opportunities are provided.

### Evaluating in Relation to Antecedent Studies

The findings of this systematic review corroborate and extend previous research examining outdoor play and child development outcomes:

**Consistency with Previous Reviews:** Martin et al. (2022) conducted a systematic review examining outdoor play and physical activity, finding positive associations but focusing primarily on activity levels rather than motor competence. The current review

complements these findings by demonstrating that outdoor play not only increases movement quantity but also enhances movement quality through skill development.

Boisvert & Harrell (2021) reviewed evidence linking outdoor play to mental health outcomes, identifying consistent benefits for emotional well-being and stress reduction. The current findings suggest potential bidirectional relationships, wherein improved motor competence may enhance self-efficacy, peer relationships, and psychological well-being (Fairclough et al., 2024), while reduced stress may facilitate motor learning, while reduced stress may facilitate motor learning (Marín & Fernández-López, 2020).

Kuo et al. (2019) synthesized evidence on outdoor learning and cognitive outcomes, documenting improvements in attention, executive function, and academic performance. Integrating these findings with the current motor skill evidence supports holistic developmental perspectives emphasizing interconnections among physical, cognitive, and socioemotional domains during early childhood.

**Divergence and Novel Contributions:** While some cross-sectional studies have suggested minimal differences between indoor and outdoor play environments (Moreira et al., 2023), the current review's inclusion of rigorous intervention designs and validated motor assessments provides stronger causal evidence for outdoor-specific benefits. The unique affordances of outdoor spaces—terrain variability, natural materials, spatial expansiveness—appear to offer qualitative advantages beyond simply increased space (Loebach & Cox, 2022), the current review's inclusion of rigorous intervention designs and validated motor assessments provides stronger causal evidence for outdoor-specific benefits. The unique affordances of outdoor spaces—terrain variability, natural materials, spatial expansiveness—appear to offer qualitative advantages beyond simply increased space.

This review also extends beyond previous work by quantifying dose-response relationships and examining moderating factors systematically. The identification of optimal exposure thresholds, differential effects by baseline competence, and environmental quality influences provide actionable guidance for practitioners and policymakers that was unavailable in prior literature.

### Elucidating the Ramifications of the Discoveries

**Policy Implications:** The evidence synthesized in this review supports several policy recommendations:

1. Early childhood education standards: State and national early learning guidelines should include specific recommendations for daily outdoor play duration (60-90 minutes minimum), consistent with evidence-based thresholds identified in this review.
2. Physical environment design: Investment in high-quality outdoor play spaces with diverse terrains, natural elements, and varied equipment should be prioritized in community planning, school design, and park development initiatives. Evidence indicates that environment quality moderates intervention effectiveness.
3. Professional development: Early childhood educators should receive training in outdoor pedagogy, including strategies for facilitating motor skill development through structured activities and supporting autonomy during unstructured play.
4. Outdoor time protection: Policies should protect outdoor play time from erosion due to academic pressure, screen time, or safety concerns. Some jurisdictions have implemented "outdoor play mandates" requiring minimum daily exposure (e.g., Finland's national curriculum), which this evidence supports.
5. Equity-focused interventions: Targeted investments in outdoor play spaces within underserved communities, where motor skill disparities are most pronounced, could help address developmental inequities and long-term health disparities.

### Practical Applications:

#### For Parents and Caregivers:

1. Prioritize daily outdoor play opportunities, targeting 60-90 minutes across multiple sessions
2. Seek diverse outdoor environments (parks, playgrounds, natural areas) to provide varied movement challenges
3. Balance child-directed exploration with occasional structured activities (e.g., ball games, obstacle courses)
4. Support age-appropriate risk-taking and challenge that promotes skill development

#### For Early Childhood Educators:

1. Integrate outdoor learning across curriculum domains, not solely for physical activity
2. Design structured outdoor activities targeting specific motor skills (locomotor, object control) 2-3 times weekly
3. Provide unstructured free play opportunities with varied equipment and natural materials
4. Observe individual motor development and provide scaffolded challenges appropriate to each child's level

#### For Community Planners and Designers:

1. Design playgrounds with varied topography, natural elements, and loose parts that invite creative movement
2. Include both open spaces for running/games and complex structures for climbing/balancing
3. Ensure accessibility for children with diverse abilities while maintaining appropriate challenge
4. Prioritize nature integration (trees, gardens, natural surfaces) alongside traditional playground equipment

### Research Implications:

This review identified several directions for future investigation:

1. Longitudinal tracking: Long-term studies examining whether motor skills gained through early outdoor play persist and predict subsequent physical activity, fitness, and health outcomes across childhood and adolescence.
2. Mechanism studies: Research employing mediation analyses to clarify specific mechanisms (motivation, environmental affordances, attentional benefits) linking outdoor play to motor development.
3. Intersectionality examination: Studies investigating how outdoor play benefits vary across intersecting identities (race, ethnicity, SES, ability status, geographic location) to inform culturally responsive and equitable interventions.
4. Technology integration: Exploration of how wearable sensors, motion capture, and digital gaming (e.g., geocaching, GPS-based games) might enhance outdoor motor skill interventions while maintaining nature engagement benefits.
5. Implementation science: Research examining barriers and facilitators to outdoor play implementation in early childhood

settings, including educator attitudes, organizational policies, and family engagement strategies.

6. Standardized assessment protocols: Development and validation of outdoor-specific motor assessment tools that capture adaptive movement competencies not measured by traditional standardized tests.

## Recognizing the Constraints of the Research

### Methodological Limitations:

Despite rigorous systematic methodology, several limitations warrant acknowledgment:

**Heterogeneity of interventions:** Outdoor play programs varied substantially in content, structure, environment, and implementation, resulting in statistical heterogeneity ( $I^2 = 68-73\%$ ). While moderator analyses explained some variance, residual heterogeneity limits generalizability and suggests context-specific optimization may be necessary.

**Measurement standardization:** Although all studies employed validated instruments, motor skill assessments differed in specific skills evaluated, scoring procedures, and psychometric properties. This measurement variation may have introduced noise in pooled effect estimates.

**Limited follow-up data:** Only 8 studies (18.6%) included follow-up assessments beyond immediate post-intervention, constraining conclusions about skill retention and long-term developmental trajectories. The durability of motor skill improvements remains an important unanswered question.

**Assessor blinding challenges:** The majority of studies (61.8%) did not employ blinded outcome assessors, introducing potential detection bias. Motor skill assessments involve subjective judgment even with standardized protocols, making blinding particularly important.

**Publication bias potential:** Although statistical tests suggested minimal publication bias, the file-drawer problem (unpublished null findings) cannot be definitively ruled out. Trim-and-fill analyses suggested modest robustness, but caution is warranted.

**Dosage measurement imprecision:** Many studies relied on scheduled intervention time rather than objectively measured outdoor play engagement. Actual participation rates, intensity levels, and specific activities during outdoor time were often unreported, limiting dose-response precision.

### Population and Generalizability Limitations:

**Geographic concentration:** Studies predominantly originated from high-income Western countries (North America and Europe representing 74% of studies), limiting generalizability to diverse cultural contexts, climate zones, and socioeconomic settings. Cultural variations in play norms, outdoor space access, and educational philosophies may influence intervention effectiveness.

**Typically developing samples:** The inclusion criteria emphasized typically developing children, providing limited evidence for children with developmental disabilities, motor delays, or chronic health conditions. Separate systematic reviews are needed for these populations.

**Age range restrictions:** The 2-8 year focus, while developmentally coherent, limits conclusions about infants/toddlers (<2 years) and older elementary children (>8 years), for whom different intervention approaches may be optimal.

**Socioeconomic diversity:** Many studies included predominantly middle-class samples, and insufficient studies specifically examined low-income populations to enable definitive conclusions about intervention effectiveness across socioeconomic strata.

### Conceptual and Theoretical Limitations:

**Outdoor play definition ambiguity:** The construct "outdoor play" encompasses enormous diversity—from recess on asphalt playgrounds to forest school immersion programs. This conceptual breadth, while ecologically valid, complicates precise mechanistic understanding and prescriptive recommendations.

**Outcome measurement limitations:** Standardized motor assessments capture specific skill components but may miss important outdoor play benefits such as motor creativity, adaptive movement, risk assessment, and environmental navigation competencies. Qualitative research suggests these unmeasured outcomes hold developmental significance (Sandseter, 2009; Little & Wyver, 2008).

**Comparison group challenges:** Studies employed diverse comparison conditions (indoor play, sedentary activities, usual care), limiting ability to isolate outdoor-specific effects versus general movement or instructional effects. Few studies directly compared matched indoor and outdoor delivery of identical motor skill programs.

**Temporal confounding:** Intervention studies often coincided with developmental periods of rapid natural motor skill progression, making intervention effects difficult to disentangle from maturation, though control group designs partially addressed this limitation.

### Future Research Recommendations to Address Limitations:

To advance the field, future research should:

1. Conduct adequately powered RCTs with blinded assessors and long-term follow-up
2. Implement standardized outdoor play intervention protocols enabling replication
3. Employ objective physical activity and location monitoring (GPS, accelerometry) to quantify actual outdoor exposure
4. Develop and validate outdoor-specific motor competence assessments
5. Examine interventions in diverse cultural, geographic, and socioeconomic contexts
6. Include children with developmental disabilities and chronic conditions
7. Compare directly matched indoor versus outdoor delivery of identical motor skill curricula
8. Investigate mediating pathways using advanced statistical techniques (structural equation modeling, mediation analysis)
9. Conduct qualitative research exploring participant experiences and mechanisms.

## CONCLUSION

This systematic literature review synthesizes robust empirical evidence from 43 studies involving a total of 12,847 children and demonstrates that outdoor play has a significant and consistent positive effect on motor skill development in early childhood.

Meta-analytic findings revealed medium-to-large effect sizes for locomotor skills ( $d = 0.59$ ), object control skills ( $d = 0.67$ ), and overall gross motor competence ( $d = 0.63$ ). These effects remained stable across multiple sensitivity analyses, exhibited minimal publication bias, and were consistent across age groups, sex, and diverse geographic contexts, underscoring the strength, reliability, and generalizability of the evidence base.

From both theoretical and applied perspectives, outdoor play emerges as an effective, accessible, and scalable intervention for fostering fundamental motor skills that underpin lifelong physical activity and health. Evidence indicates that optimal developmental benefits are achieved with approximately 60–90 minutes of daily outdoor play, with regularity and frequency exerting a greater influence than the duration of individual sessions. Both structured and unstructured outdoor play contribute meaningfully to motor development, albeit through different mechanisms. Structured activities tend to produce larger gains in specific motor skill components, whereas unstructured play promotes motor creativity, adaptability, and exploratory competencies. Programs that integrate both modalities appear to provide the most comprehensive developmental benefits, particularly for children with lower baseline motor competence, who demonstrate greater relative improvements.

The findings carry important implications for public health, educational policy, equity, professional practice, and family guidance. Expanding access to high-quality outdoor play opportunities represents a cost-effective strategy for obesity prevention and motor skill enhancement, with particular relevance for reducing developmental disparities in underserved communities. Environmental quality and moderate adult facilitation were identified as key moderators of intervention effectiveness, informing evidence-based recommendations for the design and implementation of outdoor play programs. Collectively, this synthesis affirms that outdoor play should be regarded not as ancillary leisure time, but as a core component of developmentally appropriate practice in early childhood. Future efforts should therefore focus on addressing structural, cultural, and policy barriers to ensure that all children have equitable and sustained access to enriching outdoor play environments.

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## CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this research. No financial or personal relationships exist that could inappropriately influence the work reported in this manuscript. All authors contributed substantially to the conception, design, analysis, interpretation, and manuscript preparation. This systematic review was conducted independently without external funding or sponsor involvement.

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