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The Impact of Physical Activity on the Motor Skills of Children with Chronic Diseases: A Systematic Review

La Saudi[1], Muhamad Ridlo[1], Wiwin Sulistyawati[1], Vernando Yanry Lameky[2], Ahmil[3], Siska Christianingsih[1], Wendi Muhammad Fadhli[3], Narmawan[4], Resi Putri Naulia[5], Ainun Najib Febrya Rahman[6]

[1]State University of Surabaya, East Java, Indonesia
[2]Universitas Kristen Indonesia Maluku, Ambon, Maluku, Indonesia
[3]Widya Nusantara University, Palu, Central Sulawesi, Indonesia
[4]STIKes Karya Kesehatan, Sulawesi Tenggara, Indonesia
[5]STIKes Estu Utomo, Jawa Tengah, Indonesia
[6]Tanjungpura University, Pontianak, Kalimantan Barat, Indonesia

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***Corresponding Author:**
lasaudi.unesa@gmail.com

ABSTRACT

Physical activity (PA) is essential for children's motor skills development and has been proposed as an effective intervention for enhancing these skills, particularly in children with chronic diseases. This systematic review aims to evaluate the impact of PA interventions on motor skills in children aged 5 to 18 years with chronic diseases by synthesizing evidence from studies published between 2014 and 2024. A systematic search was conducted across multiple databases, including Scopus, PubMed, Springer, ScienceDirect, Taylor & Francis, and Elicit. Studies meeting the inclusion criteria—evaluating the effects of PA interventions on motor skills in children with chronic diseases—were selected. Two reviewers independently performed data extraction and quality assessment, and results were synthesized qualitatively. Among the six randomized controlled trials (RCTs), four studies reported statistically significant improvements in motor skill development following PA interventions, while two showed no significant changes. These findings underscore the potential of PA as a beneficial intervention for enhancing motor skills in children with chronic illnesses, although outcomes may vary. This review provides valuable insights for public health strategies, future intervention designs, and clinical recommendations for incorporating PA into the care plans for this population

INTRODUCTION

Physical activity (PA) is critical to children's motor skills development. Children with conditions such as cancer, obesity, asthma, diabetes, cerebral palsy, and cystic fibrosis often encounter limitations that impede their physical development and the acquisition of motor skills [1]. Physical activity, including moderate and vigorous exercises, can significantly enhance children's motor skills [2]. During childhood, PA is instrumental in fostering motor skill development [3]. The quality of movement determines motor skills and is not necessarily linked to a specific sport. A common characteristic of all motor skills is that they require learning. An individual may be trained to be either unskilled or highly skilled, depending on how effectively the skills have been acquired and practiced [4].

PA is widely recognized for its positive effects on children's health and well-being. However, children with chronic illnesses face challenges that may hinder their participation in physical activities, such as fatigue, physical limitations, and pain, as well as psychological barriers like anxiety and low self-esteem. Despite these obstacles, tailored PA programs have been shown to significantly improve motor skills in children with chronic illnesses [5]. Proficiency in motor skills during childhood is fundamental for establishing a foundation for lifelong active living. The mastery of both gross and fine motor skills not only influences physical health and development but also substantially impacts cognitive and social development [6].

Motor skills encompass gross motor skills, which involve locomotion, balance, posture, and coordination (e.g., jumping, walking, running, and putting on shoes and pants) [7 & 8]. Fine motor skills involve the coordination of small muscle movements in the hands, fingers, and thumbs (e.g., writing and buttoning a shirt), essential for a child's overall development and ability to perform daily activities [9].

Several studies have demonstrated a reciprocal and dynamic relationship between PA and motor skills [10-12]. Empirical evidence suggests that the development of motor skills enhances various health indices in children, including cardiorespiratory fitness, muscle strength and endurance, and perceived competence, among others [13 & 14]. Consequently, the development and implementation of PA interventions aimed at improving motor skills in children have become a growing area of research [15].

Given this context, there has been an increase in PA interventions that target motor skills in children with chronic illnesses. However, no recent and comprehensive review has been conducted to assess the overall effectiveness of PA interventions on the development of motor skills in children with chronic illnesses using randomized controlled trial (RCT) designs. Some reviews have explored the relationship between PA and motor skills in children without chronic illnesses, including studies by McDonough et al. [16], Liu et al. [17], Ruggeri et al. [1], Rico-González et al. [18], Hübner et al. [19], Zeng et al. [3], and Tang & Wang [20]. Children with chronic illnesses require special consideration regarding motor development.

This systematic review aims to synthesize existing research findings on the impact of PA on motor skills in children with chronic illnesses and the instruments used to measure motor skills in this population. The findings are expected to provide deeper insights into the benefits of PA for children with chronic illnesses and to inform future support interventions. Additionally, these insights will offer recommendations to clinicians working in this field regarding appropriate PA for children with chronic illnesses.

Objectives

The primary objective of this systematic review is to evaluate the impact of PA interventions on motor skills development in children with chronic diseases. By synthesizing evidence from multiple studies, the review aims to:

- Assess the effectiveness of PA in enhancing motor skills among children aged 5 to 18 years with chronic diseases.
- Identify the characteristics of PA interventions that yield significant improvements in motor skills for this population.
- Highlight gaps in current research and suggest directions for future studies to optimize PA-based interventions for children with chronic conditions.
- Provide evidence-based recommendations to clinicians and public health practitioners for designing and implementing PA programs tailored to the needs of children with chronic diseases.
- Contribute to public health efforts by emphasizing the importance of PA in improving motor skills and overall quality of life for children with chronic conditions.
- By achieving these objectives, this review seeks to advance understanding and support clinical practices that promote motor skill development through physical activity in this vulnerable population.

METHODS

This systematic review adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines outlined by Shamseer et al. [21].

2.1 Search Strategy

In July 2024, a comprehensive search was conducted for English-language articles published between 2014 and 2024 across several reputable databases, including Scopus, PubMed, Springer, ScienceDirect, Taylor & Francis, and Elicit. The search terms were consistently applied across all databases. These terms included: ("physical activity" OR exercise) AND AND ("motor skill" OR "motor skill competency" OR "motor coordination" OR "motor development" OR "motor function" OR "motor performance" OR "motor abilities" OR "fine motor skills" OR "gross motor skills" OR "locomotor skills") AND (children OR adolescents) AND ("non-communicable diseases" OR NCDs OR "chronic diseases" OR "risk factors").

2.2 Study Selection Criteria

The inclusion criteria were determined based on the Population, Intervention, Comparison, Outcomes, Study Design (PICOS) framework: 1) The study sample included children under 18 years of age with chronic illnesses (e.g., cerebral palsy, cancer, cystic fibrosis, obesity, etc.); 2) The study evaluated the impact of physical activity on motor skills in children with chronic illnesses; 3) The study utilized motor skill assessments; 4) The study employed a randomized controlled trial (RCT) or experimental design. Additionally, only peer-reviewed studies published in English were included, while other study designs (e.g., non-experimental and cross-sectional studies) were reviewed but excluded from the analysis.

2.3 Screening, Data Extraction, and Data Synthesis

Upon completing the search, all citations were identified, and duplicates were detected using software such as Mendeley©. Subsequently, the titles and abstracts of each article were extracted from the reference manager and imported into an Excel spreadsheet for further analysis.

Three researchers (L.S., M.R., W.S.) independently screened all articles by evaluating the titles, followed by evaluating the abstracts for relevant studies. Data extraction was carried out by one researcher (M.R.) and subsequently verified for accuracy by another researcher (L.S.). A list of relevant articles was then compiled in a Microsoft Excel spreadsheet. The following information was specifically extracted: author names, year of publication, country and location of the study, research methods (e.g., study design, sample characteristics, type of physical activity intervention employed, research instruments used), and the key findings regarding the impact and potential of physical activity on motor skills in children. A meta-analysis was not conducted due to the observed heterogeneity in the types of interventions, outcomes, and study locations reviewed.

2.4 Risk of Bias Assessment

Randomized controlled trials (RCTs) were assessed using the Cochrane Risk of Bias 2.0 Tool [22]. This tool evaluates several factors, including random allocation concealment, sequence generation, blinding of participants and personnel, incomplete outcome data, blinding of outcome assessment, selective reporting, and other potential biases. Reviewers were instructed to categorize each criterion as 'yes' (indicating low risk of bias), 'no' (indicating high risk of bias), or 'unclear' (indicating insufficient information or uncertainty regarding bias). Any disagreements between the two reviewers during the quality assessment were resolved by a third reviewer (W.S.).

RESULTS

3.1 Study Selection

A data search across six databases yielded a total of 2,960 articles. After removing duplicates, 2,821 articles were retained. These articles were then subjected to an initial screening based on their titles and abstracts, resulting in 226 articles deemed relevant. A thorough review of the full texts led to the exclusion of 68 articles. Furthermore, 62 studies were eliminated based on predefined criteria, leaving six articles eligible for inclusion. A visual representation of this selection process is provided in Figure 1.

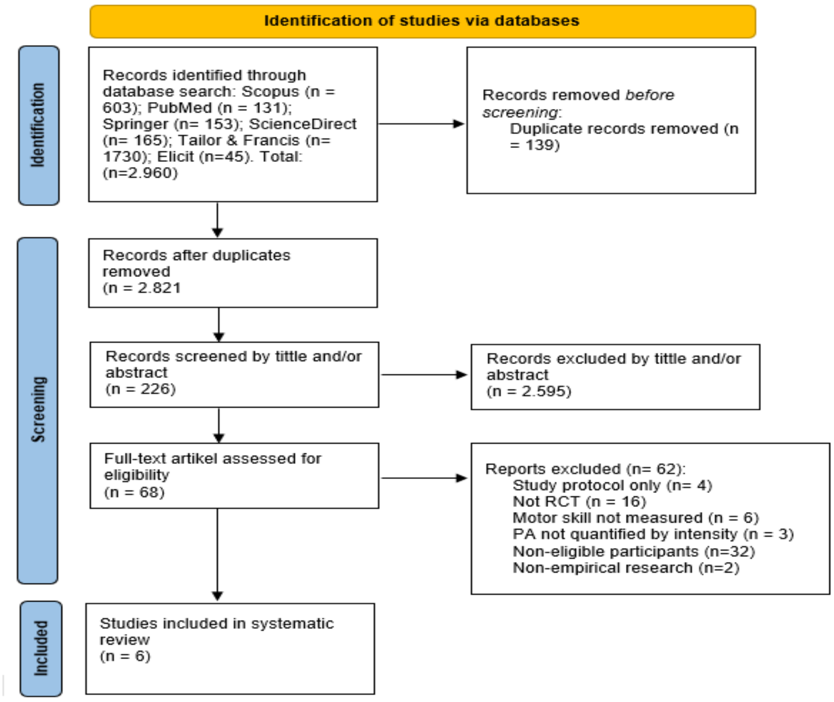

Figure 1. Flowchart of the study selection process

3.2 Study Characteristics

The characteristics of all the included studies are summarized in Table 1. Of the six RCTs, four studies evaluated the impact of physical activity interventions on the motor skills of children with chronic illnesses [23-26]. One study implemented a physical activity intervention that included various components, such as games [27]. Another study focused on a locomotor activity intervention for children, assisted by Robotic Assisted Gait Training (RAGT+LT) [28]. These studies were conducted across different countries: one in Germany [27]., one in Turkey [26], one in Egypt [23], one in Iran [24], one in Denmark [27], and one in Australia [28]. The studies included diverse samples: one article focused on children diagnosed with cancer [23], two on overweight children [27 & 26], one on children with asthma [24], one on children with cystic fibrosis (CF) [25], and one on children with cerebral palsy (CP) [28]. Four studies were conducted in hospital settings [24, 25, 28, 23] and one in a school setting [27]. (Larsen et al., 2016), And one in a laboratory setting [26].

3.3 Risk of Bias Assessment

Among the seven articles evaluated, four [23, 28, 26, 24] were determined to have a low risk of bias. In contrast, two studies [25, 27] demonstrated a high risk of bias, particularly concerning the randomization process, deviations in the intervention administered to participants, inappropriate methods of outcome measurement, differences between intervention groups, omission of certain methods, and some analyses that did not meet the required standards. The results of the risk of bias assessment are presented in Figure 2.

Study	D1	D2	D3	D4	D5	Overall
Usama, et al. 2023	+	+	+	+	+	+
Pool, et al., 2021	+	+	+	+	+	+
Khodashenas, et al., 2019	+	+	+	+	+	+
Gruber, et al., 2020	-	+	+	+	-	-
Larsen, et al., 2016	+	-	+	-	+	-
Topcu, et al., 2022	+	+	+	+	+	+

Domain	
D1	Randomisation process
D2	Deviations from the intended interventions
D3	Missing outcome data
D4	Measurement of the outcome
D5	Selection of the reported result

Judgement	
+	Low risk
!	Some concerns
-	High risk

Figure 2. Summary of Risk of Bias

3.4 Impact of Physical Activity on Motor Skills

Among the six RCTs that investigated the effects of PA interventions on motor skill development in children with chronic illnesses, four studies reported statistically significant improvements from pre-intervention to post-intervention [23-26]. Conversely, two studies found no significant relationship between pre- and post-intervention outcomes [27, 28]. One of these studies involved a short-duration intervention (60 minutes per week) conducted in a hospital setting, while the other implemented a long-duration intervention (3 hours daily). Importantly, none of the studies reported any adverse effects of increased PA on motor skill development, suggesting that PA interventions do not negatively impact motor skill development in children.

3.5 Measurement Instruments

A variety of instruments were used to assess motor skills in children, including the Deutsche Motorik Test (DMT), the Bruininks-Oseretsky Test of Motor Proficiency, Brief Form (BOTMP-BF), the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2), the Movement Assessment Battery for Children, Second Edition (M-ABC-2), HUMAC Balance Score, Ozeretski Test, Goal Attainment Scale (GAS), Children's Functional Independence Measure, Canadian Occupational Performance Measure, and the Gross Motor Function Measure (GMFM-66 and GMFM-88). The choice of measurement tools for assessing motor skills varied among the studies. Typically, the children carried out assessments or by direct observation by trained research assistants. Despite the use of different instruments across studies, the validity of these assessments has been well-established, particularly when applied to children in hospital settings (Table 1).

Table 1. Characteristics of Studies Included in the Review

Study	Country	Chronic Diseases	Sample	Desain/ Setting	Outcome/ instrument	Intervention	Dosages	Findings
Pool, et al., 2020 [28]	Australia	Cerebral Palsy (CP)	Children aged 5-12 years; n=40. Females; n=18; Males; n=22. IG; n=20; CG; n=20.	RCT Hospital	IG: Locomotor exercises combined with Robotic Assisted Gait Training (RAGT+LT). CG: Locomotor exercises only. Measurement tools utilized: Goal Attainment Scale (GAS), Children's Functional Independence Measure, Canadian Occupational Performance Measure, and Gross Motor Function Measure (GMFM-66 and GMFM-88).	IG: Locomotor exercises combined with Robotic Assisted Gait Training (RAGT+LT), followed by locomotor exercises on a treadmill, and then over-ground walking training. CG: Locomotor exercises conducted solely on a treadmill, followed by over-ground training.	Three sessions per week, each lasting 60 minutes, for a duration of 6 weeks.	No significant differences were observed between the intervention group receiving RAGT+LT and the control group undergoing standard locomotor training.
Usama, et al. 2023 [23]	Egypt	Posterior fossa tumors	Children aged 5-12 years; n=60. Males; n=38; Females; n=22. CG; n=20, Postural stability group; n=20, Coordination group; n=20.	RCT Hospital	Stability and postural stability were assessed using the Modified Clinical Test of Sensory Integration of Balance (mCTSIB), the HUMAC Balance and Tilt System, and the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2).	The control group received a Pilates exercise program. The postural stability group received a Pilates exercise program combined with HUMAC training. The coordination group received a Pilates exercise program combined with BOT-2 coordination training.	The exercise program lasted for 60 minutes.	Significant improvements in postural stability and coordination were observed across all three groups, as measured by the Modified Clinical Test of Sensory Integration of Balance, center of pressure, limits of stability, bilateral coordination, and upper limb coordination.

Khodashenas, 2019 [24]	Iran	Asthmatic	Children aged 6-18 years; n=15. IG: n=9; CG: n=6.	RCT Hospital	Fine and gross motor skills were assessed using the Ozeretski Test.	The exercise program was supervised and structured to consist of warm-up exercises, a main workout (incorporating both aerobic and strength training), and cool-down exercises in each session.	Each session lasted 45 minutes and was conducted three times per week over an eight-week period.	The selective exercise program had a significant effect on improving fine and gross motor skills in children with asthma after the intervention (P < 0.05).
Gruber, et al., 2020 [25]	Germany	Fibrosis kistik (CF)	Children aged 6-17 years; n=22 Males; n=11 Females; n=11	RCT Hospital	Flexibility, balance, strength, power, and motor performance were assessed using the Deutsche Motorik Test (DMT). Maximal exercise capacity (Wpeak) was evaluated using an ergometer cycle test.	The 12-month exercise program, conducted as part of the CFmobil project, incorporated various physical activities, including trend sports, traditional sports, video games, and games designed to enhance motor skills. The training was supervised for the first 6 months, while the subsequent 6 months were unsupervised. Participants were required to document all their activities in a training logbook and attend clinic visits at regular intervals to monitor their physical exercise regimen.	30-60 minutes per week	The findings suggest that the long-term exercise program had a positive impact on motor performance in children and adolescents with cystic fibrosis (CF). Overall motor competence and performance on the DMT test items, with the exception of the forward bend, showed significant improvement up to T3 (p < 0.05). While girls scored lower on test items that relied on strength and power, they outperformed boys in balance-related tasks (p > 0.05).
Larsen, et al., 2016 [27]	Denmark	Overweight	Children aged 11-16 years; n=115	RCT School	Vertical jump, hand grip strength, balance, aiming, catching, and overall motor skills were evaluated using the Movement Assessment Battery for Children, Second Edition (M-ABC-2).	The study's intervention included a Day-Camp Intervention Arm (DCIA) and a Standard Intervention Arm (SIA).	Each day, the intervention lasted 3 hours over a period of 6 weeks.	The findings revealed that the day camp intervention led to an improvement in physical fitness but did not result in a significant increase in motor skills compared to the Standard Intervention Arm (SIA).
Topcu, et al., 2022 [26]	Turky	Obesity	Children aged 10 years; n=45. Females; n=25; Males; n=20.	RCT Laboratorium Kardiopulmonari	Motor skills were assessed using the Bruininks-Oseretsky Test of Motor Proficiency, Brief Form (BOTMP-BF).	The intervention in this study consisted of two primary groups: the Functional Exercise Group (FEG) and the Basketball Group (BG), in addition to a Control Group (CG).	Warming up: 15 minutes Strengthening and balance-agility exercises: 35 minutes Cooling down: 10 minutes	The total BOTMP-BF score showed a significant increase in the functional training group, indicating an improvement in motor skills. This increase in the total BOTMP-BF score was statistically significant (p < 0.001).

DISCUSSION

This review aimed to comprehensively synthesize and evaluate all published RCTs that examined the relationship between PA interventions and motor skill development in healthy children under 18. Six studies met the inclusion criteria and were included in the final analysis. Findings from four of these six studies indicated that increased physical activity significantly positively affected motor skill development in children. However, two studies reported no significant impact of PA on motor development. We suspect that factors such as the severity of the illness and the type of intervention administered to the children may have influenced these outcomes [27-29].

Overall, most studies observed beneficial effects of physical activity interventions on motor skill development in children, with most being conducted in hospital settings. Of the two studies that reported no significant impact, one was conducted in a laboratory and the other in a school setting. Based on these findings, we hypothesize that interventions designed to enhance motor skills in children with chronic illnesses may be more effective in hospital settings, where children spend a significant amount of time and adhere to structured schedules. In contrast, motor skill development may not improve significantly in school and laboratory environments, where adherence to physical activity programs may be less strictly monitored. One study reported that the intervention relied heavily on robotic assistance or physical support, and the complexity of the PA intervention, coupled with its long duration, may have led to a loss of interest over time, potentially affecting the results [28]. Another study highlighted that the intervention aimed at improving motor skills in children was unstructured, making it difficult to control.

To the best of our knowledge, this is the first systematic review to investigate the impact of physical activity on motor skills in children with chronic illnesses. We applied strict inclusion criteria and included only high-quality RCTs involving a homogeneous sample of children with chronic illnesses. Additionally, we identified participant retention as a potential major source of bias across studies. All included studies adequately addressed intervention fidelity and participant retention, strengthening the review's cumulative evidence. Although language limitations did not consistently bias the results of the narrative synthesis, there was heterogeneity in the measurement protocols and assessment tools used to evaluate motor skills across the studies. Using validated testing instruments minimized potential bias, further reinforcing the evidence from this review [24-26].

Moreover, there was some heterogeneity in the dosage of physical activity administered across the studies, with some interventions being short-term and others long-term. Some interventions lasted 30-60 minutes per week, while others involved 3 hours of activity daily for 6 weeks. Additionally, none of the studies assessed PA's potential moderating effects on children's motor skill development. The risks of bias identified in some studies included issues such as the absence of a proper randomization process, deviations in the intended interventions, inappropriate outcome measurement, and data processing errors [25-30].

Therefore, we recommend that future RCTs address the limitations identified in this review to strengthen the quality of the available evidence and ensure a clearer understanding of the long-term impact of physical activity interventions on motor skill development in children with chronic illnesses.

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