Virtual reality games in improving motor skills and physical activity in children with intellectual disabilities: a scoping review

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ABSTRACT

Virtual Reality (VR) has emerged as a promising technological innovation in education and rehabilitation, particularly for supporting motor development and physical activity among children with intellectual disabilities. This study aims to map and synthesize existing empirical evidence on the effectiveness of VR-based interventions in improving motor skills and physical activity in this population. A scoping review was conducted following PRISMA guidelines by systematically searching ScienceDirect, ProQuest, and Google Scholar databases for articles published between 2019 and 2025. From an initial yield of 1,009 studies, eight articles met the predefined inclusion criteria and were included in the final analysis. The findings indicate that VR-based interventions, especially those integrating virtual and real-world games, consistently improve walking ability, object control, and gross motor skills. Several studies also reported gains in muscle strength and coordination, although evidence regarding balance improvement remains inconsistent. Despite its potential benefits, challenges related to accessibility, intervention design, and individual adaptability persist. Overall, VR represents a valuable and engaging tool for enhancing motor skills and physical activity in children with intellectual disabilities. Future research should emphasize targeted program development, long-term outcome evaluation, and interdisciplinary collaboration to optimize VR-based rehabilitation and educational interventions.

Keyword: virtual reality; motor skill; physical activity; intellectual disabilities

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1. INTRODUCTION

Virtual reality (VR) has emerged as a revolutionary technology, not only in entertainment and gaming but also in the fields of education, therapy, and rehabilitation (Samala et al., 2023). Rapid technological advancements have positioned virtual reality as a major center of innovation (Waskito et al., 2024; Yanto et al., 2023; Nasution et al., 2025). Once considered a fictional concept, VR is now a widely accessible tool. From immersive gaming experiences to architectural simulations, VR has captured the imagination of millions worldwide. This technology creates simulated environments that actively engage users, transporting them into different worlds and scenarios with a high level of realism (Bojic, 2022; Mulders et al., 2020). Beyond entertainment, educators and therapists have increasingly recognized the potential of VR as an effective medium for learning and rehabilitation (Asad et al., 2022; Kim et al., 2020).

In educational contexts, virtual reality offers immersive and interactive learning experiences. Traditional learning methods often present challenges, particularly for students with diverse learning needs. VR addresses these limitations by providing dynamic, multisensory environments that accommodate various learning styles. In history education, for example, students can virtually visit cultural heritage sites without physically traveling to those locations (Utari et al., 2021). Learners can explore the complexity of the human body, while students in physics can conduct laboratory experiments virtually. Such immersive experiences not only increase learner engagement but also facilitate deeper understanding and long-term retention of complex concepts (Dwiasih, 2022; Harahap et al., 2023).

In the field of special education, where individualized learning is essential, virtual reality shows considerable potential. Children with intellectual impairments often face significant challenges in conventional learning environments (Munajah et al., 2020; Widiyanto & Putra, 2021). These challenges include difficulties in learning, social interaction, and accessibility (Clarisa et al., 2023). Students with intellectual disabilities typically have IQ scores ranging from 50 to 60. Although they may demonstrate relatively better social communication skills, they often experience delays in gross motor development compared to typically developing students (Cahyati Ngaisah et al., 2023; Putri & Damri, 2020; Yumaika & Ardisal, 2020). Therefore, gross motor skills—such as hand–eye coordination, balance, and overall motor control—can and should be systematically trained.

Virtual reality can serve as a bridge for learners with intellectual impairments by simulating real-world scenarios and providing practical, hands-on experiences. One notable application of VR is in the development of motor skills and physical activity. For individuals with intellectual impairments, limitations in motor skills can hinder daily activities and participation in physical exercise. Regular physical activity is essential for overall health; however, individuals with intellectual disabilities often experience low levels of physical fitness due to limited opportunities for physical engagement (Maulana et al., 2023).

Through immersive simulations and interactive games, individuals can practice and refine motor skills within a safe and supportive environment. VR enables targeted interventions, continuous feedback, and progress monitoring. Moreover, the benefits of virtual reality extend beyond skill acquisition to broader aspects of physical and mental well-being. Intellectual impairment encompasses a spectrum of cognitive limitations that affect learning, communication, and social interaction. For children with intellectual disabilities, access to quality and adaptive education is crucial for future development. Virtual reality presents a promising solution by offering learning experiences tailored to individual abilities. By further exploring this phenomenon, future research can better uncover the full potential of virtual reality in enhancing motor skills and physical activity among individuals with intellectual impairments.

2. RESEARCH METHOD

This study employs a qualitative descriptive research model in the form of a literature review, utilizing various scholarly sources to strengthen the research analysis. The research process begins with the collection of relevant literature, followed by the identification and examination of key terms related to the study. Subsequently, selected research articles are reviewed in depth, and an analytical synthesis is conducted by compiling and comparing findings across studies. Based on this analysis, conclusions are formulated, and recommendations are proposed in accordance with the results obtained.

The article search process was conducted through online databases, including ScienceDirect, ProQuest, and Google Scholar, using the keywords *"Virtual Reality," "Motor Skills," "Physical Activity,"* and *"Intellectual Disability."* The search was limited to publications from 2019 to 2025 to ensure the relevance and recency of the literature. Articles that met the inclusion criteria were selected for further analysis and summarized according to the following components: author(s), year of publication, research design, research objectives, sample characteristics, instruments used, and key findings.

The selected journal articles were compiled into a summary table, organized alphabetically by author and chronologically by year of publication, following a standardized format. This literature review included only scientific articles available in full-text PDF format. To ensure clarity and accuracy, both the abstracts and full texts of the selected articles were carefully read and examined. The analysis focused on identifying patterns, similarities, and differences in research findings related to the use of virtual reality.

Through clearly defined inclusion and exclusion criteria, this literature review investigates the impact of virtual reality on motor skills and physical activity in children with special needs, particularly those with intellectual impairments. By synthesizing evidence from multiple studies, this research provides a comprehensive overview of the potential benefits of virtual reality interventions in this context.

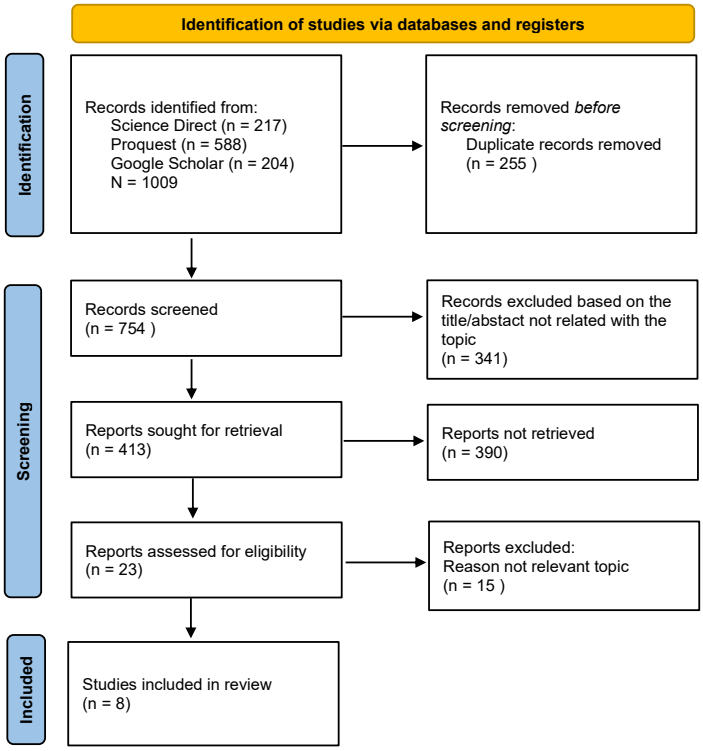

Figure 1. PRISMA Flowchart

3. RESULTS AND DISCUSSION

In this section, the results of the research are explained and followed by a comprehensive discussion. The results can be presented in the form of images, graphs, tables, and other findings. The article search process from three databases resulted in 1,009 articles, and after passing through the initial to final screening stages in accordance with the inclusion criteria, a total of eight articles were selected. Table 1 describes the analysis of the selected articles, including the researchers, research titles, and research results.

Table 1. Article Search Matrix Results

Researchers	Research Title	Research Results
Regaieg et al., 2021	Hybrid program based on virtual and real games increases fundamental movement skills in children with intellectual disability: A quasi-experimental study	This study evaluated two pedagogical strategies in customized physical education (virtual vs. conventional hybrid) in children aged 7–10 years with intellectual impairment. The children (N = 24) were randomly assigned to hybrid (experimental) or conventional (control) groups and evaluated over 10 weeks. Hybrid programs used virtual and real games, while conventional programs focused on customized sports. Results showed significant improvement in walking skills in both groups, with greater improvement in the hybrid group. Significant improvements were also observed in object control skills and gross motor skills in the hybrid group. These findings suggest that hybrid programs could be beneficial for improving fundamental movement skills in children with intellectual impairment.
Flores-Gallegos et al., 2022	Effects of a virtual reality training program on visual attention and motor performance in children with reading learning disability	The study found that training with action and motor integration using virtual reality games had statistically positive effects on motor balance, motor coordination, and visual attention in children with reading learning disabilities. The results demonstrate the potential of designing cognitive training programs using commercial games and customized designs for specific purposes and populations, opening new possibilities in rehabilitation program development.
Cheung et al., 2022	Virtual reality-based multiple life skill training for intellectual disability: A multicenter randomized controlled trial	In a multicenter randomized controlled trial, participants were divided into three groups: VR training, traditional training, and control. The study evaluated the transformation of traditional life skills training into a virtual reality environment. Key outcomes

Researchers	Research Title	Research Results
		included performance assessments in shopping, cooking, and cleaning tasks. VR training involved the same tasks as traditional training but in a virtual environment with gradual levels of difficulty. The study focused on improving independence, self-efficacy, and decision-making skills through immersive VR simulations, with assessments conducted before and after training.
Wang et al., 2022	Eight-week virtual reality training improves lower extremity muscle strength but not balance in adolescents with intellectual disability: A randomized controlled trial	Virtual reality (VR) technology is emerging as an alternative intervention method to improve motor skills in individuals with developmental disorders. Although VR training showed positive effects on lower extremity muscle strength, balance improvements were not significant. The study highlights the need for further research to optimize VR intervention designs for individuals with developmental disorders.
Park et al., 2022	Effect of a cognitive function and social skills-based digital exercise therapy using IoT on motor coordination in children with intellectual and developmental disability	The study compared a cognitive and social skills-based virtual reality exercise system (CS-VR) with a conventional VR exercise system (C-VR). The CS-VR group showed significant improvements in motor coordination, particularly in horizontal jumping, jumping, and hand-top throwing, compared to the C-VR group. Significant improvements were also observed in standing long jumps. These findings suggest the importance of developing exercise programs that reflect cognitive and social skill levels for improving motor skills in children with intellectual impairment.
Lee et al., 2022	The effect of a virtual reality exergame on motor skills and physical activity levels of children with a developmental disability	The study showed that VR-based physical activity programs effectively improved locomotor skills in children with developmental disabilities. Ball skills also improved but without significant differences. Physical activity levels did not significantly increase in either group. Exergames were found to be effective in improving motor skills, as well as executive and cognitive functions, using a randomized pretest–posttest design.
Li et al., 2023	Effects of virtual reality-based exercise on physical fitness in people with intellectual disability: A systematic review of randomized controlled trials	This systematic review included 13 randomized controlled trials with good research quality. Outcomes evaluated included muscle fitness, cardiorespiratory endurance, flexibility, body composition, balance, coordination, speed, agility, and overall motor proficiency. Early evidence suggests that VR-based exercise can improve muscle fitness, cardiorespiratory endurance, balance, and speed and agility in individuals with intellectual disability, although evidence for other outcomes remains limited.

The application of Virtual Reality (VR) technology in improving motor skills and physical activity in individuals with intellectual impairment has shown promising results. Virtual reality is a computer simulation technology that creates environments that look and feel realistic (Brivio et al., 2021). The advantages of VR include total immersion, realistic simulation, limitless exploration opportunities, and the potential for interactive learning experiences (Waskito et al., 2023).

Across the eight reviewed studies, the integration of virtual and real games was found to effectively improve walking ability, object control, and gross motor skills in children with intellectual impairment. These findings indicate that VR not only provides an engaging simulation environment but also produces tangible improvements in motor skills and physical activity.

However, limitations in VR application must be acknowledged. One key limitation is the inconsistency of evidence regarding balance improvement. Motor balance refers to the ability to maintain body stability during movement or rest to prevent falls (Gusril et al., 2024; Lengkana et al., 2020; Pranoto et al., 2023). Despite observed increases in muscle strength, balance improvement remains a challenge and requires further investigation.

Additionally, not all individuals with intellectual impairment may have equal access to or benefit optimally from VR technology, particularly those with more severe cognitive or physical limitations. These findings suggest that while VR is effective in improving motor skills and physical activity, further research is needed to optimize its application across varying levels of intellectual impairment. The development of tailored VR content and clear implementation guidelines for health and education professionals is essential.

Future research should focus on developing more targeted intervention programs that integrate physical and cognitive health holistically. Exploring personalized VR-based therapy approaches that consider individual characteristics and needs is also recommended. Long-term evaluations are necessary to assess sustained effects on motor skills and physical activity. Collaboration among researchers, healthcare

professionals, educators, and VR developers will be crucial in creating effective, inclusive, and sustainable VR-based interventions that enhance the quality of life of individuals with intellectual impairment.

4. CONCLUSION

Virtual Reality (VR) technology opens up new opportunities for improving the motor skills and physical activity of children with intellectual impairments. The integration of virtual and real games has proven effective in enhancing walking ability, object control, and gross motor skills. However, challenges remain, including limitations in balance improvement and accessibility. Therefore, the development of more targeted intervention programs, long-term evaluations, and stronger collaboration between researchers, health professionals, and VR technology developers is needed. These efforts aim to design more effective and inclusive solutions to improve the overall quality of life of children with intellectual impairments.

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