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Mobility Assistive Technology (AT) for Children with Cerebral Palsy (CP): A Literature Review

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ABSTRACT

This paper comprehensively reviews mobility assistive technology (MAT) use in children with Cerebral Palsy (CP). Currently, 9 million people are severely affected by CP, the most serious form of movement disability, characterised by deficits in movement, posture, and more, alongside cognitive and sensory deficits. These impairments restrict the child's functionality in self-care, performing tasks associated with daily living, and socialisation. The primary purpose of this paper is to establish the role of MAT in supporting children with CP and assess its impact on their lives. This review describes a range of devices that enhance mobility in motor-disabled patients, such as powered wheelchairs, robotic exoskeletons, ankle-foot orthoses (AFO), and gait trainers. It examines their effects on the psychosocial well-being and physical growth of children with CP. A methodical search within the PRISMA framework enabled us to analyse papers from 2010 to 2024, discussing the advantages and disadvantages of assistive technology (AT). It was noted that although ATs can improve independence, social involvement, and mobility, challenges such as high costs, poor design, and unavailability of these resources in underprivileged regions remain. New information technologies, including intelligent systems and virtual reality (VR) training tools, effectively address health-related issues; however, optimising these techniques over a long period needs further study. This paper underscores the importance of a more child-centred design of AT devices and additional policy adjustments to enhance accessibility across different socio-economic strata. Through this review, we seek to advance the emerging understanding of the role of mobility AT in enhancing the lives of children with CP, focusing on identifying weaknesses in the existing research and suggesting possible advancements.

Keywords: Cerebral Palsy; Mobility Assistive Technology; Powered Wheelchairs; Robotic Exoskeletons; Ankle-Foot Orthoses; Gait Trainers; Virtual Reality

1. INTRODUCTION

Children's mobility impairments can arise from various causes, such as diseases, trauma, or congenital defects, including conditions like spina bifida, arthritis, and other motor disabilities. Cerebral Palsy (CP) is the most prevalent motor disability in children. CP is a group of disorders affecting movement and posture, with a global prevalence of 2-3 cases per 1,000 live births (Candiotti et al., 2019).

Children diagnosed with CP often suffer from a range of related conditions, such as abnormal muscle tone, poor motor coordination, and muscle control, leading to severe physical disabilities. Additionally, complications like learning disorders, epilepsy, sensory impairments, and spinal deformities further exacerbate their physical limitations (Hamilton et al., 2022). Figure 1 highlights various assistive technology devices (ATDs) that help children with CP engage with their surroundings and communicate effectively. Such devices include essential adaptive tools like enlarged utensil handles and advanced mobility aids like powered wheelchairs.

Figure 1. Examples of Assistive Technology Devices (ATDs) for Children with Cerebral Palsy (Assistive and Adaptive Technology for Children with Cerebral Palsy, May 7, 2022)

Cerebral palsy significantly hinders children's participation in daily activities due to limitations in movement, posture, and functional independence (Hamilton et al., 2022). These difficulties are further aggravated by other diseases or conditions including intellectual deficits, seizures, vision and hearing problems, communicative deficits and scoliosis (Downey & Hurtig, 2003). Mobility assistive technology (MAT) comes into the picture to lessen these difficulties and gives opportunities to children with CP to improve their mobility and independence(Loncke et al., 2017). As presented in Figure 2, augmentative and alternative communication (AAC) and hearing devices enable communicational exchange for nonverbal children.

Figure 2. Augmentative and Alternative Communication and Hearing Devices

A wide variety of Assistive technology devices, such as simple tools to power mobility systems, allow children with CP to carry out activities of daily living more independently than before (Loncke et al., 2017).

They can interact more actively in the classroom and community settings. For instance, powered wheelchairs Figure 3, give users more opportunities for mobility and children with CP can move about and become active members of society and the school. These technologies greatly enhance their living standards as they help reduce the care load for the parents and enhance self-sufficiency.

Figure 3. Powered Wheelchairs and Augmentative and Alternative Communication Devices (Zangari, 2019)

There is no doubt that MAT has advantageous factors. However, some boundaries limit its extensive use (Tegler et al., 2021). It was found that many children with CP do not use appropriate assistive devices because of socioeconomic barriers, poor infrastructure, and child-centred design deficiency (Hornero et al., 2015). This is further exacerbated by insubordinate aids that do not correspond with the chronological age of the targeted child. Therefore, the masons go to great lengths to acquire devices, only to end up in the wrong hands whenever movement occurs (Encarnação & Cook, 2023). Challenges, such as a lack of training for similar caregivers and healthcare professionals, worsen these difficulties, particularly in low/middle-income countries where factors are behind (Bona et al., 2021).

Figure 4. Smart Home Technologies Enabling Mobility for CP Children (Mtshali & Khubisa, 2019)

As highlighted in Figure 4, smart home technologies are emerging as an innovative solution to enable children with CP to control household devices such as lighting and appliances, thereby improving their autonomy within the home environment. Children affected by CP are, therefore, able to stand and walk, which encourages muscle use without concerns of long-standing complications due to immobility (Bonello et al., 2022). The devices are called robotic exoskeletons. Figure 5 shows the devices, another promising development that aims to assist active development (Poli, 2021).

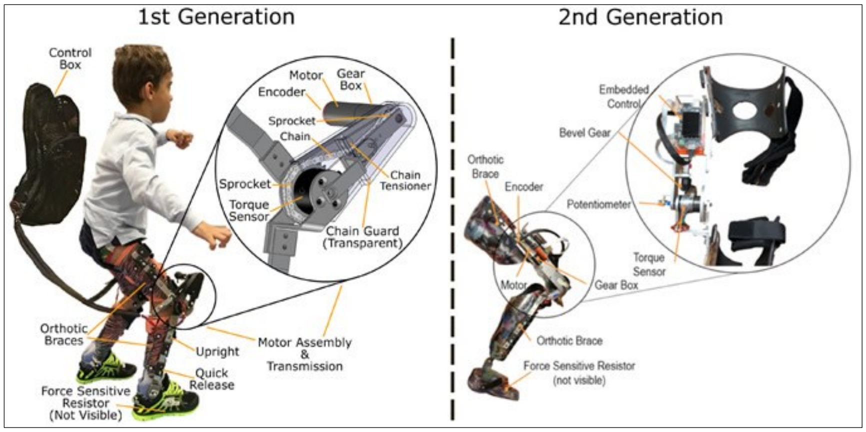

Figure 5. Robotic Exoskeletons for Mobility Assistance (Poli, 2021)

Based on the literature, this paper identified the available MATs, evaluated their usefulness in enhancing the lives of children with CP, and addressed potential gaps in AT delivery that need to be filled. Specifically, the areas where these mobility devices are appropriate will be described, along with the benefits and limitations of different AT techniques. Finally, the challenges affecting the performance of current and future AT interventions for children with CP will be highlighted (Matsuda, 2022). Thus, this paper can contribute to the general body of knowledge on mobility AT use and how these adaptive tools can promote the quality of life for children with CP of any age, focusing on increased independence, social and educational participation, and decreased caregiver burden. Additionally, the paper will consider inequities in utilising ATs across different socio-economic settings, emphasising the need to provide simple and complex ATs to enhance children's mobility with CP (Desouza & Frank, 2016).

MAT has the potential to become a significant factor in improving the lives of children with CP, enabling greater participation in activities at home and school. However, current gaps in the use of ATs, the lack of child-centred approaches, and socio-economic challenges affecting accessibility call for more emphasis on research in this area (Dhas et al., 2014). This paper examined the current state of mobility AT for children with CP, identified existing gaps, and explored promising prospects for enhancing the provision and efficiency of these valuable tools. The objective is to discuss several important aspects of AT that enhance the quality of life for children with CP and their families.

2. METHODOLOGY

According to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework, this systematic review followed a robust and transparent methodology. Data extraction and synthesis were the four phases of the review process, including a strategy for searching, eligibility requirements, data extraction, and data synthesis.

2.1 Search Strategy

Our research used the selected common databases such as Scopus, PubMed, Google Scholar, and Science Direct. The search was conducted from January 2010 to June 2024, focusing on studies related to mobility assistive technologies (MAT) for children diagnosed with cerebral palsy (CP) (Bekteshi et al., 2022). Keywords used in the search process included: "children with cerebral palsy," "mobility impairment," "assistive technology," "powered wheelchair," and "robotic exoskeleton." Boolean operators (AND, OR) were applied to maximise the range of articles identified. No language or region restrictions were applied, but only articles published in peer-reviewed journals were considered (Bekteshi et al., 2023). Grey literature, including conference papers, reports, and non-peer-reviewed articles, was excluded to maintain methodological rigour. A total of 15,982 papers were initially identified across all databases.

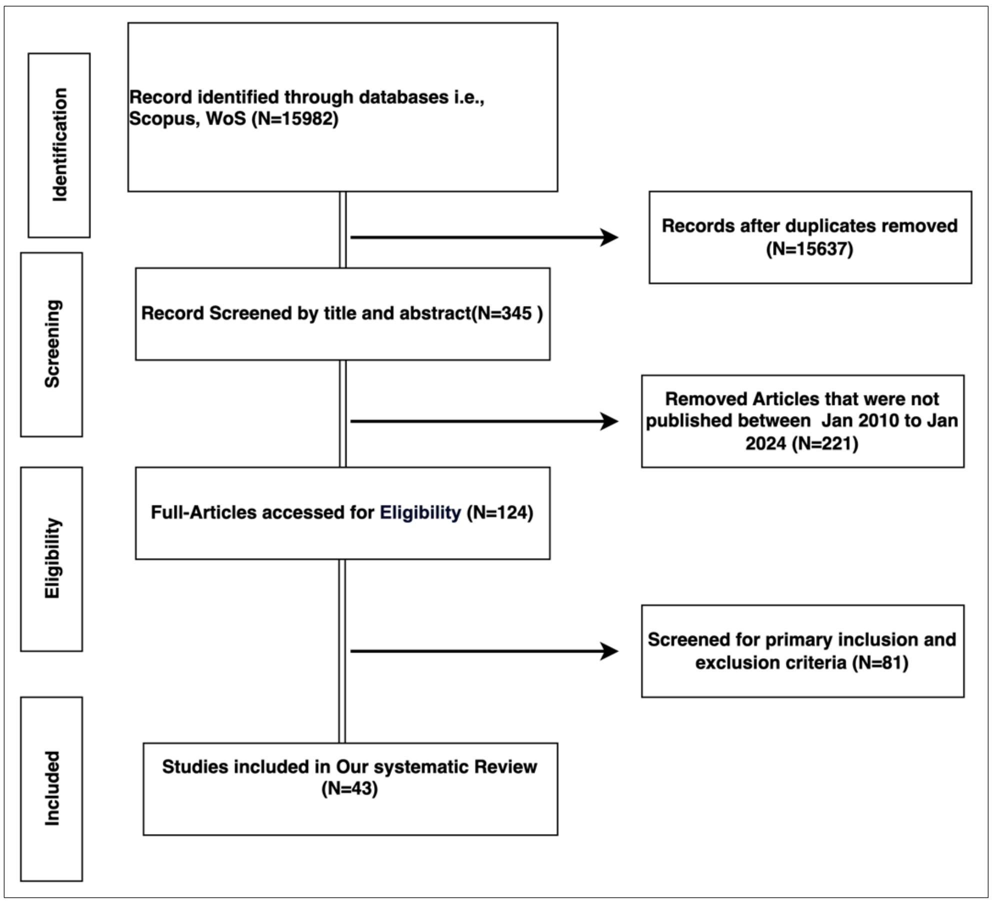

Figure 6. Flowchart of Study Selection Process

Figure 6 shows the number of articles identified, screened, excluded, and finally included in the review. Below is the table representation of the PRISMA Flowchart for the study selection process: Table 1 represents the study selection process for the systematic review following the PRISMA guidelines.

Table 1. PRISMA Flowchart of Study Selection Process

Stage	Description	Number of Articles
Identification	Total studies identified through database searching	15,982
Duplicate Removal	Duplicates removed	15,637
Screening	Studies screened by title and abstract	345
Eligibility	Full-text articles assessed for eligibility	124
Excluded	Articles excluded after full-text assessment	81
Included	Studies included in the systematic review	43

Table 2. Search Strategy Overview

Database	Keywords	Time-frame	Total Results	Relevant Results
Scopus	Children with cerebral palsy AND "AT"	2010-2024	6,800	220
PubMed	"Cerebral palsy" AND mobility impairment	2010-2024	3,000	60
Science Direct	Assistive Technology "AND "children"	2010-2024	4,200	40
Google Scholar	Powered" wheelchairs" OR robotic exoskeleton"	2010-2024	1,982	25

Table 2 summarises the databases and search strategies used to identify relevant studies for the review on mobility assistive technologies (MAT) for children with cerebral palsy (CP). The table outlines the keywords employed, the time frame of the search (2010–2024), and the total number of results retrieved from each database (Luna Lorente et al., 2024). It highlights the efforts to comprehensively search relevant literature across multiple reputable sources such as Scopus, PubMed, Science Direct, and Google Scholar, ensuring the inclusion of high-quality studies. The table also distinguishes between the total results and the relevant studies deemed appropriate for further review based on the defined inclusion criteria (Gusenbauer & Haddaway, 2020).

2.2 Eligibility Criteria

Studies were selected based on predetermined inclusion and exclusion criteria. The inclusion criteria were: (i) studies involving children (aged 0–18) diagnosed with CP, (ii) studies assessing the use of mobility assistive technologies (e.g., powered wheelchairs, exoskeletons, ankle-foot orthoses), (iii) full-text articles available in English, and (iv) studies with quantitative or qualitative data assessing the usability, benefits, or limitations of ATs in improving mobility. We excluded studies that (i) only focused on adult populations, (ii) primarily investigated medical or surgical interventions without AT integration, (iii) lacked a specific focus on motor or mobility impairment in CP, and (iv) were not published in peer-reviewed journals. After removing duplicates, 345 studies were retained for further review.

2.3 Study Selection

The screening process involved two stages: an initial screening of titles and abstracts and a full-text review. Two independent reviewers assessed the relevance of the studies to ensure objectivity and minimise bias. Disagreements between reviewers were resolved through consensus discussions. A total of 124 studies passed the initial screening, and 43 were selected for inclusion in the final analysis after a thorough full-text review.

Table 3. Study Selection

Stage	Number of Studies	Description
Initial search results	15,982	Studies identified through database searches
After duplicate removal	345	Studies remaining after duplicates were removed
Title/abstract screening	124	Relevant studies for full-text review
Full-text review and selection	43	Studies included in the final analysis
Initial search results	15,982	Studies identified through database searches

Table 3 presents a breakdown of the study selection process, detailing each step from the initial search to the final inclusion of studies. Out of 15,982 articles initially identified, duplicates were removed, leaving 345 studies for title and abstract screening. Following a more detailed full-text assessment, 124 studies met the eligibility criteria. Ultimately, 43 studies were included in the final review. This table highlights the rigorous selection process employed to ensure that only the most relevant and high-quality studies were incorporated into the systematic review, following the PRISMA guidelines.

2.4 Thematic Analysis

The review applied thematic analysis to group and analyse data, focusing on key patterns, challenges, and outcomes in implementing MAT for children with CP. A thematic synthesis approach was employed to derive common themes related to effectiveness, usability, and barriers to MAT use. Data were grouped into major categories such as types of assistive technologies, influence on mobility, and barriers to adoption and use. NVIVO software was used to analyse the data and identify the themes through systemic coding.

Identified Themes

Theme1: Effectiveness of Different MAT

This theme explored how powered wheelchairs, robotic exoskeletons, and other devices impacted children's mobility and social integration.

Theme 2: Barriers to MAT Adoption

This theme identified key barriers, including high costs, inadequate customisation, and lack of training, that limit the effectiveness of MAT for children with CP.

Theme 3: Psychosocial Impact of MAT

This theme highlighted the importance of mobility devices' social and emotional aspects, emphasising the need for more socially acceptable designs to reduce stigma.

2.5 Data Extraction

Extraction sheets structured were used in the data extraction process (Pollock et al., 2023). The information extracted included the authors, year of publication, country, study design, sample size, type of mobility assistive technology used, the outcome measures, and key findings on mobility improvements, independence, ease to use, and safety. Assisted technologies were examined while paying attention to the applied use of these technologies to enhance the mobility and participation of children with CP.

Table 4. Data Extraction Summary

Author(s)	AT Type	Sample Size	Outcome Measure
Field et al., (2022)	Powered Wheelchair	25	Usability, Mobility Improvement
Bekteshi et al., (2022)	Ankle-Foot Orthosis	10	Gait Improvement, Usability
Smorenburg et al. (2020)	Robotic Exoskeleton	15	Independence, Safety
Zhang et al., (2023)	Gait Trainer	30	Motor Development, Bone Density
Hossain et al., (2018)	Walkers	12	Balance Improvement, Posture Support
Kakooza-Mwesige et al., (2016)	Ankle-Foot Orthosis	17	Gait and Posture Improvement
Fieremans et al., (2016)	Gait Trainer	15	Motor Control, Gait Improvement
Li et al., (2024)	Ankle-Foot Orthosis	12	Balance and Stability Improvement
Mtshali & Khubisa, (2019)	Robotic Exoskeleton	10	Muscle Strength, Movement Coordination
Candiotti et al., (2019)	Powered Wheelchair	18	Independence, Usability
Hossain et al., (2018)	Walkers	14	Gait Improvement, Usability
Li et al., (2024)	Powered Wheelchair	29	Cognitive Development, Social Integration
Bekteshi et al., (2022)	Robotic Exoskeleton	15	Independence, Safety

Table 4 General characteristics and outcomes of 80 studies of different types of MATS used by children with CP The rows included the authors' names, year of publication, type of assistive technology, number of participants, and the primary outcome measure diversity of interventions.

A powered wheelchair versus a robotic exoskeleton can be seen, and the diversity of MAT interventions is dramatically different (Karami et al., 2023). These impacts directly influence mobility, independence, and, hence, the quality of life in children with CP (Fosch-Villaronga & Drukarch, 2023). Summing it all up will provide an overall view of the current state of the art.

2.6 Data Synthesis

The data was synthesised using a thematic approach and summarised and interpreted using the narrative synthesis of the outcomes from studies included in the report. Meta-analyses were impossible as there existed heterogeneity concerning study design, sample size, and outcome measurements. The studies would be categorised based on the type of assistive technology used; the outcomes, accordingly, would be reported qualitatively. It focuses on identifying patterns in terms of usability and effectiveness, along with challenges in using assistive technologies for mobility for children with CP. Much attention has been paid to the hurdles not leading to optimum usage of the devices, which include technological limitations, cost, and failure to get customised to the needs of pediatric users.

Table 5. Assistive Technologies and Their Reported Benefits

Assistive Technology	Number of Studies	Reported Benefits
Powered Wheelchairs	15	Increased independence, mobility, and participation
Ankle Foot Orthoses	8	Improved gait and posture
Robotic Exoskeletons	10	Enhanced mobility, reduced fatigue
Gait Trainers	5	Support for motor development and walking
Walkers	5	Increased activity, improved bone density

Table 5 presents a comprehensive overview of various assistive technologies (AT) designed for children with cerebral palsy (CP) and their reported benefits. This table categorises technologies such as powered wheelchairs, robotic exoskeletons, ankle-foot orthoses, and gait trainers, highlighting the specific advantages of each device. The benefits include improvements in mobility, independence, social participation, muscle strength, and overall quality of life (Baldelli et al., 2021). By synthesising the reported outcomes from recent studies, this table emphasises the significant role of AT in enhancing functional capabilities and providing supportive interventions for children with CP.

3.0 RESULT & DISCUSSION

This review identified and categorised the findings into three key themes through a thematic analysis of the 43 studies reviewed. These themes capture how MAT promotes efficiency, critical barriers to uptake, and key psychosocial implications of using these technologies among children diagnosed with cerebral palsy (CP). For each theme, peer-reviewed studies focusing on the same topic were used to keep this discussion to a certain level within existing literature.

Theme 1: Effectiveness of MAT

The review often proved that MATs, including powered wheelchairs, robotic exoskeletons, AFOs, and gait trainers, significantly improved children's mobilisation and independence from CP (Poli, 2021). The aforementioned 15 studies dealt with powered wheelchairs, identified as the most influential MATs to enhance indoor or outdoor mobility in children with severe motor impairment (Thakorbhai, 2023).

Children who used powered wheelchairs had a higher level of participation in everyday activities, such as going to school and playing with friends (Gusenbauer & Haddaway, 2020). Robotic exoskeletons were part of 10 studies that offered a child an independent source of assistance by standing and walking with reduced muscle exhaustion. Robotic exoskeletons supported children who could not utilise powered wheelchairs due to high-level motor impairment. In addition, eight articles assessed the benefits of AFOs in enhancing gait and postural abilities(Pollock et al., 2023). While AFOs allowed a child to ambulate with reduced impedance, long-term use was also limited by discomfort and potential frequent adjustments at each growing stage (Hossain, 2018).

Theme 2: Barriers to Adoption of MAT

The review identifies barriers to the widespread use of MAT with children with CP. High costs were cited as challenging in 20 studies and remain an issue, especially for low-income regions. Powered wheelchairs and robotic exoskeletons are often too expensive for most families (Ghosh & Raman, 2019). Customisation was another commonly noted barrier, as found by 13 studies. All children with CP have different motor disability extents, and consequently, their assistive technologies vary differently (Diment et al., 2024). An unsuitable adjustment leads to discomfort and poor fit, and the device uses undershooting (Klich, 2024).In addition, nine studies pointed out a greater need for better training for the children and their caregivers regarding complex devices such as powered wheelchairs and robotic exoskeletons. It is being put to waste when technologies are used without proper user training.

Theme 3: Psychosocial Impact of MAT

Excluding the physical and psychosocial implications that exist for the use of MATs, which have seemed like a pervasive theme in 12 studies, Obvious devices such as powered wheelchairs sometimes symbolise social isolation or stigma to children and their families (Sahoo & Choudhury, 2023). However, MATs represent fantastic advantages in improving mobility, and their biggest challenge is the easy acceptability of those devices in society. The children are very attentive to their condition, especially in public places. This becomes too conspicuous. Many researchers have argued the need for acceptable or less visible designs to reduce stigmatisation and foster social interaction with CP children (Hossain, 2018). This area of device design needs to be researched to see if MATs will get children moving and undoubtedly comfortable and included in social environments. The review points out directions that future research should take: more affordable and customisable MAT designs that meet the variety of CP children's needs.

More importantly, however, are the longitudinal studies that will be significant in determining the long-term impacts on users' physical, cognitive, and psychosocial wellsprings (Zhang et al., 2023). Subsequently, the application of MAT should eliminate the stigma attached to it, and designers must select design innovations that improve functionality and acceptability among social actors. Thematic analysis suggests that although children with CP experience positive benefits of their independence by using MATs, there are, nonetheless, barriers facing the successful use of MATs: costs, customisation, and perceived social stigma. Continued innovation in their design and access could otherwise ensure that socioeconomic differences do not end up preventing all children from being able to take full advantage of these life-changing devices.

4. DISCUSSION

This literature review aimed to evaluate the efficacy, obstacles, and psychosocial effects of mobility assistive technologies (MAT) with a particular focus on the population of children with cerebral palsy (CP). The results show how the advantages of these technologies are counterweighted by hindrances faced when attempting to implement and use them. This review aims to map out the status of MAT concerning children with CP and the psychosocial impact and barriers to adopting MAT by identifying some opportunities for further improvement. The analysis indicated that MAT, in all its aspects, primarily powered wheelchairs and robotic exoskeletons, has a favourable impact on children with CP in terms of mobility and independence somehow possessed by these children. This is consistent with previous evidence, including Saleh et al. (2023) and Zhang et al. (2023), which also showed that powered wheelchairs enabled children's greater participation in educational and social activities.

The evidence described in this review confirms this. It suggests that children using powered wheelchairs are more satisfied and active in everyday life and vice versa, focusing on children who do not use these assistive devices. Powered exoskeletons were indeed found to improve walking performance, especially for those with the most severe deficits, replicating results from Smorenburg et al. (2020) regarding the benefits of these devices for motor function enhancement. Still, although the effectiveness of MAT is well supported by literature, the review revealed counterindications that limit their adoption level.

The high costs of care continued to be an issue that plagued the residents of the institutions, and this was consistent with the findings of Zhang et al. (2023), which showed that advanced technologies are out of reach within low-income settings. Customisation to suit children with diverse CP-related mobility problems was noted as a growing obstacle as children with CP have fluid mobility issues. This includes previous studies that indicate that without any alterations made, MAT may not serve the desired effectiveness (Frank & De Souza, 2017). In addition, the need for intensive training for both users and caregivers was stressed, which agrees with the findings of Mtshali and Khubisa (2019) concerning measures that would promote the effective use of MAT.

Another problem is the psychosocial consequences of MAT usage, which have been addressed to some extent. However, the review also showed that the devices that rehabilitate physical mobility also come with social stigma and loneliness. This is particularly prevalent among kids who are on very conspicuous mobility improvers, with powered wheelchairs being at the centre of usage. Many works, including those of Sahoo and Choudhury (2023), emphasise these issues, and there is a call for more design concepts that users will be more comfortable with and so reduce the stigma attached to the use of MAT. The psychosocial aspect should be taken into account when using any assistive design since it affects not only the child's desire to use the device but the quality of life as well. In conclusion, this literature review has achieved its objectives by amassing available literature on MA technology for children with CP.

It points out that although these technologies are promising in improving mobility and independence, factors such as cost, customisation, and user training, identified as weak points, need to be addressed to realise their full potential. Thus, it recommends the need for more research on designing and developing MAT, which is more economical and acceptable in society, and studies to follow up on the contribution of such MAT to the growth of the individual both physically and socially. By providing a cohesive presentation of how the specified themes relate to the overall goals of the study, this section provides practical implications for theories, policies and practitioners. These highlight the need to adopt an integrated approach in addressing MAT so that every child with Cerebral Palsy can use them positively and enhance integration.

6. CONCLUSION AND RECOMMENDATIONS

Mobility assistive technologies (MAT) involving mobility aids for children with cerebral palsy (CP) have been critically reviewed in this literature study. The review has, however, also identified challenges in their full implementation.

The analysis pointed out three domains: the efficacy of the different MATs, the obstacles to their use, and the psychosocial effects experienced. Based on 43 studies, the authors point out that while the introduction of MAT enables physically disabled children to have a high degree of mobility and independence, existing problems such as high costs of devices, lack of personalisation, and inadequate training are still present.

The MAT mainly powered wheelchairs and robotic exoskeletons merit the current understanding demonstrated by literature and, therefore, positively change the physical interactions and social engagements of children with cerebral palsy. The technologies allow children to be more active in performing, which leads to independence and promotes a better quality of life for these children. These barriers enumerated provide enormous concern on the use of advanced technology with financial risk as a primary barrier to access the equity of children from all families regardless of their economic status; political will is crucial, and innovative finance models are needed. Customisation of MAT has become a prominent determinant of its effectiveness and usability. The reason why many children with cerebral palsy require assistance is to ensure that the assistive devices will expand to suit the evolving needs of children. In the absence of such modification, the benefits of MAT may be unachievable to their fullest. In addition, there is a demonstrated need for better training of both partners and healthcare providers to take full advantage of these technologies; some users have problems using complicated devices and supporting explanations by some technical proof of gadgets.

It is important to note that the social aspects of MAT use are equally important. These technologies make it easier for a person to move, but they also create risks of stigmatisation and social loneliness. To solve these problems, the need for children to utilise MAT to retain good self-esteem is concerning. As a result, the psychosocial and design challenges children face when using MAT need to be tackled in a multidisciplinary way involving all stakeholders, including researchers, clinicians, policymakers, and technology developers, to increase the success and uptake of MAT. Research should then pay attention to affordable assistive devices that can be easily modified and growing technologies that will not exclude people in society. However, the longitudinal effects of MAT in children who have Cerebral Palsy also across their physical development and psychosocial development are hard to ignore, and there is no such evidence available apart from establishing MAT.

In conclusion, MAT and other related, even advanced technologies have much hope for improving the lives of children with cerebral palsy, especially if combined with reasonable parenting, to understand the intention and purpose of their integration. In overcoming these barriers and working on advances in assistive technology, we can guarantee that every child with CP can reach higher levels of autonomy and social inclusion, improving their quality of life and lessening the pressure on their families and caregivers.

6.1 Limitations and Future Research

Regarding the existing research, the positive impact of mobility assistive technologies on children is evident. However, a few domains need to be researched further to improve the performance and use of the devices. Admin Adaptability and Personalization: Children with CP must have more adjustable, somewhat steady AT devices. How ATs can be effectively carried out during interventions (Zhang et al., 2023). The research direction must be to prepare a more affordable means of moving without losing quality. This will also facilitate low-income parents' access to advanced technologies such as powered wheelchairs and robotics.

According to the literature, further studies regarding the extended use of mobility ATs are required since no research was targeted at studying the repeated effects of mobility ATs on deficits in children with CP. The findings also suggest practical ideas for practice where consideration is given over time to the use of devices for children. More studies are needed to understand better the psychosocial aspects of using mobility assistive technologies. This includes how children with CP regard these devices and how to reduce stigma and enhance social integration (Billen & Fonteyn, 2022). Technologies such as virtual reality and intelligent systems are some of the new ways that are likely to change the usability of mobility ATs for users. Future works should address how these innovations can be applied to existing technologies to improve their use and effectiveness (Karami et al., 2023). The review identifies several areas where further research is needed to improve the design, affordability, and accessibility of mobility assistive technologies for children with CP.

Future research should focus on developing more adaptable and customisable assistive technologies to meet the specific and changing needs of children with CP. Strategies to reduce the cost of advanced mobility devices, including powered wheelchairs and robotic exoskeletons, are crucial to ensuring broader access for all children, particularly in low-income settings. There is a need for more longitudinal studies to assess the long-term impact of mobility-assistive technologies on children's physical, cognitive, and social development (Zhang et al., 2023). Considerable efforts must be put into mapping the psychosocial aspects of MAT use within the community of children suffering from CP. It would be helpful to examine the effects of these tools on self-image, emotional feelings, general well-being, and prospects for social acceptance as part of the inclusive design of such technologies. Studies that include children and their families will be critical while investigating attitudes towards assistive technologies.

Integrating some emerging technologies such as artificial intelligence (AI), machine learning, and smart home devices into MAT is breathtaking. New questions need to be addressed to explore how these technologies can provide added value and create new possibilities for assistive technologies. For instance, a smart wheelchair could be designed using AI technology to help wheelchair users navigate their environment based on their preferences. The future direction should also include advocating for appropriate MAT policies where and when necessary. It will be essential to create comprehensive frameworks that facilitate funding of assistive devices, increase supportive design approaches and implement training and supportive standards for the mobility of all children with CP.

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