Review of Interventions for the Movement Disabled Individuals in the recent past

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Abstract. This paper provides a comprehensive review of movement disability, highlighting challenges faced by the movement disabled individuals and the interventions by the research community. It analyses evolving assistive mobility devices and emerging technologies like Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality(AR),which offer innovative solutions for rehabilitation.Mobility is a fundamental aspect of human life, and individuals with mobility impairments, whether temporary or permanent, often require the support of wheelchairs, assistive canes, crutches, hoists, and walking frames. The integration of these technologies and devices in the rehabilitation process and potential synergy between traditional and advanced solutions are explored. The paper also addresses challenges, ethical considerations, and future directions in assistive mobility devices and rehabilitation,emphasizing user-centric design and accessibility.Future research should prioritize addressing these challenges to enhance mobility and improve the quality of life for individuals with movement disabilities.

Keywords: Movement disability, Assistive devices, wheelchair, Virtual Reality

1 Introduction

Movement disability is a common problem faced by people who are across age groups as there is a prevalence of difficulties with lower extremity mobility among all adults [1]. Disabled elderly people are not able to perform their activities of daily living independently. The activities of daily living include basic self-care activities such as bathing, eating, and dressing etc [2]. This is a serious problem to be addressed when there is no availability of caregiver to assist the disabled elderly people. Individuals with significant physical disabilities, such as tetraplegia, a state in which all four limbs are paralyzed, depend upon assistive technologies for the mobility of wheelchairs to improve quality of life [3]. The current assistive technologies and mechanisms lack ease of use and further study should be done about the usability, mobility, and performance of the same [4].

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Assistive technologies provide individuals with the tools and support they need to lead more independent and healthy life, reducing their reliance on formal healthcare and support services. By promoting self-care, remote monitoring, and enhancing overall well-being, these technologies can contribute to a more sustainable and patient-centered healthcare system [5].

The World Health Organization (WHO) has reported that more than one billion individuals require one or multiple assistive devices, and it is anticipated that these numbers will potentially increase two-fold by 2050 [6]. Nevertheless, approximately 90% of those who could benefit from assistive devices currently lack access to them [7].

Moreover, existing walking aids often lack the flexibility to navigate environmental challenges like rough terrain and hard to navigate pathways crucial for community access in developing countries. Additionally, they may not meet the affordability requirements needed for widespread adoption [8].

2 Product Interventions

2.1 Wheelchairs

Wheelchairs are one of the most widely used for movement disability as their assistive devices. These wheelchairs have been used throughout all the age categories from the age of 3 years of infant till the elder people who are more than 80 years of age. Wheelchairs are available in more variants based on the mechanism, cost, convenience or mobility, accessibility, features, ergonomic structure, technology etc. These factors classify the wheelchair into main categories:

- Manual wheelchairs
- Electric wheelchairs
- Smart wheelchairs
- Standing wheelchairs

Manual wheelchairs: This category of wheelchair requires a lot of manual force for movement based on the weight of the user. These are simple to operate the mechanism built for it which implies on the easy accessibility which makes economically affordable. But these manual wheelchairs an image of which is shown in Figure1do come with a compromise in terms of the comfort and versatility for the user.

Fig. 1. Manual wheelchair

Electric wheelchairs: These are semi-automated device which reduce the dependability of the others to carry on the user to one place to another through their manual force, which is replaced by the electric motor which gives enough force for movement of wheelchair. The electronics of the wheelchair can be control via remote or control panels which will communicate the microcontrollers, sensors, and electric drive system to function under control. These factors contribute to the self-sustainability to the users to move and use the wheelchair at any situations. But these electric wheelchairs an image of which is shown in Figure2 are on costlier side which may be suitable for some users who can afford it to have relatively more comfort than the manual wheelchairs.

Fig. 2. Electric wheelchair

Smart wheelchairs: These wheelchairs are the advanced or evolved version of electric wheelchair which integrates technologies such as Internet of Things (IoT), Bluetooth communication, artificial intelligence and more. Another area where these smart wheelchairs are distinguished from the electric ones is on human machine interface (HMI) where the user control and interact with the wheelchair and these interactions are controlled through different communication protocols such as:

a) Brain Communication Interface (BCI): uses nerve electric pulse generated by brain to communicate with the computer to control the wheelchair.

b) Sip and Puff: where users interact through their lips and chin region to move or control the wheelchair.

c) Tongue drive system: which is controlled by the user via tongue.

d) Eye ball tracking: these are implemented with high-definition tracking camera to track the eye movement in order to control the system.

e) Joystick controller: these are most commonly used in both smart electric and electric wheelchair, where joystick movements are pre-programmed for the user to control the movements as per his intention. It is used widely due to this type of easy control.

Standing wheelchairs: Standing wheelchairs offer users the ability to stand upright, promoting better circulation, posture, and social interaction. They enhance mobility and accessibility for individuals with disabilities, improving their quality of life and independence.

Literature review on wheelchairs: A control system was presented which can be used for electric wheelchairs that enhance the protection and ease of wheelchair users. The sensor module is responsible for identifying the wheelchair user's position and relaying this data to the main controller. The main controller assesses whether the user is in a secure position and, if so, provides power to the wheelchair's propulsion mechanism. If not, an alarm signal is issued. The system also includes obstacle detection and road condition sensors, as well as an auxiliary module with speech synthesis and display capabilities. The system improves the well-being and convenience of individuals who use wheelchairs, thus positively impacting their rehabilitation and their everyday living circumstances [9].

Authors have highlighted the importance of considering ergonomic factors in wheelchair design and introduce the use of Human Digital Models (HDM) for computational analysis. The authors conducted Rapid Upper Limb Assessment (RULA) analysis using HDM to assess user comfort and made design modifications based on the analysis results. The paper also presents an innovative footrest design to improve user experience. Overall, the study emphasizes the need for user-friendly and ergonomic wheelchairs for better comfort and safety [10].

The researchers collected data from 14 wheelchair users using wearable sensors for a week. They discovered that the act of changing direction is crucial in the use of wheelchairs, with an average of 900 directional changes occurring daily. Approximately 25% of the observed turns were identified as "turns-on-the-spot", and they frequently commenced from a stationary position. The research indicates that wheelchair users enhance their energy efficiency by initiating motion with a pivot in place and traversing shorter, direct segments while making slight and precise adjustments in their directional changes [11].

A study on the creation and putting into practice an affordable control system for electric wheelchairs that utilizes a permanent magnet direct current motor was presented. The research focused on creating a control system for managing the direction and speed of a wheelchair, which included the development of both a push-button interface and a graphical user interface. The findings indicated that the fuzzy logic controller demonstrated superior performance compared to other controllers, exhibiting reduced overshoot and quicker settling time. The hardware implementation utilized an Arduino microcontroller and pulse width modulation control technique. Overall, the fuzzy logic controller demonstrated superior performance in the control of the electric wheelchair [12].

It discussed the creation of a module that can be easily connected to and removed from a manual wheelchair, providing electric propulsion when needed. Here is a general outline of the design and control process. The existing electric module for wheelchairs is complicated to assemble and increases the size and turning radius of the wheelchair. To tackle these problems, a novel electric module comprising two omni-wheel driving units has been suggested. The module allows independent movement and direction change, enabling the same movement as a manual wheelchair. The article also presents a mechanism for easy attachment and detachment of the module [13].

It discussed the impact of satisfaction with manual wheelchairs on the quality of life in individuals with spinal cord injury. The study found that satisfaction with manual wheelchairs positively influenced the physical, environmental, and social domains of quality of life. The study also highlighted the importance of providing satisfactory and appropriate wheelchairs to improve the quality of life of individuals with spinal cord injury [14].

Authors focused on the development of a control system for an electric wheelchair using wrist rotation based on the analysis of muscle fatigue. The conventional method of operating a wheel chair using fingers can be inconvenient for individuals with finger problems. The research introduces an innovative control approach that involves utilizing hand gestures, particularly wrist rotations, to control the wheelchair. The investigators conducted experiments involving 65 participants, examining five distinct hand gestures for executing forward, backward, right, left, and stop manoeuvres. Two gesture-classifying methods were investigated, with the naïve bayes approach showing promising accuracy and precision of 99%. The evaluation of the method was conducted with six participants, who successfully controlled the wheelchair system without any collisions. The suggested method demonstrates a high level of accuracy and has the potential to address the issues related to reliance on finger movements and the onset of hand fatigue during the course of operating a wheelchair [15].

It discussed the development of a smart voice and gesture-controlled wheelchair to assist physically impaired individuals. The existing wheelchairs are expensive and heavy, making them difficult to use for independent mobility. The proposed prototype uses a voice recognition module and Arduino Uno to control the wheelchair through hand, finger, elbow, leg, head gestures, or voice commands. The wheelchair also incorporates features like obstacle avoidance and wireless communication. The research aims to provide a cost-effective solution that improves the mobility and independence of physically disabled individuals [16].

2.2 Walking Frame

This type is used for standing purpose with the support of frame along with the walking frame to enhance mobility through walking. These are mostly used in physiotherapy sessions where people with difficulty in walking can be assisted for mobility. A walking frame is shown in Figure3.

Fig. 3. Walking frame

The study examined how well older adults followed guidance on the usage of walking frames and measured the stability of users when using these walking aids. Data was collected using smart walkers and pressure-sensing insoles from 17 participants in their home environment. The study found that a significant percentage of single and dual support periods had incorrect use of walking frames, which was associated with reduced stability. There search also delved into the perspectives of both users and healthcare professionals regarding the utilization of walking aids. The researchers concluded that current guidance needs improvement to address environmental constraints and facilitate stable walking with walking aids. The study highlights the importance of considering environmental factors and providing detailed training in the safe use of walking aids to reduce falls risk among older adults [17].

Walking frames are typically intended for providing structural support during walking, but there is a known association between self-reported use of a walking aid and an increased risk of falling. This study examined the impact of walking frame height and width on the stability of older adults while walking. The findings indicated that lowering the frame height did not enhance stability. However, stability was positively correlated with the amount of body weight transferred onto the frame for all frame conditions. When using an ultra-narrow frame compared to a standard-width frame, stability was reduced. The study concludes that it is crucial to actively encourage the transfer of body weight onto the walking frame to improve stability. Additionally, caution should be exercised when recommending and using ultra-narrow frames [18].

The study found that there was little difference in stability among different frames, but frames with rear ferrules were less manoeuvrable. It emphasized the importance of considering individual needs and environmental factors when selecting a frame. The study also highlighted the need for professional advice and access to a range of products. Overall, wheeled walking frames can enhance mobility and independence but should be chosen carefully to ensure safety and effectiveness. The study involved testing frames in a controlled environment and in participants' homes, using geometric measurements and simulated user loads.

It found that all frames had adequate stability on flat surfaces, but carrying a load affected stability indifferent ways. Users' ratings and comments were inconsistent, suggesting that they may not accurately detect frame instabilities in short trials. The study concluded that no single frame provides optimal stability and manoeuvrability, and selection should be based on individual clinical assessments [19].

The traditional walkers require users to lift and move them, which can be tiring and fatiguing. This proposed walker aims to address this issue by using a linear actuator to assist users in the sit-to-stand motion. The design includes wheels for easy movement, brakes for stability and a safety harness for fall prevention. The analysis demonstrates that the walker is secure and capable of supporting the anticipated weight. The goal is to create a cost-effective walker that can improve mobility and independence for elderly and disabled individuals [20].

A study was conducted to investigate the challenges and issues faced by elderly individuals when using walking frames or walkers in Kuala Lumpur and Selangor, Malaysia. The research employed focus group discussions and quality function deployment sessions, involving input from elderly users, caregivers, industry professionals and researchers. The results highlighted that the primary concerns raised by the participants were related to quality, design, and cost. The top priority customer requirements for anew walking frame or walker design were identified as safety, stability, suitability for outdoor use, user friendliness and comfortable design.

Regarding technical requirements, the most important aspects are adjustable height and width, a two-level handle design, 'R' shape design, Acrylonitrile Butadiene Styrene (ABS) plastic castor wheels, and functional accessories. The study recommends using the gathered information as a reference for future research aimed at developing appropriate walking frames and walkers for the elderly population in Malaysia [21].

2.3 Stair Lift

Stair lift which is shown in Figure4is used to transfer people with disability from one floor to another floor based on their requirements. For implementing this system in workplace and house, a special modification needs to be done where in case of workspace it is very difficult to implement but in house case, we can modify it according to the staircase lift space occupancies. But these are expensive.

Fig. 4. Stair lift

It attempted to develop an indoor as well as outdoor stair lift. Modern stair lifts come equipped with various features to enhance comfort, user friendliness, and aesthetic appeal within the home. Stair lifts allow people with mobility problems to live independently. The proposed smart stair lift is a cost-effective and easily installable solution that reduces production costs and construction time. It integrates an IoT-based electro-mechanical system that can be controlled through an android application. The system uses a pressure sensor to detect the force when a person sits on the chair and ensures their safety and comfort while moving up or down the stairs. The smart stair lift can be operated in automatic mode or through the mobile application [22].

It discussed about the goal to refine the design of stair lifts to guarantee secure transportation for elderly and disabled individuals when traversing stairs. The study aims to develop lighter designs and materials without compromising the lift's capability. A braking system is also designed for the stair lift. The optimization process involves selecting materials for guide rails, driving links, and the braking system. The study compares the suitability of A36 Steel and 6063 T5 Aluminium for use as guiderails in the stair lift. The merit value suggests thatA36 Steel may be a good choice for the guide rails. The strength of 6063 T5 Aluminium is also compared to A36 Steel, and both materials have maximum deflection below the allowable displacement.

The study discusses the materials for the braking system, driving links, and electric motors. Overall, the study concludes that 6063 T5 Aluminium can be used as a substitute material for guide rails, but reinforcement of weld connections and strengthening of driving links are necessary. The kinetic energy required for the braking system is calculated, and the required motor power for the stair lift is determined. Numerical simulations provide stress and displacement results for the guide rails, driving links, and disc brakes. The temperature distribution on the disc brake is also observed, showing that the material's mechanical properties are not affected.

The article highlights the importance of accessibility for elderly and disabled individuals and highlights the advantages of using a stair lift instead of elevators or escalators. The research provides valuable insights for improving the design and safety of stair lifts [23].

2.4 Assistive Cane

It is the traditional way that the older age people used before 2000’s and even now some old age people in rural areas use this cane as the assistive device for their movement via walking. An assistive cane is shown in Figure 5. Technology assisted white cane is one of the recent technologies for visually impaired disability. White canes can be used with other existing technologies like electronic travel aids [24].

Electronic travel aids employ sensors to gather sensory data in order to utilize this information for navigation purposes.

Fig. 5. Assistive cane

2.5 Crutch Walking Stick

These are used by the older people with lower limb injuries who have better upper limb strength and people with low upper limb strength are not suitable for the usage. This cannot be used for transversely longer distances and avoid obstacles as it may led to fall of users, but due to its cost effectiveness and simple mechanism these are used among old age people. Crutches come in various types, including axillary crutches (the traditional underarm crutches), forearm crutches (also known as elbow crutches), and platform crutches. The choice of crutch type depends on the user's specific needs and comfort. A pair of crutch walking stick is shown in Figure 6.

Fig. 6. Crutch walking stick

2.6 Hoist

It is an assistive device which is used to lift and transfer people from one end to another end. Hoist which is shown in Figure7 is mostly used in medical industries especially in hospitals where many types of hoist systems are used. But while using this in household, a special interior modified needs to be done which makes it more complex to implement but it is still easy and convenient to use.

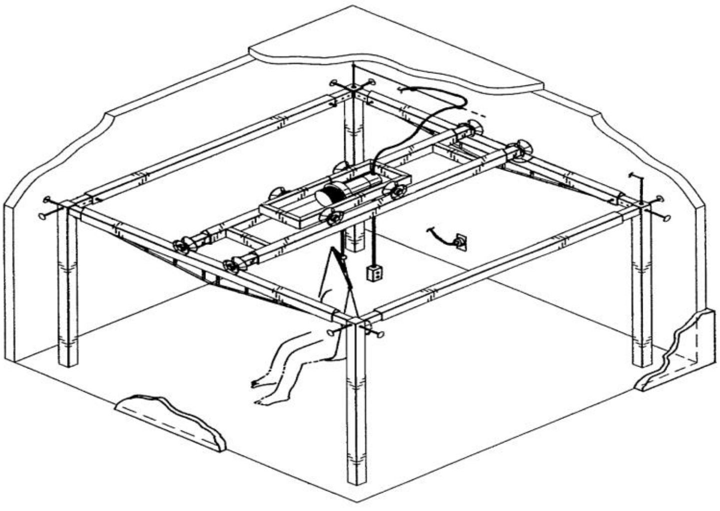

Fig. 7. Hoist[25]

3 Technological Interventions

3.1 Bionics

It outlines a clinical trial that aims to study the effect of a community-based training program using a bionic leg on various aspects of individuals who have experienced a stroke. The study involved a 10-week program group that combines physiotherapy and community-based bionic leg training, alongside control groups that received either physiotherapy alone or standard care. Integrating robotic devices into at-home rehabilitation programs could prove to be a cost-effective, feasible, and advantageous resource for these individuals [26].

Here, investigation was done about how bionic prosthetic devices impact stereotypes and perceptions of individuals with physical disabilities. The researchers proposed that individuals with disabilities who utilize bionic prostheses would be viewed as more capable than those with disabilities who do not use such devices. They also hypothesized that these individuals as cyborgs would amplify these effects. Two online studies were conducted to test these hypotheses. The results partially supported the hypotheses. The study suggests that technology can indeed influence stereotypes and interpersonal perceptions [27].

The study suggests that legged robots outperform wheeled robots on uneven or discontinuous terrains. The paper introduces a three-dimensional model of a quadruped robot equipped with bionic springy legs. This robot achieves a maximum speed of 2.0 m/s and can maintain its balance even when subjected to lateral disturbances. The control algorithms applied in both simulations and experiments demonstrate that legged robots exhibit favourable biological characteristics, including ground reaction force and leg behaviour resembling the properties of springs [28].

The authors explored an innovative design and the performance assessment of a high-speed bionic mechanical leg. Traditional legged robots typically incorporate motorized components at the joints of the legs, leading to increased mass and rotary inertia, which in turn restricts the mobility and speed of legged robots. To address this issue, the authors propose a new mechanical design in which the drive motors are positioned on the robot's body to diminish the rotary inertia of the legs. They employ a crank-rocker mechanism to convert the continuous rotation of the motors into a back-and-forth motion of the leg. Through kinematic and dynamic analyses, it is shown that this new design extends the leg's range of motion, reduces the required driving torque, and enhances the ground reaction force, resulting in a faster leg movement [29].

3.2 Virtual Reality (VR) and Augmented Reality (AR)

The study explores the potential of leveraging emerging technologies, particularly VR and AR, to enhance the accessibility of tourist experiences for individuals with disabilities. Qualitative interviews were conducted with individuals with disabilities, as well as their parents or caregivers, to identify the primary challenges they encounter during their travels and their perspectives on the use of VR and AR for virtual tours.

The findings underscore the necessity for improved information and accessibility for individuals with disabilities. Furthermore, the results indicate that VR and AR technologies can offer valuable insights and immersive experiences of tourist destinations, enabling individuals with disabilities to explore and engage with these destinations from the comfort of their own homes [30].

It discussed the use of VR in physical rehabilitation and therapy for people with disabilities. It explains how VR can be used for diagnosis, training, and rehabilitation purposes. The document highlights specific examples of how VR can benefit individuals with motor disturbances, speech disabilities, and visual defects. It also explores the use of VR in assisting physicians with diagnosis and visualization of medical data. The technical aspects of VR, including display techniques and input devices, are discussed as well [31].

The meta-analysis examined the impact of VR-based interventions on depression in stroke patients. The findings indicated that VR-based interventions led to a significant reduction in depression scale scores when compared to control groups. Subgroup analysis further revealed that these interventions were particularly effective for patients with moderate depression and when the intervention lasted for more than 6 weeks. However, VR interventions did not have a significant impact on patients aged 60 years or older. The study underscores the potential of VR as a valuable rehabilitation tool for addressing depression in stroke patients [32].

Mirror therapy is a technique employed to alleviate phantom pain and aid in the rehabilitation of post-stroke patients. A novel system is introduced that integrates virtual reality and head mounted displays to implement mirror therapy in virtual environments. This system necessitates the use of a separate virtual reality headset equipped with hand-tracking capabilities for the patient, along with an external computer or tablet device for the rehabilitation professional. The system offers features that enable the rehabilitator to plan and monitor rehabilitation sessions, while providing the patient with a virtual environment for conducting their rehabilitation exercises. The system has undergone testing with post-stroke patients, and solutions have been devised to address issues related to hand positioning, hand object interactions, and patient limitations [33].

It explores the application of the Oculus Rift,VRdevice, for conducting neuropsychological assessments aimed at evaluating visual processing capabilities. By immersing participants in virtual environments, clinicians can identify specific impairments in visual attention, perception, and spatial awareness, leading to more targeted interventions and rehabilitation strategies. The Oculus Rift and similar VR devices have the potential to be used as valuable tools for conducting neuropsychological assessments of visual processing capabilities. Future research in this area may further refine VR-based assessment protocols and explore additional applications in clinical practice [34].

3.3 Internet of Things (IoT)

The whoops system is a scalable architecture for fall detection in older adults using mobile IoT devices and machine learning. The system can be implemented in the cloud or on the edge IoT device, and it has been validated with various machine learning models, with boosted decision trees showing the best classification performance. The system minimizes the volume of data stored and transmitted by executing fall detection at the edge, leading to substantial reductions in storage requirements and network data traffic [35].

Authors presented a study on the development of a prediction model for the thermal comfort sensation of people with disabilities. The study focuses on three types of disabilities: physical, learning, and neurological. An IoT architecture is proposed for data collection, which includes sensor installation in a building and data transfer to a remote cloud. The collected data is used to train a deep learning model called the artificial neural classifier to predict the indoor thermal comfort of disabled individuals. The model achieved an accuracy of94%, precision and recall of 98% and 97%, respectively [36].

An outline of the IoT for people with disabilities was provided. It discusses the proposed architecture of the IoT, different application scenarios, and the benefits and research challenges of implementing IoT for disabled individuals [37].

Today, people are experiencing longer and healthier life spans, contributing to the expansion of the elderly population. Nevertheless, the elderly encounter obstacles like diminished physical capabilities, the management of multiple health concerns, and adapting to digital technology as newcomers. These challenges frequently result in a loss of control over their own well-being. Authors of this paper suggest involving the elderly in the participatory design of IoT technologies to enhance their role in managing their health and enhancing their overall quality of life [38].

In recent years, there has been a notable increase in human life expectancy, driven by substantial improvements in infrastructure, healthcare, and global economies. This longer lifespan has led to a significant shift in global demographics, resulting in a larger elderly population compared to previous years. This demographic shift has created a demand for additional care and support services to assist aging individuals. Particularly, innovative assistance methods are crucial for seniors who continue to live independently in their own homes. Concurrently, the proliferation of IoT devices such as sensors and actuators has accelerated the growth of smart homes [39].

The study focused on the remote monitoring of physical rehabilitation for stroke patients, utilizing IoT technology and virtual reality. The primary goal is to enhance patient engagement and tailor exercises by employing wearable sensor networks and virtual reality serious games. The paper encompasses the system's implementation, validation process, and presents the experimental results obtained from the study [40].

4 Service Interventions

This study involved six men and two women whose ages ranged from 22 to 77 years where the mean age is 51 years. Their lower limbs are amputated due to Peripheral Vascular Disease (PVD) and some due to PVD with diabetes. The level of amputation is transfemoral and transtibial. This study was conducted in England. The primary outcomes of this research were associated with themes such as uncertainty from past experiences and current circumstances for the future, a lack of understanding about what to anticipate and a desire for guidance, personal obstacles on the horizon, coping with the loss of a limb and striving to return to a sense of normalcy [41].

It discussed the impact of the ongoing conflict in Ukraine on public health, rehabilitation, and assistive technologies. It highlights the additional burden of disease caused by the conflict, including traumatic injuries and psychological disturbances. The surge in rehabilitation needs is identified as a major health issue, affecting tens of thousands of people. The article emphasizes the importance of assistive technologies in improving functioning and reducing disability. It also highlights the challenges faced by Ukraine in providing adequate rehabilitation services, including the lack of quality assistive products and trained professionals. The ongoing conflict further exacerbates these challenges and hampers efforts to improve the situation. The article calls for urgent action to deploy relevant assistive technologies and ensure their wide spread distribution throughout the country [42].

The sample size used here is 239 participants with stroke who were admitted to inpatient rehabilitation in Brisbane, Australia. Stroke is the major disease which affects the motor function. The Functional Independence Measure (FIM) was used to evaluate motor disability. Up to 83% of patients achieved a Minimal Clinically Important Difference (MCID), indicating clinically important improvements in motor function. Around 85% of patients experienced an improvement in their motor disabilities during their stay in inpatient rehabilitation, transitioning from severe motor disability to either moderate or mild motor disability by the time of their discharge [43].

5 Results and Discussion

Research indicates that modern wheelchairs have made significant advancements in terms of design, materials, and accessibility features. Lightweight and electric wheelchairs have improved the independence and mobility of wheelchair users. Traditional canes and walking frames have evolved to include ergonomic designs and additional features like adjustable height, foldability, and anti-slip grips. These improvements enhance stability and reduce the risk of falls. Stair hoists have been critical for individuals with mobility disabilities living in multi-storey buildings .Studies show that these devices have improved accessibility and independence, allowing users to navigate stairs safely. Modern crutches have seen advancements in materials and designs, leading to increased comfort and support for individuals who need them ergonomic handles and adjustable features have been particularly beneficial. IoT technology has been integrated into mobility aids to enhance functionality. Smart wheelchairs, for example, can provide real-time data on user location and health status, improving safety and communication. Artificial Intelligence (AI) algorithms are being used to develop predictive models for fall detection and prevention. Mobility aids have also shown promise in optimizing routes for users.

Virtual reality has been used for rehabilitation and mobility training for individuals with disabilities. VR simulations can help users practice navigating different environments and improve their confidence and mobility skills. However, challenges remain. Cost remains a significant barrier for many individuals, preventing them from accessing these advanced devices and technologies. Furthermore, user training is crucial to ensure the safe and effective use of these aids and efforts should be made to make training programs more widely available. Customization remains essential to meet the unique needs of every individual. The accessibility of public spaces and infrastructure is an ongoing concern, as mobility aids and technological interventions should complement improvements in the physical environment.

Looking ahead, it is imperative that research and development continue to address these challenges. The future of mobility aids and technologies is likely to be marked by more affordable options, further integration of AI and IoT for real-time data, predictive analytics, and the continued expansion of VR applications for rehabilitation and training. As society becomes more inclusive and technology continues to advance, the lives of individuals with movement disabilities are expected to improve significantly.

6 Conclusion

Mobility devices and technological interventions have come a long way in improving the lives of people with mobility disabilities. Advancements in design of assistive devices and walking aids, materials, and the integration of AI, IoT and VR have contributed to increased independence and safety. However, there are still challenges to address, including cost, training, customization, and accessibility.

Future research and development efforts must focus on addressing these challenges and further enhancing the mobility and quality of life of individuals with movement disabilities. It should be extended and improvised so that the concerned people and stakeholders related to movement disability will be benefitted and will be able to solve problems quickly and effectively. The focus on loss of gross motor skills should be more. Various technological interventions to solve movement disability should be extended.

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References

[1]Lisa I.Iezzoni, Ellen P, McCarthy, Roger B. Davisand Hilary Siebens.: Mobility difficulties are not only a problem of old age.Vol. 16, pp. 235–243. Journal of General Internal Medicine(2001)

[2]Xin Peng, XinYu Bao, Yi Xian Xie, Xiao Xia Zhang, Jun Xuan Huang, Yan Liu, Meng Jiao Cheng, Nan Liu and Pei Xi Wang.: The Mediating Effect of Pain on the Association between Multimorbidity and Disability and Impaired Physical Performance among Community-Dwelling Older Adults in Southern China. Vol. 32, pp. 1327–1334. Aging Clinical and Experimental Research (2019)

[3]Rwegoshora, Florian Mwijage, Judith Leo and Shubi Kaijage.: A Comparative Study of Assistive Technologies for Physically Challenged Peoples for Usability of Powered Wheelchair Mobility Aid. Vol. 8, pp. 44–51. International Journal of Advances in Scientific Research and Engineering (2022)

[4]Elliott W. Flockhart, William C. Miller, Jory A. Campbell, Johanne L. Mattie and Jaimie F. Borisoff.: Evaluation of Two Power Assist Systems for Manual Wheelchairs for Usability, Performance and Mobility: A Pilot Study. Vol. 16, pp. 1-13. Disability and Rehabilitation: Assistive Technology (2021)

[5]World Health Organization. Priority assistive products list. World Health Organization (2016)

[6]World Health Organization. Global priority research agenda for improving access to high-quality affordable assistive technology .World Health Organization (2017)

[7]UNDP. Barriers and opportunities at the base of the pyramid: The role of the private sector in inclusive development (2014)
[8]UN Convention, (2016), https://www.un.org
[9]W. Yang, Y. Tang, Q. Wang, Z. Lan, and H. Su.: A Control System of Electric Wheelchair. Vol. , pp. IOP Conference Series: Materials Science and Engineering, Institute of Physics Publishing (2020)
[10]B. P. Paul, D. Gnanaraj, and S. Paul.: Ergonomic Design and RULA Analysis of a Motorised Wheelchair for Disabled and Elderly. Vol. 10, pp. 1014–1025. International Journal of Mechanical Engineering and Technology (IJMET) (2019)
[11]Togni, R., Kilchenmann, A., Proffe, A., Mullarkey, J., Demkó, L., Taylor, W.R. and Zemp, R.: Turning in circles: understanding manual wheelchair use towards developing user-friendly steering systems. Vol. 10, pp. 831528. Frontiers in Bioengineering and Biotechnology (2022)
[12]V.Sankardoss and P. Geethanjali.: Design and Low-Cost Implementation of an Electric Wheelchair Control. Vol. 67, pp. 657–666. IETE J Res (2021)
[13]D. Lee and S. Kim.: Design and Control of a Novel Detachable Driving Module for Electrification of Manual Wheelchairs. Vol. 11, pp. 10169–10179. IEEE Access (2023)
[14]Mehmood, B.: Does satisfaction with the manual wheelchair have an impact on the quality of life in spinal cord injury?. Vol. 11. Healthcare in Low-resource Settings (2023)
[15]Rusydi, M.I., Hadi, K., Setiawan, A.W., Reni, I., Nugroho, H. and Windasari.:Electric Wheelchair Control Using Wrist Rotation Based on Analysis of Muscle Fatigue. Vol. 10, pp. 102907–102918. IEEE Access (2022)
[16]R.Khande and S. Rajapurkar.: Smart Voice and Gesture Controlled Wheel Chair. pp. 413-417. 6th International Conference on Trends in Electronics and Informatics (ICOEI),IEEE (2022)
[17]Thies, S.B, Bates, A, Costamagna, E, Kenney, L, Granat, M, Webb, J, Howard, D, Baker, R. and Dawes, H.: Are older people putting themselves at risk when using their walking frames?.Vol. 20, pp.1-11. BMC geriatrics (2020)
[18]Thies, S.B, Russell, R, Al-Ani, A, Belet, T, Bates,A, Costamagna, E, Kenney Land Howard, D.: An investigation of the effects of walking frame height and width on walking stability. Vol. 82, pp. 248-253. Gait & Posture (2020)
[19]Anslow, R, Pinnington, L.L, Pratt, D.J, Spicer, J, Ward, C.D. and Weyman, N.: Stability and manoeuvrability of wheeled walking frames. Vol. 87, pp. 402-412. Physiotherapy (2001)
[20]Bonde, A., Mandavgade, N.K., Wankhede, S., Ghate, K., Nandi, S., Muchulwar, P. and Burde, P.: Design and analysis of walker with sit to stand assistance. Vol. 47, pp. 6074-6077. Materials Today: Proceedings, Elsevier Ltd (2021)
[21]Hussain, M.R., Haron, N.A., Effendi, R.A.A.R.A., Ibrahim, R., Sulaiman, R., Ahmad, S.A., Rokhani, F.Z., Ashari, A., Hassan, M.K., Dolah, M.S. and Ramli, S.H.: Walking frame design recommendation based on experience of elderly user, carer, and the industry in Kuala Lumpur & Selangor, Malaysia. Vol. 23, pp.261-271. Malaysian Journal of Public Health Medicine (2023)
[22]P. Rao Kapula, Bp. Kumar, G.H. Mounika, K. Prabhakara Rao, and I. A. Pasha.: Smart stair lift for disabled and elderly Vol. 120, pp. 4647–4660. International Journal of Pure and Applied Mathematics (2018)
[23]M. Bhalerao and S. Ohol.: Smart Vertical Lift for Disabled Person.pp. 1758-1770. Proceedings of the 2nd Indian International Conference on Industrial Engineering and Operations Management
[24]I. Khan, S. Khusro, and I. Ullah.:Technology-assisted white cane. Vol.6, pp. e6058. Peer J (2018)
[25]Beck Jr, John R. "Patient hoist,"US5337908,Aug 16,1994, https://patents.google.com/patent/US5337908A/en, Accessed on Apr 1, 2024.[Online]

[26]Wright, A., Stone, K., Lambrick, D., Fryer, S., Stoner, L., Tasker, E., Jobson, S., Smith, G., Batten, J., Batey, J. and Hudson, V.: A community-based, bionic leg rehabilitation program for patients with chronic stroke: clinical trial protocol. Vol. 27, pp. 372-380. Journal of Stroke and Cerebrovascular Diseases (2018)
[27]Meyer, B. and Asbrock, F.: Disabled or cyborg? How bionics affect stereotypes toward people with physical disabilities. Vol. 9, pp. 420419. Frontiers in psychology (2018)
[28]M. Li, Z. Jiang, P. Wang, L. Sun, and S.S. Ge.: Control of a quadruped robot with bionic springy legs in trotting gait. Vol. 11, pp. 188–198. Journal of Bionic Engineering(2014)
[29]H. Nie, R. Sun, C. Guo, G. Qin, and H. Yu.: Innovative Design and Performance Evaluation of a High-speed Bionic Mechanical Leg. Vol. 12, pp. 352–360. Journal of Bionic Engineering (2015)
[30]G.Epuran, A. S. Tecău, C. P. Constantin, B. Tescașiu, and I. B. Chițu.: Opportunities of using new technologies (VR/AR) in order to facilitate the access of persons with disabilities to tourist products. Vol. 13, pp. 55–64. Bulletin of the Transilvania University of Brasov. Series V: Economic Sciences (2020)
[31]Kuhlen, T. and Dohle, C.: Virtual reality for physically disabled people. Vol. 25, pp. 205-211. Computers in Biology and Medicine (1995)
[32]H. Liu, Z. Cheng, S. Wang, and Y. Jia.: Effects of virtual reality-based intervention on depression in stroke patients: a meta-analysis. Vol. 13, pp. 4381. Scientific Reports (2023)
[33]D.Quintana, A. Rodríguez, and I. Boada.: Limitations and solutions of low-cost virtual reality mirror therapy for post-stroke patients. Vol. 13, pp.14780. Scientific Reports (2023)
[34]Foerster, R.M., Poth, C.H., Behler, C., Botsch, M. and Schneider, W.X.: Using the virtual reality device Oculus Rift for neuropsychological assessment of visual processing capabilities. Vol. 6, pp. 37016. Scientific Reports (2016)
[35]D. Mrozek, A. Koczur, and B. Małysiak-Mrozek.: Fall detection in older adults with mobile IoT devices and machine learning in the cloud and on the edge. Vol. 537, pp. 132–147. Information Sciences (2020)
[36]B. Brik, M. Esseghir, L. Merghem-Boulahia, and H. Snoussi.: An IoT-based deep learning approach to analyse indoor thermal comfort of disabled people. Vol. 203, pp. 108056. Building and Environment (2021)
[37]M. C. Domingo.: An overview of the Internet of Things for people with disabilities. Vol. 35, pp. 584–596. Journal of Network and Computer Applications (2012)
[38]D.Gkouskos and J. Burgos.: “I m in! Towards participatory healthcare of elderly through IOT. Vol. 113, pp. 647-652. Procedia computer science (2017)
[39]A. J. Perez, F. Siddiqui, S. Zeadally, and D. Lane.: A review of IoT systems to enable independence for the elderly and disabled individuals. Vol. 21, pp. 100653. Internet of Things (2023)
[40]O. Postolache, D. J. Hemanth, R. Alexandre, D. Gupta, O. Geman and A. Khanna.: Remote Monitoring of Physical Rehabilitation of Stroke Patients Using IoT and Virtual Reality. Vol. 39, pp. 562–573.IEEE Journal on Selected Areas in Communications (2021)
[41]C. Ostler, C. Ellis-Hill, and M. Donovan-Hall.: Expectations of rehabilitation following lower limb amputation: A qualitative study. Vol. 36, pp. 1169–1175. Disability and rehabilitation (2014)
[42]Armitage, R.C.: War in Ukraine: public health, rehabilitation and assistive technologies. Vol. 17, pp. 989–990. Disability and Rehabilitation: Assistive Technology (2022)
[43]Hayward, K.S., Kuys, S.S., Barker, R.N. and Brauer, S.G.: Clinically important improvements in motor function are achievable during inpatient rehabilitation by stroke patients with severe motor disability: A prospective observational study. Vol. 34, pp. 773–779. Neuro Rehabilitation (2014)