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ADVANCED ASSISTIVE TECHNOLOGIES FOR MOBILITY

Dragana Djuric[1], Sunitha Bhagavathi Mysore[2]

Abstract: The rapid development of high technology and artificial intelligence at the end of the last century and into the 21st century has led to the creation of advanced assistive devices for mobility, particularly for neurological and geriatric patients. Evidence was drawn from PubMed, EBSCO databases, Cochrane Library, and Google Scholar, focusing on publications from the last ten years in English. The main aims of this paper are to describe the most common high-technology mobility devices, discuss their practical applications, and review evidence-based practices. This literature review highlights commonly used high-tech devices, such as smart walkers, smart wheelchairs, robotic-assisted treadmill systems, and wearable exoskeletons. The robotic-assisted treadmill system is the most commonly used device in clinical practice. Advanced assistive technologies have demonstrated significant benefits in neurorehabilitation and among geriatric populations. However, their practical use remains limited due to resource constraints, accessibility issues, and knowledge gaps. Future research should address these barriers by focusing on healthcare professional training, efficacy in improving quality of life, and accessibility.

Keywords: assistive mobility technologies, smart devices, neurology, geriatrics

1. INTRODUCTION

According to Global Report on Assistive techology 2022 the rise in aging population, increase in chronic diseases, will increase population in need for one or more assistive devices and its predicted to be 3.5 billion people in 2050 [1]. Despite the benefits derived from the use of assistive technology devices only 10% of people with disabilities have access to them [2]. Increasing accessibility, affordability, adaptability, aviliability, and quality of assistive technology in all countries is global demand [1].

The International Classification of Functioning, Disability, and Health (ICF) identifies mobility as a subcategory of activity and participation domains. Mobility encompasses changing and maintaining body positions, independent walking (with or without devices), and moving using transportation. For many individuals, mobility loss is a significant limitation on activity [3], negatively impacting participation, social interaction, and overall quality of life.

Conventional mobile assistive devices such as canes, crutches, walkers, and manual/powered wheelchairs are widely used in rehabilitation due to their affordability and ease of use. However, they do not fully address sensory and cognitive assistance needs [4-5].Challenges such as maintaining balance and high energy demands raise concerns about the safety and efficiency of conventional devices [6].

The rapid advancement of technology in the 21st century has significantly impacted physical medicine and rehabilitation. High-technology devices are increasingly used in geriatric populations and individuals with neurological conditions [3], [7]. Robotic technologies and electronics have been integrated, resulting in the development of intelligent devices or "smart" mobility aids to assist patients with neuromuscular diseases, acquired brain injuries, strokes, multiple sclerosis, amyotrophic lateral sclerosis, Parkinson’s disease, spinal cord injuries (SCI), and cerebral palsy.

The main aims of this paper is to describe the most common high-technology mobility devices. discuss the practical application, evidence-based practice and challengess for implementation.

[1]Dragana Djuric, Physiotherapy department, Fatima College of Health Sciences, Abu Dhabi, UAE
email: dragana.djuric11@gmail.com
[2]Sunitha Bhagavathi Mysore, Physiotherapy department, Fatima College of Health Sciences, Abu Dhabi, UAE
email: sunitha.mysore@actvet.gov.ae

2. METHODOLOGY

The articles referred for development of this presentation are drawn from the medical and rehabilitation databases, mainly PubMed, EBSCO, Google Scholar published in the last ten years. We used as a keywords: assistive mobility technologies , smart devices, neurology, geriatrics. Inclusion criteria were only articles published in English in the last 10 years, focusing only on mobility assissstive high tehnology devices in neurology and geriatric population. Exlusion criteria were articles published on other language, and duplicate articles. We identifed 24 publications which we inlude in our literature review.

3. HIGH TEHNOLOGY MOBILITY DEVICES

This section highlights the functionality, benefits, and barriers of commonly used high-tech devices, including smart walkers, smart wheelchairs, robotic-assisted treadmill systems, and wearable exoskeletons.

3.1. Smart walkers

Smart walking aids are designed to enhanced mobility, for patients with multiple challenges, such as sensory, cognitive impairments, perceptual difficulties, and movement challanges. Equipped with actuators and sensors, these devices provide biomechanical monitoring, movement assistance, and safety features such as obstacle detection and fall prevention [6]. Human–Robot–Environment Interaction (HREI) interfaces are required to provide safety rules and fall prevention system. The HREI was focused on the development of shared control strategies (i.e., natural and intuitive user interaction while multiple systems are running), as well as on the implementation of a robust Robot–Environment Interaction (REI) interface (i.e., a safety system for collision prevention, a navigation system and a social interaction system) [8].

Key benefits of smart walker include: improved aesthetics and ease of movement, path detection and optimal navigation, sensors for obstacle avoidance, touchscreen options for selecting functions, remote control and data storage on walking speed and distance. Compared to standard walkers, smart walkers improve safety, encourage walking, and improve walking endurance. Smart walkers have higher-quality mobility options designed for individuals with complex needs by providing effectiveness, comfort, safety and different control strategies during rehabilitation and assistance tasks [7-8].

Smart walkers are not commonly used because of high cost, heavier weigh, limited availability, lack of specialized training for healthcare professionals.

3.1.1. Smart wheelchair

The wheelchair should provide greater comfort and functionality for users. The wheelchair could be standardased or customised based on the individual’s functional status and to achieve optimal posture for those with fixed deformities. Both the types allow adjustable seating angles and tilting options to redistribute pressure and reduce strain on muscles.

Smart wheelchairs provide enhanced mobility and postural correction, catering to patients' diverse needs. Advanced features include adjustable seating, tilting options, and assistive standing functions.

High tehnology wheelchair serve not only as primary mobility tool but also aid in facilitation activities of daily living. This multifunctional approach is necessary to address the diverse needs of the neurological and aging population with addiational features for postural correction, automatic lifting, assisstive standing, assissted bathing and toileting,

Human- machine interaction interface allow users to operate and control the wheelchair easily through remote control, joystick control, voice control, touch screens. Multiple-sensor fusion tehnology (cameras, laser radar, ultrasonic sensors) allow to achieve safe and autonomous navigation, obstacle avoidance, path planning [9]. Smart wheelchairs could identify the object detection, recognition, localization and tracking through measurement sensors and algorithms. The wheelchair needs to recognize its home environment with high accuracy in order to detects a door and automatically controls the wheelchair to navigate to it, and then detects the handle on the door to allow opening [10].

Smart wheelchair significantly improve patients’ quality of life and reduce the workload of healthcare providers [9]. The main benefit of technological capabilities for independent wheelchair users in improving terrain detection and maneuverability by increasing independence and safe mobility with high satisfaction [11].

The cost of these wheelchairs are high, limited availability for those living in rural areas and underdeveloped areas, wheelchair maintaince centers are few and the heavy weight of the wheelchair limits its use outside home or clinical environment. There appears to be very little evidence on the protocol and/or policies on the prescription of smart wheelchairs.

3.1.2. Robotic-assistive tredmill training

Robotic-assistive tredmill training (RATT) is commonly used for patients with traumatic brain injuries, spinal cord lesions, strokes, Parkinson’s disease, multiple sclerosis, and cerebral palsy enabling movements that patients cannot perform independently or correcting pathological movement patterns.

Lokomat® (Hocoma AG, Volketswil, Switzerland) is one of the most popular RATT that supports patient on a treadmill with adjustable robotic orthoses (exoskeletons) for each leg, suspension system controlling body weight, treadmill, and feedback screen [12]. The multimodal Lokomat control has adjustable settings, variety of functioning mechanisms, including strength training, basic passive mobilization, and robot-assisted mobilization, which impedes in varying degrees [13]. Patient activity could increase reducing dependence on robotic support by progressively decreasing body weight support and guidance while increasing the treadmill speed [12]. RATT provides intensive, repetitive, task-oriented motor activities by increasing motivation, attention, and active participation with virtual reality, gaming, and real-time feedback, which influenced motor learning and neuroplasticity [14]. Lokomat is a stationary type of robot, widely use worldwide with 1.200 devices in 892 rehabilitation centers [15].

RATT is considering as complementary method to the traditional rehabilitation therapy. RATT provide high intensive, consistent personalised gait training in engaging settings, reduce workload of the therapist, provide objective assessment and data collection. Research findigs are contraversal but many studies showed positive effect on gait speed and endurance, balance, cardiorespiratory endurance, range of motion, gross motor functions [14], [16-18].

RATT has a few limitations: costly device, takes up large space, its use only in hospital/rehabilitation center, therapists require training, ongoing maintenance of the equipment, and health-insurance problem. It allows only forward walking without any opportunities to change direction, practice backward walking, or walking on uneven terrain [19].

3.2. Wereable exoskeleton

Wearable exoskeletons, or exosuit robotic devices, are mechanically and concurrently attached to the human body, focusing on various biomechanical aspects, including degrees of freedom (DoF), ranges of movement (ROM), and joint torque, to provide better alignment and stability [20]. Wearable exoskeleton technology provides powered hip and knee motion to help individuals with spinal cord injuries (SCIs) initiate and control basic locomotion movements such as standing upright, walking, turning, climbing, and descending stairs [21]. Wearable exoskeletons are used with elbow crutches to allow stability and safety, and they have great potential to be utilized as community assistive equipment.

Standing and walking in an upright position with an exoskeleton may also help prevent secondary health complications after SCIs, such as spasticity, impaired cardiovascular function, and muscle tone issues [22], promoting physical health and well-being.

The Hybrid Assistive Limb (HAL) was the first exoskeleton used for stroke, SCI, and progressive neuromuscular disorders. A wide range of lower-limb exoskeletons is under development; some are used in clinical research, and only a few devices, such as ReWalk, Ekso, and Indego, are approved for use [23]. ReWalk is commonly used for SCI levels T 7 to L 5. Compared to robotic-assisted treadmill training (RATT), wearable exoskeletons are rarely used in clinical practice. Pioneering work in wearable exoskeleton technology aims to improve technical performance, ensuring safety and reducing the risk of falls. It is expected that within the next decade, exoskeletons will become an integral part of daily life [24]. However, the high cost of these devices and limited battery life, which allows for approximately four hours of continuous walking, remain significant challenges.

4. CONCLUSION

Advance assistive technologies provide opportunities for enhancing mobility and independence in patients with neurological conditions and geriatrics. These advanced devices represent a significant step forward in enabling mobility, improving quality of life, and encouraging active participation in daily life for patients worldwide. Despite rapid technological advancements, the implementation of high-techology devices in neurorehabilitation remains highly limited. Addressing barriers such as cost, availability, accessibility, specialized training, and maintenance is crucial for broader implementation and long-term success. Efforts should focus on increasing awareness among healthcare professionals, conducting user-centered research, updating policies, and enhancing financial support at the governmental level.

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