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Artificial Intelligence and Digital Technologies in Neurorehabilitation: Current Applications, Challenges and Future Perspectives

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ABSTRACT

Artificial intelligence (AI) and digital technologies are transforming neurorehabilitation by enabling personalized, data-driven, and accessible patient care. Technologies such as machine learning, robotic-assisted rehabilitation, virtual reality, brain–computer interfaces, wearable sensors, and tele-rehabilitation enhance assessment, treatment planning, and functional recovery in neurological conditions including stroke, Parkinson's disease, spinal cord injury, and traumatic brain injury. These innovations improve patient engagement and rehabilitation outcomes while supporting remote monitoring and continuous care. However, challenges such as data privacy, ethical concerns, high costs, limited clinical validation, and unequal access hinder widespread implementation. Future advancements in explainable AI, predictive analytics, and integrated digital rehabilitation platforms are expected to further improve precision, accessibility, and effectiveness. This review summarizes the current applications, key challenges, and future perspectives of AI and digital technologies in neurorehabilitation.

Keywords: Artificial Intelligence; Neurorehabilitation; Virtual Reality; Tele-rehabilitation

INTRODUCTION

Neurological disorders, including stroke, traumatic brain injury, spinal cord injury, Parkinson's disease, multiple sclerosis, and cerebral palsy, are among the leading causes of long-term disability worldwide.[1] These conditions often result in motor, sensory, cognitive, and communication impairments that significantly reduce functional independence and quality of life. Neurorehabilitation aims to restore lost neurological functions, maximize recovery, and promote patient independence through individualized, multidisciplinary interventions. However, conventional rehabilitation approaches are often resource-intensive, dependent on therapist expertise, and limited by variability in treatment intensity and patient access.[2,3]

Recent advances in artificial intelligence (AI) and digital technologies have transformed the field of neurorehabilitation by enabling personalized, data-driven, and technology-assisted care. AI techniques, including machine learning, deep learning, computer vision, and natural language processing, can analyze complex clinical data, predict recovery trajectories, and optimize rehabilitation strategies. At the same time, digital technologies such as robotic rehabilitation systems, wearable sensors, virtual reality (VR), augmented reality (AR), brain–computer interfaces (BCIs), tele-rehabilitation platforms, and mobile health applications provide continuous monitoring, real-time feedback, and remote rehabilitation opportunities. These innovations have the potential to improve treatment precision, patient engagement, and clinical outcomes while expanding access to rehabilitation services.[4-6]

Despite these promising developments, several challenges remain, including concerns related to data privacy and security, ethical and regulatory issues, algorithm transparency, interoperability, implementation costs, and limited high-quality clinical evidence. Addressing these challenges is essential for the safe and effective integration of AI into routine neurorehabilitation practice.

This review provides a comprehensive overview of the current applications of artificial intelligence and digital technologies in neurorehabilitation, discusses the major challenges associated with their clinical implementation, and highlights future perspectives that may shape the next generation of intelligent rehabilitation systems.

Artificial Intelligence in Neurorehabilitation: Artificial intelligence refers to computational systems capable of performing tasks that traditionally require human intelligence, including learning, reasoning, problem-solving, and decision-making. In neurorehabilitation, AI has emerged as a transformative technology by enabling personalized rehabilitation strategies through the analysis of large and complex datasets. Machine learning (ML), deep learning (DL), computer vision, and natural language processing (NLP) are the most commonly applied AI techniques.

Machine learning algorithms analyze clinical records, neuroimaging findings, gait parameters, electromyography (EMG), electroencephalography (EEG), and wearable sensor data to predict functional recovery, classify disease severity, and recommend individualized treatment plans. Deep learning models, particularly convolutional neural networks (CNNs) and recurrent neural networks (RNNs), have demonstrated excellent performance in interpreting MRI, CT, and EEG data for neurological assessment.

AI also facilitates clinical decision support by predicting rehabilitation outcomes based on patient-specific variables such as age, lesion location, severity of impairment, and treatment response. Predictive analytics enables clinicians to identify patients at risk of poor recovery and modify rehabilitation protocols accordingly. Furthermore, AI-powered virtual assistants and chatbots provide patient education, medication reminders, and rehabilitation guidance, thereby improving adherence to therapy.[7-9]

DIGITAL TECHNOLOGIES IN NEUROREHABILITATION

Robotic-Assisted Rehabilitation: Robotic rehabilitation systems have become one of the most successful applications of digital technology in neurological rehabilitation. These devices provide repetitive, intensive, and task-oriented exercises that stimulate neuroplasticity and motor relearning. Robotic systems are broadly categorized into end-effector devices and exoskeletons.

Upper-limb robots assist patients in performing reaching, grasping, and fine motor tasks, while lower-limb robotic systems facilitate gait training and balance rehabilitation. Robotic devices can precisely control movement trajectories, measure muscle performance, and provide real-time feedback to both therapists and patients. Integration of AI further allows these devices to automatically adjust exercise intensity according to patient performance, ensuring optimal rehabilitation.

Clinical studies have consistently demonstrated improvements in motor recovery, walking speed, muscle strength, and functional independence among patients with stroke, spinal cord injury, and Parkinson's disease receiving robotic-assisted therapy.[10]

Virtual Reality (VR) and Augmented Reality (AR): Virtual reality creates computer-generated immersive environments that simulate real-life activities, whereas augmented reality overlays digital information onto the real-world environment. These technologies have significantly enhanced patient engagement by transforming repetitive rehabilitation exercises into interactive experiences.

VR-based rehabilitation improves upper limb function, balance, gait, coordination, cognitive function, and activities of daily living. Patients can safely practice walking, obstacle avoidance, object manipulation, and memory exercises within virtual environments while receiving immediate visual and auditory feedback.

Augmented reality assists therapists by providing visual cues during movement training, posture correction, and balance exercises. The combination of VR, AR, and AI enables adaptive rehabilitation programs that automatically increase task difficulty based on patient performance, maximizing motor learning and motivation.[11]

Brain–Computer Interfaces (BCIs): Brain–computer interfaces establish direct communication between the brain and external devices by decoding neural activity. Electroencephalography (EEG) is the most commonly used non-invasive method for recording brain signals.

BCIs enable patients with severe motor impairments to control prosthetic limbs, wheelchairs, robotic devices, or communication systems using brain signals alone. During rehabilitation, BCIs provide neurofeedback that encourages activation of motor-related brain regions, promoting cortical reorganization and neuroplasticity.

Recent AI algorithms have significantly improved the accuracy of EEG signal classification, reducing noise and enhancing real-time decoding of motor intentions. Combined with robotic exoskeletons and functional electrical stimulation, BCIs have shown promising results in improving upper-limb recovery after stroke.[12]

Wearable Sensors and Internet of Medical Things (IoMT): Wearable technologies include smart watches, inertial measurement units (IMUs), pressure sensors, electromyography sensors, and biosensors that continuously monitor patient movement and physiological parameters.

These devices collect real-time information regarding gait characteristics, joint angles, posture, muscle activity, heart rate, sleep quality, and daily physical activity. AI algorithms analyze these continuous datasets to detect abnormal movement patterns, predict falls, monitor rehabilitation progress, and provide personalized recommendations.

The Internet of Medical Things (IoMT) connects wearable devices with cloud-based healthcare platforms, allowing clinicians to remotely monitor patients and modify rehabilitation programs without requiring frequent hospital visits.[13]

Tele-rehabilitation and Mobile Health: Tele-rehabilitation delivers rehabilitation services remotely through secure video consultations, web-based exercise platforms, smartphone applications, and wearable monitoring systems.

This approach became particularly valuable during the COVID-19 pandemic and continues to improve healthcare accessibility for patients living in rural or underserved regions. Tele-rehabilitation reduces travel costs, increases therapy adherence, and enables long-term follow-up.

AI-powered mobile applications can automatically assess exercise quality, count repetitions, monitor treatment compliance, and provide real-time corrective feedback. Many systems also incorporate gamification techniques that improve patient motivation and participation.[5,6]

Clinical Applications: AI and digital technologies are now integrated into the rehabilitation of several neurological disorders.[5,6,8,9]

Stroke Rehabilitation: Stroke remains the leading application of AI-assisted neurorehabilitation. Machine learning models predict functional recovery, robotic systems facilitate upper- and lower-limb rehabilitation, BCIs improve motor recovery, and VR enhances balance, gait, and cognitive function. Wearable devices continuously monitor patient mobility and recovery outside the clinical setting.

Parkinson's Disease: Digital technologies assist in monitoring tremor severity, gait disturbances, freezing episodes, and medication response. AI analyzes wearable sensor data to detect disease progression and optimize individualized treatment strategies. VR-based balance training reduces fall risk and improves mobility.

Traumatic Brain Injury: Patients with traumatic brain injury benefit from AI-assisted cognitive rehabilitation, VR-based memory training, computerized attention exercises, and wearable monitoring systems that objectively assess recovery.

Spinal Cord Injury: Robotic exoskeletons restore walking ability and improve muscle strength, while BCIs facilitate communication and control of assistive devices. Functional electrical stimulation combined with AI supports motor recovery.

Multiple Sclerosis: Wearable sensors continuously assess fatigue, balance, gait, and mobility. AI predicts disease progression using imaging and clinical data, enabling early intervention.

Cerebral Palsy: Children with cerebral palsy benefit from robotic gait training, VR-based motor exercises, AI-assisted movement analysis, and wearable monitoring systems that support long-term rehabilitation.

Advantages of AI and Digital Technologies The integration of AI into neurorehabilitation offers several advantages:

Personalized rehabilitation programs based on individual patient characteristics.

Objective assessment using quantitative digital biomarkers.

Continuous monitoring beyond hospital settings.

Improved patient engagement through immersive technologies.

Enhanced clinical decision-making using predictive analytics.

Reduced therapist workload through automation.

Increased accessibility through tele-rehabilitation.

Better long-term outcomes through adaptive rehabilitation protocols.

CHALLENGES AND LIMITATIONS

Despite substantial progress, several challenges hinder widespread implementation. High development and maintenance costs restrict access, particularly in developing countries. Data privacy and cybersecurity remain major concerns because AI systems require large volumes of sensitive patient information. Ethical issues related to informed consent, algorithm bias, transparency, and accountability require careful consideration.

Many AI models function as "black boxes," limiting clinician trust due to poor interpretability. Additionally, limited interoperability among healthcare information systems complicates integration into routine clinical workflows. Regulatory approval processes are evolving, and reimbursement policies for AI-assisted rehabilitation remain inconsistent. Most importantly, many technologies still require validation through large multicenter randomized controlled trials before routine adoption.

Future Perspectives: Future neurorehabilitation is expected to move toward precision rehabilitation driven by explainable AI, multimodal data integration, and digital twins that simulate individual patient recovery. The combination of AI with robotics, BCIs, wearable sensors, VR, and AR will enable highly adaptive rehabilitation systems capable of continuously modifying therapy according to patient progress.

Advances in cloud computing, edge computing, 5G communication, and the Internet of Medical Things will support real-time remote rehabilitation. Generative AI and conversational virtual assistants may improve patient education, motivation, and adherence. Future research should focus on improving algorithm transparency, ensuring ethical AI implementation, reducing healthcare disparities, and establishing standardized clinical guidelines for AI-assisted neurorehabilitation.

Overall, AI and digital technologies have the potential to revolutionize neurological rehabilitation by making treatment more personalized, efficient, accessible, and outcome-oriented.

Table 1. Representative Studies on Artificial Intelligence and Digital Technologies In Neurorehabilitation

Author (Year)	Technology	Neurological Condition	Key Findings
Rodríguez-Hernández et al. (2021)[14]	Virtual Reality (VR)	Stroke	VR combined with conventional therapy significantly improved upper-limb motor function compared with conventional therapy alone.
Bai et al. (2022)[15]	AI-integrated Virtual Reality	Stroke	AI-personalized VR rehabilitation significantly improved motor recovery, balance, and activities of daily living compared with standard treatment.
Ali et al. (2023)[16]	Gamified Virtual Reality	Parkinson's disease	Gamified VR training significantly improved balance, mobility, and quality of life compared with conventional physiotherapy.
House et al. (2016)[17]	BrightArm Duo robotic-assisted VR system	Chronic stroke	Robot-assisted, team-based VR gaming improved upper-limb range of motion (ROM), motivation, and patient engagement, demonstrating feasibility for rehabilitation in nursing home settings.
Zhang et al. (2025)[18]	AI-Gamified Rehabilitation	Post-stroke dysphagia	AI-assisted swallowing therapy improved swallowing function and treatment adherence.

CONCLUSION

Artificial intelligence and digital technologies are transforming neurorehabilitation by enabling personalized, efficient, and patient-centered care. Innovations such as robotics, virtual reality, brain–computer interfaces, wearable sensors, and tele-rehabilitation have shown significant potential to improve functional recovery, patient engagement, and access to rehabilitation services. However, challenges including data privacy, ethical concerns, high implementation costs, and the need for robust clinical validation must be addressed. With continued technological advancements and interdisciplinary collaboration, AI-driven neurorehabilitation is expected to play a pivotal role in delivering precision rehabilitation and improving outcomes for individuals with neurological disorders.

REFERENCES

Feigin, V. L., Vos, T., Nichols, E., Owolabi, M. O., Carroll, W. M., Dichgans, M., Deuschl, G., Parmar, P., Brainin, M., & Murray, C. (2020). The global burden of neurological disorders: Translating evidence into policy. *The Lancet Neurology, 19*(3), 255–265.

Feigin, V. L., & Vos, T. (2019). Global burden of neurological disorders: From Global Burden of Disease estimates to actions. *Neuroepidemiology, 52*(1–2), 1–2.

Ridler, C. (2018). Artificial intelligence accelerates detection of neurological illness. *Nature Reviews Neurology, 14*, 572.

Abdalla, N., El Arab, R. A., Abdrbo, A., Almari, M., Ayoub, M. Y., Alsaaideh, B., Dagamseh, M. S., Almagharbeh, W. T., Abuadas, F., Abu Mahfouz, M. S., & Gaballah, M. K. (2026). Artificial intelligence in rehabilitation: A review of clinical effectiveness, real-world performance, safety, and equity across modalities and settings. *Frontiers in Digital Health, 8*, 1737957.

Yau, T., Chan, J., McIntyre, M., Bhogal, D., Andreoli, A., Leochico, C. F. D., Bayley, M., Kua, A., Guo, M., & Munce, S. (2024). Adverse events associated with the delivery of telerehabilitation across rehabilitation populations: A scoping review. *PLoS ONE, 19*(11), e0313440.

Alshami, A., Nashwan, A., AlDardour, A., & Qusini, A. (2025). Artificial intelligence in rehabilitation: A narrative review on advancing patient care. *Rehabilitación, 59*(2), 100911. https://doi.org/10.1016/j.rh.2025.100911

Priya, P. K. (2024). AI-powered rehabilitation: Innovations in physical therapy and recovery. *International Journal of Medical Informatics and Artificial Intelligence, 4*.

Calderone, A., Latella, D., Bonanno, M., Quartarone, A., Mojdehdehbaher, S., Celesti, A., & Calabrò, R. S. (2024). Towards transforming neurorehabilitation: The impact of artificial intelligence on diagnosis and treatment of neurological disorders. *Biomedicines, 12*, 2415. https://doi.org/10.3390/biomedicines12102415

Banyai, A. D., & Brișan, C. (2024). Robotics in physical rehabilitation: Systematic review. *Healthcare, 12*(17), 1720. https://doi.org/10.3390/healthcare12171720

Calabrò, R. S., Calderone, A., Bonanno, L., Quartarone, A., Naro, A., De Nunzio, A. M., & Filoni, S. (2026). Robot-assisted upper-limb rehabilitation after stroke: A systematic review and meta-analysis of cortical reorganization and neuroplasticity biomarkers. *Neural Plasticity, 2026*(1), e9282578.

Hariharan, V., Kumari, P. K., & Rajanandh, M. G. (2024). Extended reality in revolutionizing neurological disease: A new era for chronic condition treatment. *Cureus, 16*(8), e67633.

Swarnakar, R. (2025). Brain-computer interfaces in rehabilitation: Implementation models and future perspectives. *Cureus, 17*(7), e88873.

Micali, G., Corallo, F., Cappadona, I., Giambò, F. M., Duca, A., D'Aleo, P., et al. (2026). Wearable technologies in neurorehabilitation and cardiac rehabilitation: A narrative review. *Journal of Bodywork and Movement Therapies, 47*, 80–89.

Rodríguez-Hernández, M., Polonio-Lopez, B., Corregidor-Sánchez, A.-I., Martin-Conty, J. L., Mohedano-Moriano, A., & Criado-Álvarez, J.-J. (2021). Effects of specific virtual reality-based therapy for the rehabilitation of the upper limb motor function post-ictus: Randomized controlled trial. *Brain Sciences, 11*, 555. https://doi.org/10.3390/brainsci11050555

Bai, Y., Liu, F., & Zhang, H. (2022). Artificial intelligence limb rehabilitation system on account of virtual reality technology on long-term health management of stroke patients in the context of the Internet. *Computational and Mathematical Methods in Medicine, 2022*, 2688003.

Ali, F., Suleman, R., Noor, A., Ahmad, I., Shakeel, M., & Aqeel, M. (2023). Effectiveness of a virtual reality-based rehabilitation program versus conventional physical therapy in improving motor function and balance in stroke survivors: A randomized controlled trial. *Journal of Health and Rehabilitation Research, 3*, 817–821.

House, G., Burdea, G., Polistico, K., Grampurohit, N., Roll, D., Damiani, F., Keeler, S., & Hundal, J. (2016). A rehabilitation first-tournament between teams of nursing home residents with chronic stroke. *Games for Health Journal, 5*, 75–83.

Zhang, B., Wong, K. P., Liu, M., Hui, V., Guo, C., Liu, Z., Liu, Y., Xiao, Q., & Qin, J. (2025). Effect of artificial intelligence-based video-game system on dysphagia in patients with stroke: A randomized controlled trial. *Clinical Nutrition, 45*, 81–90.

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