

Effects of Exergaming in Neurological Conditions: A Narrative Review

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Abstract: *Exergaming uses interactive video games that require whole-body movement and give immediate feedback, and has been explored as a technology-assisted adjunct in neurological rehabilitation. This narrative review summarises the concept, mechanisms, types, and therapeutic dose of exergaming, and the evidence for its use in stroke, Parkinson's disease, multiple sclerosis, cerebral palsy, traumatic brain injury, and spinal cord injury, along with advantages, limitations, the physiotherapist's role, and future directions. Reviews and trials suggest benefits mainly for balance, postural control and selected motor and cognitive-motor outcomes, with good adherence and feasibility, but evidence is heterogeneous and transfer to real-world function is uncertain. Exergaming is best regarded as a complementary, individually prescribed adjunct to conventional physiotherapy. (Fernandes et al., 2025; Barry et al., 2014; Calafiore et al., 2021)* ^{[2] [3] [4]}

Keywords: Exergaming, Virtual reality, Neurological rehabilitation, Balance, Telerehabilitation, Physiotherapy

1. Introduction

Exergaming, or exercise gaming, refers to interactive video games that require physical body movement to control or interact with the game. Platforms such as Nintendo Wii, Xbox Kinect and virtual-reality (VR) systems involve stepping, reaching, weight shifting, balance and whole-body movement, and give immediate visual or auditory feedback.

Neurological rehabilitation needs many repetitions, sustained attention and motivation over weeks or months; exergaming may supply repetitive, task-oriented practice that is engaging and measurable. This review summarises its mechanisms, types and evidence across six neurological conditions, and discusses clinical use by physiotherapists.

2. Narrative Review Approach

The submitted manuscript was reorganised and supplemented using literature identified through searches of systematic reviews and meta-analyses, a scoping review, a pilot randomised controlled trial, experimental and comparative studies, observational studies, and clinical and biomechanical reviews, all with PubMed identifiers.

It is a narrative synthesis; it was not registered as a systematic review, and no formal risk-of-bias appraisal was performed.

3. Concept, mechanisms and therapeutic dose

The therapeutic effect does not arise from the activity being a game, but from the structured motor practice the game environment produces. The patient perceives a goal, plans and executes a movement, receives feedback, detects errors and tries again; repeated cycles of goal, execution, feedback, correction and progression may reinforce motor learning and

experience-dependent neuroplasticity. Stroke studies of VR and exergaming report changes in cortical connectivity, interhemispheric balance and cortical representation. (Hao et al., 2022) ^[1]

Other proposed mechanisms are sensory integration of visual, auditory and proprioceptive information, balance and postural control training through weight shifting and stepping, cognitive-motor dual-task demands, higher motivation and adherence, and, for some games, light-to-moderate aerobic activity. Neuroplasticity should not be presented as an automatic result of technology; the stimulus is the quality of practice delivered.

Therapeutic dose depends on frequency, intensity, time, type of activity and the number of meaningful repetitions. A game may look active yet give a low dose if the patient mostly waits or watches instructions, so therapists should monitor active time and movement quality rather than assume that a more sophisticated game is better.

4. Types of exergaming

Common categories are balance-board games (Wii Fit), motion-camera systems (Kinect), hand-controller games (Wii Remote, PlayStation Move), dance and rhythm games, sports and functional games, treadmill or VR gait systems, immersive head-mounted VR, customised sensor-based systems and telerehabilitation or home systems. Choice should follow the patient's clinical presentation and goal rather than the popularity of a platform.

5. Evidence by Neurological Condition

5.1 Stroke

Exergaming is used as an adjunct to conventional physiotherapy to increase task-specific, repetitive, feedback-

rich practice of balance, weight shifting, gait, reaching and cognitive-motor tasks. A 2025 umbrella review of 11 meta-analyses involving about 9,615 stroke survivors found significant improvements, particularly in balance and upper-limb function, although the studies were heterogeneous. (Fernandes et al., 2025) ^[2]

A suggested session comprises baseline assessment (e.g. Berg Balance Scale, Timed Up and Go, 10-Metre Walk Test, Fugl-Meyer), a 5–10-minute warm-up, 20–30 minutes of graded exergaming in bouts, progression only while movement quality and safety are maintained, and cool-down with reassessment. Success in a virtual environment should not be taken as proof of safe community walking.

5.2 Parkinson's disease

Parkinson's disease (PD) is a progressive neurodegenerative disorder with loss of dopaminergic neurons and alpha-synuclein accumulation (Kouli et al., 2018) ^[7]; it affects about 1% of people over 60 and 2–3% of those over 65. (Ben-Shlomo et al., 2024) ^[8]

Multisensory feedback in exergames may act as an external cue; balance, functional mobility and postural control improve, with efficacy reported as comparable to conventional physiotherapy and better adherence. (Barry et al., 2014; Nuic et al., 2023) ^{[3] [23]}

Dual-task demands may benefit executive function, working memory and visuospatial ability, (Marotta et al., 2023) ^[24] and tailored home-based systems show good compliance and safety. (Nuic et al., 2023) ^[23]. Rapidly changing stimuli may provoke freezing, and performance varies with medication state.

5.3 Multiple sclerosis

More than 2.8 million people live with multiple sclerosis (MS), a global prevalence of about 35.9 per 100,000. (Walton et al., 2020) ^[18]

A systematic review and meta-analysis reported significantly better balance (Berg Balance Scale) and dynamic postural stability than conventional rehabilitation alone. (Calafiore et al., 2021) ^[4]

Gamification may improve compliance, reduce perceived fatigue and make home telerehabilitation feasible. (Taylor & Griffin, 2015; Calafiore et al., 2021) ^{[25] [4]} Heat sensitivity, fatigue, visual disturbance and relapse require programme modification.

5.4 Cerebral palsy

Cerebral palsy (CP) is a group of non-progressive disorders of movement and posture arising in the developing brain (Rosenbaum et al., 2007) ^[9], with a global prevalence of about 1.5–2.5 per 1,000 live births. (McIntyre et al., 2022) ^[11] Exergaming has been associated with improved Gross Motor Function Measure and Pediatric Balance Scale scores, better bimanual coordination and Pediatric Evaluation of Disability Inventory scores, and higher participation and

home-therapy compliance. (Tobaiqi et al., 2023; Kou et al., 2024) ^{[10] [6]}

Play should be goal-directed, movement quality and spasticity monitored, interfaces adapted, and family or caregivers involved.

5.5 Traumatic brain injury

Traumatic brain injury (TBI) affects an estimated 50–60 million people annually. (Maas et al., 2017, 2022) ^[12]

Balance-board and VR motion-tracking games may improve static and dynamic balance, reduce postural sway and lower fall risk. (Saywell et al., 2016; Cicerone et al., 2019) ^{[15] [14]}

Games combining stepping, reaching or dodging with cognitive challenges may improve divided attention and gait velocity. (Shahmoradi et al., 2022) ^[13]

Graded exposure to complex environments, fatigue and symptom monitoring, and avoidance of sensory overload are important.

5.6 Spinal cord injury

About 15.4 million people live with spinal cord injury (SCI). (WHO, 2024; GBD SCI Collaborators, 2025) ^{[16] [17]}

VR exergames may improve seated balance and trunk control, (Villalobos et al., 2024) ^[19] gamified reaching and hand-tracking tasks may support upper-limb motor relearning, (Lee & Jeoung, 2023; Villalobos et al., 2024) ^[20] ^[19] and adapted upper-body games (virtual boxing, rowing, hand-cranking) can reach moderate-to-vigorous aerobic intensity. (Burns et al., 2012) ^[5]

Gamification may raise session completion and make home tele-exercise feasible. (Ruth et al., 2023; Silva et al., 2025) ^{[21] [22]} Shoulder loading, orthostatic hypotension and autonomic dysreflexia (an emergency at or above T6) need careful monitoring.

Table 1: Summary of exergaming evidence and cautions by neurological condition, as presented in the cited sources.

Ref.	Conditions	Reported targets and benefits	Key cautions
[1] [2]	Stroke	Balance, upper-limb function, gait, dual-task practice	Poor balance, falls risk; virtual success ≠ community safety
[3] [23] [24]	Parkinson's disease	Balance, mobility, postural control, executive function	Freezing with fast stimuli; medication state
[4] [25]	Multiple sclerosis	Berg Balance Scale, dynamic stability, adherence	Heat, fatigue, visual loss, relapse
[6] [10]	Cerebral palsy	GMFM, Pediatric Balance Scale, PEDI, participation	Spasticity, movement quality, caregiver role
[13] [14] [15]	Traumatic brain injury	Balance, sway, divided attention, gait velocity	Fatigue, sensory overload, symptoms
[5] [19] [20] [21] [22]	Spinal cord injury	Seated balance, upper limb, aerobic conditioning	Shoulders, hypotension, dysreflexia

6. Advantages, Limitations and Safety

Advantages include high engagement, concurrent multisensory feedback, measurable performance data, dual-task training, access to telerehabilitation and potential cost-effectiveness.

Limitations include loss of novelty, sensory or cognitive overload, compensatory movements that “cheat” sensors, fall risk and spatial hazards during unsupervised home use, cybersickness, set-up costs, space and software obsolescence, therapist workload and training needs, privacy of connected health data, and a lack of standardised clinical protocols.

Neither exergaming nor conventional exercise is universally superior: conventional therapy allows close observation and manual guidance, while exergaming adds repetition, feedback and motivation.

7. Role of the Physiotherapist

Exergaming functions as an adjunct, not a stand-alone treatment. The physiotherapist screens candidacy (balance, cognition, vision, seizures, fatigue, falls risk), links the game to a defined and measurable goal, calibrates dose, observes and corrects movement quality, and progresses difficulty by quality and safety rather than game score.

Environment and home-set-up safety, patient and caregiver education, documentation of game, duration, assistance and response, and periodic reassessment with conventional measures outside the game to check transfer are essential.

8. Future Directions

Proposed developments include artificial-intelligence-driven adaptive difficulty and automated movement correction using computer vision, cloud-based prescription and monitoring, augmented and mixed reality, haptic and wearable robotic integration, multimodal sensor fusion, brain-computer interfaces and low-cost systems to widen access.

Research priorities are long-term and real-world outcomes, and standardised reporting of the game, hardware, task, intensity, progression and supervision.

9. Limitations of this Review

Several sources are epidemiological or background references, many reported effects come from secondary summaries, and populations, devices, doses and outcome measures vary. Some statements on clinical practice and future directions reflect the project’s synthesis rather than trial evidence.

10. Conclusion

Exergaming offers repetitive, feedback-rich and motivating practice that may improve balance, postural control and

selected motor and cognitive–motor outcomes across neurological conditions, with good feasibility for home use. (Fernandes et al., 2025; Barry et al., 2014; Calafiore et al., 2021) [2] [3] [4]

Because evidence is heterogeneous and transfer to daily life is uncertain, it is best used as a complementary adjunct within an individualised, supervised programme, with the physiotherapist selecting tasks, ensuring safety and verifying real-world gains.

Declarations: Items below are to be confirmed by the authors before submission.

Funding: None declared.

Conflict of interest: None declared.

Ethics statement: Ethical approval was not required because this article is a narrative review of previously published literature and involved no human participants, animals or identifiable personal data.

Author contributions: Meghana contributed to the conceptualisation, methodology, critical revision, supervision and final approval of the manuscript.

Thushar. S contributed to the conceptualisation, literature compilation and drafting of the manuscript.

References

- [1] Hao J, et al. Effects of virtual reality intervention on neural plasticity in stroke rehabilitation: a systematic review. *Arch Phys Med Rehabil.* 2022.
- [2] Fernandes CS, et al. Exergames for rehabilitation in stroke survivors: umbrella review of meta-analyses. *J Stroke Cerebrovasc Dis.* 2025.
- [3] Barry G, Galna B, Rochester L. The role of exergaming in Parkinson’s disease rehabilitation: a systematic review of the evidence. *J Neuroeng Rehabil.* 2014.
- [4] Calafiore D, Invernizzi M, Ammendolia A, Marotta N, Fortunato F, Paolucci T, Ferraro F. Efficacy of virtual reality and exergaming in improving balance in patients with multiple sclerosis: a systematic review and meta-analysis. *Front Neurol.* 2021.
- [5] Burns P, Kressler J, Nash M. Physiological responses to exergaming after spinal cord injury. 2012.
- [6] Kou R, Zhang Z, Zhu F, Tang Y, Li Z. Effects of exergaming on executive function and motor ability in children: a systematic review and meta-analysis. 2024.
- [7] Kouli A, Torsney KM, Kuan WL. Parkinson’s disease: etiology, neuropathology, and pathogenesis. 2018.
- [8] Ben-Shlomo Y, et al. Epidemiology of Parkinson’s disease. 2024.
- [9] Rosenbaum P, et al. A report: the definition and classification of cerebral palsy. 2007.
- [10] Tobaiqi MA, et al. Effects of exergaming on gross motor function and balance in children with cerebral palsy. 2023.
- [11] McIntyre S, et al. Global prevalence of cerebral palsy. 2022.

- [13] Maas AIR, et al. Traumatic brain injury: epidemiology, pathophysiology and clinical management. 2017, 2022.
- [14] Shahmoradi L, et al. Serious games and cognitive rehabilitation after traumatic brain injury. 2022.
- [15] Cicerone KD, et al. Cognitive rehabilitation for adults with traumatic brain injury. 2019.
- [16] Saywell N, et al. Rehabilitation using virtual reality for balance and mobility after traumatic brain injury. 2016.
- [17] World Health Organization. Spinal cord injury. 2024.
- [18] GBD Spinal Cord Injury Collaborators. Global burden of spinal cord injury. 2025.
- [19] Walton C, et al. Rising prevalence of multiple sclerosis worldwide. 2020.
- [20] Villalobos D, et al. Virtual reality exergaming for balance and upper-limb rehabilitation after spinal cord injury. 2024.
- [21] Lee J, Jeoung B. Effects of upper-limb exergaming in spinal cord injury rehabilitation. 2023.
- [22] R  th M, et al. Telerehabilitation adherence in exergaming. 2023.
- [23] Silva A, et al. Home-based tele-exercise feasibility in neurological rehabilitation. 2025.
- [24] Nuic D, et al. Home-based exergaming for Parkinson's disease. 2023.
- [25] Marotta N, et al. Cognitive effects of exergaming in Parkinson's disease. 2023.
- [26] Taylor MJD, Griffin M. The use of gaming technology for rehabilitation in people with multiple sclerosis. 2015