

GAMIFICATION IN ACTIVITIES OF DAILY LIVING REHABILITATION AFTER STROKE: A SCOPING REVIEW

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ABSTRACT

Background: Stroke is a leading cause of long-term functional disability, limiting independence in activities of daily living (ADLs). Gamification is an innovative strategy that can boost engagement and rehabilitation dose by delivering biofeedback and supporting neuroplasticity. **Objective:** To map the scientific evidence on gamification for ADL-oriented rehabilitation after stroke, describing the platforms used, the most common gamification mechanics, and the nature of trained activities. **Methods:** A scoping review was conducted and reported according to PRISMA-ScR. Searches were performed in PubMed, Scopus, Web of Science, and ScienceDirect using the Population–Concept–Context framework. Only studies employing gamified intervention protocols targeting upper-limb rehabilitation were included. **Results:** Twenty-four articles were included. The findings reveal a paradigm shift from commercial gaming consoles toward serious games and immersive virtual reality. The dominant gamification mechanics were real-time kinematic biofeedback and adaptive difficulty adjustment. Intervention protocols typically ranged from 3 to 5 weekly sessions lasting 30–45 minutes, with a growing trend toward asynchronous telerehabilitation. **Conclusions:** Current evidence suggests that gamification is a promising approach to enhance functional independence, especially when embedded in direct, task-specific ADL practice. The move toward specialized serious games may improve clinical precision and ecological validity in post-stroke recovery.

Keywords: Neurological Rehabilitation, Gamified Rehabilitation, Self-Care, Virtual Reality.

1. INTRODUCTION

Stroke is one of the major contributors to long-term disability worldwide (Khrulev *et al.*, 2022). The resulting upper-limb impairments frequently limit essential Activities of Daily Living (ADLs), including dressing, feeding, and personal hygiene, ultimately reducing functional independence and overall quality of life for survivors (Tabah *et al.*, 2020). These limitations also increase the physical and emotional burden on caregivers and impose substantial costs on healthcare systems (Darmadi *et al.*, 2023; Awan *et al.*, 2024). Although intensive, repetitive, and task-oriented training is fundamental for promoting neuroplasticity and functional recovery after stroke (Alsubiheen *et al.*, 2022), conventional rehabilitation often struggles with low adherence and limited patient motivation. The repetitive nature of traditional therapy can lead to fatigue and disengagement, compromising long-term outcomes.

Gamification, defined as the application of game-design elements to therapeutic contexts, has gained relevance as an innovative strategy to enhance engagement and increase training intensity. By incorporating mechanisms such as real-time feedback, reward systems, and adaptive difficulty, gamified environments transform repetitive motor exercises into more motivating and meaningful activities. This approach not only improves user engagement but also supports the high-intensity practice required to stimulate cortical reorganization following stroke (Sánchez-Gil *et al.*, 2025).

Advances in technology have expanded the range of available tools, from commercial gaming consoles to immersive Virtual Reality (VR) systems and purpose-built serious games specifically designed for rehabilitation. Despite this diversity, consensus remains lacking on which gamification mechanics are most effective for ADL-focused training, or on how these interventions should be structured, particularly when distinguishing direct ADL practice from inferred motor training. Additionally, the transition from clinic-based interventions to telerehabilitation remains an emerging area, with important implications for accessibility and continuity of care (Olana *et al.*, 2025).

Therefore, this scoping review aims to map and synthesize the scientific evidence regarding the application of gamification in ADL rehabilitation for stroke survivors. Specifically, it seeks to identify the types of technological platforms (serious games vs. commercial consoles), the dominant gamification mechanics, and the nature of the tasks trained (direct vs. inferred), providing an integrated overview to inform clinical practice and guide future technological development.

2. MATERIALS AND METHODS

2.1 STUDY DESIGN

This scoping review followed the Joanna Briggs Institute (JBI) methodology (Peters *et al.*, 2020) and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PR ISMA-ScR) reporting guidelines (Tricco *et al.*, 2018). The Population, Concept, Context mnemonic (PCC) guided the review:

- Population: adults with ischemic or hemorrhagic stroke
- Concept: gamification, virtual reality, serious games, exergames
- Context: upper-limb rehabilitation targeting ADLs in clinical or home-based settings

2.2 SEARCH STRATEGY

The search was conducted across the PubMed, Scopus, Web of Science, and ScienceDirect databases. The search strategy covered articles published from January 2010 to December 2025, ensuring a comprehensive mapping of both early commercial systems and recent technological advancements. The final search was performed on December 15, 2025. Keywords were combined using Boolean operators (OR/AND) as follows: ("stroke" OR "cerebrovascular accident") AND ("gamification" OR "virtual reality" OR "serious games" OR "Exergames") AND ("activities of daily living").

2.3 ELIGIBILITY CRITERIA

Studies were included if they were peer-reviewed scientific articles published in English. Inclusion criteria targeted protocols involving gamified interventions for upper-limb motor rehabilitation in adults after stroke.

Studies with lower scientific relevance (such as case studies) were excluded. Publications focused on neurological disorders other than stroke, studies evaluating interventions unrelated to games (e.g., conventional rehabilitation), and articles that mention "gamification" or "game" only abstractly or conceptually, without applying it to the intervention, were also excluded. Likewise, studies that did not address occupational performance or failed to report outcomes related to functional independence were removed from the final sample. Studies assessing the impact of gamification on cognitive deficits but

referencing upper-limb motor function were screened separately to determine their relevance for inclusion.

In addition to studies with completed results, this review included ongoing research protocols. This decision aligns with the exploratory nature of scoping reviews, which aim to map not only consolidated evidence but also emerging technological trends and clinical approaches that may shape the future of gamification in post-stroke rehabilitation.

2.4 SELECTION AND DATA EXTRACTION

Screening was performed using Rayyan by two independent reviewers. Extracted data items included study characteristics, participant demographics, intervention features, gamification mechanics, the nature of the targeted ADLs, and reported outcomes.

2.5 METHODOLOGICAL QUALITY ASSESSMENT

Although not mandatory for scoping reviews, methodological appraisal was conducted using the appropriate JBI critical appraisal tools for randomized controlled trials and quasi-experimental studies (Peters *et al.*, 2020). Two reviewers independently assessed methodological quality, resolving discrepancies through consensus. Results were summarized descriptively, without assigning cumulative scores, in accordance with JBI recommendations. Studies classified as high-risk were retained but interpreted cautiously during synthesis.

3. RESULTS

3.1 STUDY SELECTION AND CHARACTERIZATION

A total of 570 records were identified; after removing duplicates and applying eligibility criteria, 24 studies were included. Figure 1 presents the PRISMA-ScR flowchart.

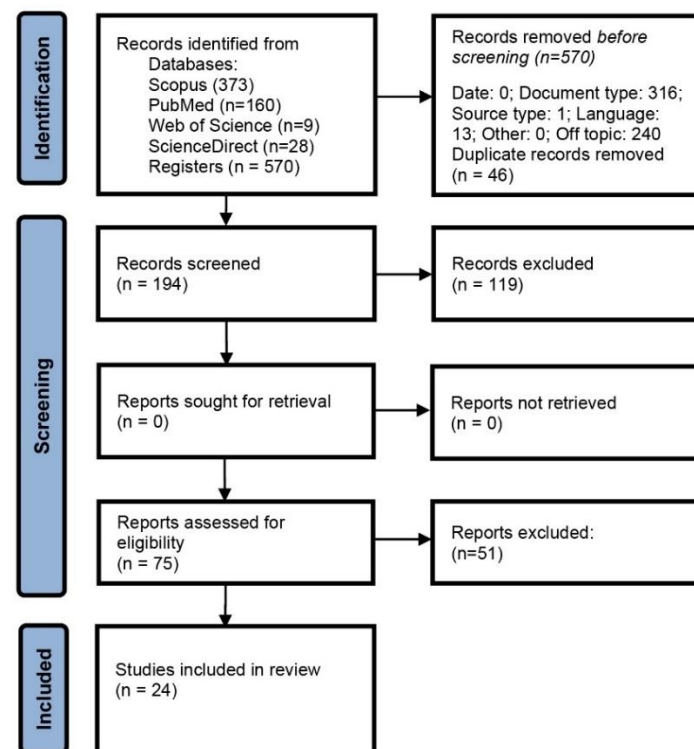


Figure 1: Flowchart of the PRISMA-ScR (adapted from PRISMA-ScR guidelines; Tricco *et al.*, 2018).

Geographical distribution

The geographical distribution of the included studies demonstrates a broad international spread. South Korea contributed the highest number of publications (n=4), followed by Italy, Spain, and Canada (n=3 each). Additional contributions came from China, Brazil, the United States, the United Kingdom, Hong Kong, Hungary, Malaysia, Australia, Turkey, and Colombia, reflecting global interest in gamification-based stroke rehabilitation.

Study designs and settings

The sample included 15 randomized controlled trials, 8 quasi-experimental studies, and 1 protocol. Most interventions were conducted in hospital settings, particularly those requiring advanced equipment (e.g., smart gloves, VR with electrical stimulation). Home-based and telerehabilitation approaches were increasingly represented.

Rehabilitation phase

The studies including (Table 1) were classified according to the time elapsed since the neurological event. The majority of the interventions focused on the chronic phase, typically defined as more than six months post-stroke (Adams *et al.*, 2023; Ballester *et al.*, 2016; Marques-Sule *et al.*, 2021). In these protocols, virtual reality is employed as a strategy to maintain functional gains and stimulate neuroplasticity in patients with stable sequelae.

The sub-acute phase also represented a significant portion of the sample (Tollár *et al.*, 2021; Choi *et al.*, 2014; Liu *et al.*, 2024). Notable among these is the study by Tollár *et al.* (2021), which included a large sample of 641 patients, consolidating the safety and feasibility of intensive training during this recovery period. Finally, the acute phase was identified in studies introducing virtual reality during initial hospitalization (Park *et al.*, 2021; Ho *et al.*, 2019). These interventions aimed to promote early mobilization and reduce the duration of the inpatient stay.

3.2 TECHNOLOGICAL TYPOLOGIES AND GAMIFICATION MECHANICS

A paradigm shift was observed from commercial consoles (n=7) (Table 1) toward specialized serious games and immersive VR systems (n=17). These technologies facilitate the simulation of functional tasks with high ecological validity through two main types of gamification mechanics across all 24 included studies:

- Kinematic and Adaptive Mechanics (n=14): Focused on real-time biofeedback and automatic difficulty adjustment to ensure the "flow zone" (e.g., Adams, 2015, 2019; Park, 2021; Rodríguez, 2021; Liu, 2022; Cui, 2025).
- Engagement and Sensory Mechanics (n=10): Utilized extrinsic rewards, 360° immersion, and narrative elements (e.g., Ögün, 2019; Tieri, 2024; De Giorgi, 2023; Marques-Sule, 2021; Choi, 2014)

Nature of ADLs

The sample is evenly divided (Table 1) between direct-nature tasks (n=12), which mimetize real-world ADLs/IADLs using task-oriented training (e.g., Adams, 2015, 2019, 2023; Ögün, 2019; Tieri, 2024; De Giorgi, 2023), and inferred-nature tasks (n=12), focusing on underlying motor components through abstract or recreational games (e.g., Choi, 2014; Lee, 2016; Tollár, 2021; Marques-Sule, 2021).

Intervention protocols

Standard protocols (Table 1) averaged 30–45 minutes per session, 3–5 times per week, over 4 weeks (e.g., Rodríguez, 2021; Park, 2021; Turolla, 2013; Lee, 2018). Intensive or long-term programs (8–12 weeks) were less frequent but demonstrated high adherence (e.g., Marques-Sule, 2021; Standen, 2015; Gonçalves, 2018).

Table 1: General characterization of the included studies (n = 24)

Author (year)	Purpose of the study	Rehabilitation Phase	Rehabilitation setting	Technology & platform	Intervention Protocol (duration/frequency)	Main outcomes
Adams (2015)	To assess the feasibility of a VR- based telerehabilitation intervention for ADLs	Chronic	Hospital / Outpatient Clinic	VOTA System (Serious Game)	4 sessions of virtual practice	Validated VOTA system as an assessment tool for IADLs, correlating it with the Wolf Motor FunctionTest
Ballester (2016)	To compare the RGS system with conventional therapy in the functional recovery of MS	Chronic	Rehabilitation Center	RGS System (Serious Game)	20 min/day, 3x/week, 3 weeks	Reinforcement-based intervention (RIMT) resulted in significant and sustained long-term motor gains (12 weeks)
Lee (2016)	Investigating the effect of training with Nintendo Wii on arm function and ADLs	Chronic	Community (Health Center)	Nintendo Wii (Commercial)	60 min/day, 5x/week, 4 weeks	VR was superior in proximal physical function, while group therapy benefited more from perceived quality of life
Ögün (2019)	To assess the effect of immersive VR on motor function and functional independence	Chronic	Hospital	Leap Motion (Serious Game)	45 min/day, 5x/week, 3 weeks	Significant improvement in motor function (FMUE, ARAT) and self-care skills (PASS)
Choi (2014)	Compare Xbox Kinect vs. conventional OT	Subacute	Hospital	Xbox Kinect (Serious Game)	30 min/day, 5x/week, 6 weeks	Efficacy of commercial VR on motor function (FMA-UL, MFT) and ADLs (K-MBI)
Marques-Sule (2021)	Analyzing the impact of Wii Fit on balance, mobility and autonomy	Chronic	Health Unit	Nintendo Wii Fit (Commercial)	30 min/day, 3x/week, 8 weeks	Improvement in functionality (FMA-UE), balance (BBS) and daily activities (Barthel Index)

Author (year)	Purpose of the study	Rehabilitation Phase	Rehabilitation setting	Technology & platform	Intervention Protocol (duration/frequency)	Main outcomes
Cui (2025)	Protocol for testing VR combined with action observation (EE) in the upper limb function	Acute/Subacute	Hospital	VR + Action Observation	Protocol testing (4 weeks)	FMA-UE (primary), MBI (ADLs), and neural mechanisms via fNIRS and sEMG
Park (2021)	Evaluate the effectiveness of a gamified smart glove on hand function	Acute	Hospital	Smart Glove (Serious Game)	30 min/day, 5x/week, 4 weeks	FMA, Jebsen-Taylor Test, and Rehabilitation Participation Scale (focus on motivation)
Rodriguez (2021)	Compare the Rehametrics platform with conventional rehabilitation	Acute/Subacute	Hospital	Rehametrics (Serious Game)	45 min/day, 3x/week, 5 weeks	FMA-EU, muscle tone (Ashworth) and stroke impact
Gonçalves (2018)	Verify the influence of exergames (Kinect) on motor function and ADLs	Acute/Chronic	Hospital	Xbox Kinect (Commercial)	30 min/day, 2x/week, 12 weeks	Functional independence, dexterity and Quality of Life; CT lesion analysis
Long (2020)	Assess the impact of virtual tasks on performance and satisfaction (COPM)	Acute/Subacute	Hospital	Doctor Kinetic (Serious Game)	45 min/day, 5x/week, 4 weeks	Self-efficacy (SSEQ) and Occupational Performance (COPM) as the primary outcomes; improvement in FMA-EU
Tieri (2024)	Explore the use of immersive art therapy in VR for motor and cognitive rehabilitation	Subacute	Hospital	Immersive VR Art-therapy	45 min, 3x/week, 4 weeks	Efficacy of Art-Therapy in VR; improvement in Barthel Index, strength and spasticity
Tollár (2021)	Testing high-intensity training with exergames vs. conventional exercise	Subacute	Hospital	Commercial Exergames	180 min/day, 3 weeks	Modified Rankin Scale (mRS) and Barthel; reduction of depressive symptoms and improvement in balance

Author (year)	Purpose of the study	Rehabilitation Phase	Rehabilitation setting	Technology & platform	Intervention Protocol (duration/frequency)	Main outcomes
Ho (2019)	To evaluate the feasibility of exergames in the acute phase of stroke in a hospital setting	Acute	Hospital	Xbox Kinect (Commercial)	Daily sessions (Variable)	Significant improvement in NIHSS and mRS; Demonstration of the cost-effectiveness of early VR
Standen (2015)	Evaluate the acceptability and results of a home VR system	Chronic	Home	Home-based VR (Serious Game)	20 min/day, 5x/week, 8 weeks	Feasibility and adherence to the system at home; measured via WMFT and MAL (actual arm use)
Adams (2023)	Compare video telerehabilitation vs. VR in instrumental housework	Chronic	Home	Video Telerehab vs. VR	Remote training sessions	Compared video telerehabilitation vs. VR in IADL tasks; significant difference in FMA-UE and MAL
Adams (2019)	Validate the use of SaeboVR as an ADL assessment and training tool	Chronic	Clinical/Outpatient Clinic	SaeboVR + Smart Glove	4 validation sessions	Validated the use of SaeboVR as an assessment and training tool for IADLs; high correlation with FMUE and WMFT
Acevedo (2021)	Test the usability of a customized virtual environment for range training	Post-acute	Laboratory/Clinical	Customized VR Environment	Usability/feasibility testing	Focus on user-centered design; Accuracy and response time metrics
De Giorgi (2023)	To evaluate the impact of virtual artistic activities on fine motor skills and autonomy	Subacute	Hospital	VR Art-therapy (Serious Game)	45 min, 3x/week, 4 weeks	FMA, Barthel Index and impact of the "Michelangelo Effect" (Virtual Art Therapy)
Liu (2022)	Investigating the effect of VR with circuit training functional independence	Subacute	Hospital	VR + Circuit Training	40 min VR, 5x/week	Synergy between VR and circuit training (TOCT); gains in FMA-UE and SIS
Turolla (2013)	Determine the effectiveness of task-based VR vs. conventional	Acute / Subacute	Hospital	Non-immersive VR	60 min, 5x/week, 4 weeks	Study with 376 patients; improvement in FMA- UE and

Author (year)	Purpose of the study	Rehabilitation Phase	Rehabilitation setting	Technology & platform	Intervention Protocol (duration/frequency)	Main outcomes
	therapy					FIM (Functional Independence)
Lee (2018)	To analyze the combined effect of VR and EE games on distal arm function	Chronic	Hospital	VR Games + FES	30 min/day, 5x/week, 4 weeks	Superiority of the RV + FES combination in FMA and WMFT-FAS
Mouawad (2011)	Evaluating the effectiveness of an intensive protocol with Wii Sports on <u>upper limb function</u>	Chronic	Hospital / Home	Nintendo Wii (Commercial)	1h (Hosp) + 3h (Home), 10 days	Improvement in WMFT and FMA; Increased range of motion (ROM)

Note: ADLs = Activities of Daily Living; VOTA = Virtual Occupational Therapy Assistant; IADLs = Instrumental Activities of Daily Living; WMFT = Wolf Motor Function Test; RIMT = Reinforcement-Induced Movement Therapy; VR = Virtual Reality; FMA-UE = Fugl-Meyer Assessment for Upper Extremity; PASS = Performance Assessment of Self-care Skills; K-MBI = Korean Version of the Modified Barthel Index; FES = Functional Electrical Stimulation; fNIRS = Functional Near-Infrared Spectroscopy; sEMG = Surface Electromyography; mRS = Modified Rankin Scale; CT = Computed Tomography; NIHSS = National Institutes of Health Stroke Scale; MAL = Motor Activity Log; BBS = Berg Balance Scale; SIS = Stroke Impact Scale; FAS = Functional Ability Scale; WMFT-FAS = Wolf Motor Function Test - Functional Ability Scale; ROM = Range of Motion; RCT = Randomized Controlled Trial.

3.3 METHODOLOGICAL QUALITY AND RISK OF BIAS

In accordance with JBI guidance, results were summarized descriptively without assigning cumulative scores.

Most randomized controlled trials were assessed to be at low risk of bias, reflecting overall methodological rigor (e.g., Alsubiheen *et al.*, 2022; Tollár *et al.*, 2021; Sánchez-Gil *et al.*, 2025). The most frequent limitations concerned blinding, which is inherently challenging in technology-based rehabilitation interventions (Choi & Paik, 2014; Tieri *et al.*, 2024). Quasi-experimental studies generally demonstrated low to moderate risk of bias, with strengths in outcome measurement reliability but occasional limitations in group comparability (Adams *et al.*, 2015; Gonçalves & Silva, 2018). The included research protocol (Cui *et al.*, 2025) clearly reported its methodological procedures, including randomization, blinding strategies, and validated outcome measures.

4. DISCUSSION

4.1 THE TECHNOLOGICAL EVOLUTION AND THE SHIFT TO SERIOUS GAMES

The findings of this review reveal a clear technological shift in post-stroke rehabilitation. Early interventions predominantly relied on commercial consoles like the Nintendo Wii (Mouawad, 2011; Lee, 2016) and Xbox Kinect (Choi, 2014; Gonçalves, 2018) due to their low-cost accessibility. However, these systems often lacked clinical precision, as they did not allow for the adjustment of essential therapeutic parameters.

Current evidence demonstrates a significant transition toward serious games (n=17), which account for approximately 70% of the articles in this synthesis. Unlike commercial platforms, specialized systems such as Rehametrics (Rodríguez, 2021) and the Rehabilitation Gaming System (Ballester, 2016) allow therapists to set a "challenge zone" tailored to the patient's functional level. This customization ensures the progressive intensity required to drive neuroplasticity and functional recovery (Sánchez-Gil *et al.*, 2025; Park *et al.*, 2021).

4.2 DIRECT TRAINING, IADLs, AND GAMIFICATION MECHANICS

A central finding is the distinction between direct and inferred training. While conventional gamification often practices isolated motor components (Tollár, 2021; Marques-Sule, 2021), specialized platforms increasingly emphasize task-oriented, direct-nature interventions. Platforms such as SaeboVR and VOTA (Adams *et al.*, 2015, 2019) enable the realistic simulation of Instrumental Activities of Daily Living (IADLs), such as cooking and household management. This ecological validity is vital in Occupational Therapy, as it reduces the gap between clinical training and functional autonomy.

This clinical impact is further enhanced by evolving gamification mechanics. While early studies focused on extrinsic rewards (points/scores), contemporary systems incorporate intrinsic motivators and kinematic biofeedback (Park *et al.*, 2021; Lee, 2018). Furthermore, immersive VR (Ögün, 2019; Tieri, 2024) introduces the "Michelangelo Effect," where avatar identification enhances motivation and sensorimotor integration, particularly in complex grasp-related tasks.

4.3 METHODOLOGICAL QUALITY AND THE FUTURE OF TELEREHABILITATION

The overall methodological rigor observed in most randomized controlled trials (Tollár *et al.*, 2021; Alsubiheen *et al.*, 2022) supports the reliability of these findings. Although blinding remains a challenge in technology-based interventions, the results consistently support the feasibility of gamification across recovery phases. Notably, while the chronic phase is most studied, introducing gamified VR in the acute stage (Park *et al.*, 2021) is shown to be a safe strategy to prevent "learned non-use."

Finally, the evidence suggests that the transition to telerehabilitation models can be safely executed (Adams *et al.*, 2023; Standen *et al.*, 2015). Platforms that allow remote monitoring ensure that high-intensity training is integrated into the patient's daily routine. The future of rehabilitation appears to be a hybrid model centered on serious games and telerehabilitation, ensuring therapeutic continuity and long-term functional gains from the hospital to the home environment.

5. LIMITATIONS AND FUTURE RESEARCH

Despite promising findings on the integration of gamification in stroke rehabilitation, several limitations must be acknowledged to contextualise the scope of this review. A major challenge across the literature is the high heterogeneity of intervention protocols - particularly in session duration, frequency, and intensity - which complicates the establishment of a standardized therapeutic dosage for gamified interventions. Additionally, most available evidence focuses on the chronic phase of stroke, leaving a notable gap in understanding the specific benefits and safety of these technologies during the acute and subacute phases, where neuroplasticity is greatest.

Methodologically, although many included studies are randomized controlled trials, several rely

on small sample sizes or pilot designs, which may limit the generalizability of the findings to the broader stroke survivor population.

Looking ahead, future research should prioritize longitudinal studies with larger, multi-center cohorts to evaluate the long-term retention of functional gains and the cost-effectiveness of gamified interventions within public health systems. There is also a need to advance the standardization of gamification mechanics across different levels of motor impairment, with particular emphasis on the transition to home-based telerehabilitation. Further investigation into the synergy between immersive virtual reality and neuromodulation techniques may also help optimize recovery outcomes. Addressing these gaps will support the development of more personalized, evidence-based digital rehabilitation strategies that effectively bridge the divide between clinical settings and daily functional independence.

6. CONCLUSIONS

This scoping review highlights the growing integration of gamification as a significant approach in the rehabilitation of ADLs after stroke. The evidence demonstrates a clear evolution from generic commercial gaming technologies toward specialized serious games and immersive virtual reality systems. These platforms are capable of delivering clinically precise and feedback-driven motor training, which are considered essential elements for potentially promoting neuroplasticity.

The findings suggest that gamified interventions appear to be particularly promising when they incorporate the direct practice of ADLs, which may help bridge the gap between clinical exercises and functional independence. The emergence of telerehabilitation models further indicates a shift toward more accessible and continuous rehabilitation pathways.

While the mapped literature frequently points to high levels of user engagement, future research should systematically evaluate how gamification influences motivation and adherence as primary outcomes. Furthermore, longitudinal studies are needed to examine the long-term maintenance of functional gains, ensuring that technological innovation translates into sustained improvements in stroke survivors' quality of life and autonomy.

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