The utilization of virtual reality, gamification, and haptic feedback in physical rehabilitation: A systematic review

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Abstract
Recovery after injury is often hindered by pain, joint stiffness, limited mobility, and low patient motivation. Conventional rehabilitation methods are frequently considered painful and repetitive, reducing patient engagement and slowing recovery. This study presents a systematic literature review of the use of Virtual Reality (VR), Gamification, and Haptic Feedback (HBFE) in physical rehabilitation. Following systematic review guidelines, 61 relevant articles were selected and analyzed. The findings show that VR creates immersive and controlled rehabilitation environments while helping reduce pain perception. Gamification increases motivation, engagement, and therapy adherence through challenges and rewards. Haptic Feedback provides realistic tactile sensations that support motor learning and improve interaction quality. Most studies reported positive outcomes when combining two technologies; however, integrating all three technologies demonstrated the greatest potential for enhancing rehabilitation effectiveness through comprehensive therapeutic feedback. Overall, the combination of VR, Gamification, and Haptic Feedback offers a promising approach to making rehabilitation more engaging, interactive, and effective. This integrated framework can help address limitations of traditional therapy and improve patient participation during recovery. Further research is needed to develop and validate fully integrated rehabilitation platforms for broader healthcare implementation.

1. Introduction

Physical rehabilitation, especially for accident trauma victims, is a long, mentally demanding, and often painful process. One of the biggest challenges in this recovery process is not only physical limitations but also low patient compliance and motivation. Traditional exercises are often perceived as monotonous and repetitive (Han et al., 2025), leading to boredom and low adherence (Guede-Rojas et al., 2025). One study even highlighted the severity of this problem, with 87% of patients reporting a lack of motivation to attend therapy, leading to a high number of missed appointments (Rodriguez et al., 2022). Patients often feel "left to their own devices," are unable to "see their improvement or progress," and find the feedback they receive "monotonous" (Kungwengwe & Evans, 2020).

To address this motivation crisis, gamified immersive technologies such as Virtual Reality (VR) have emerged as a highly promising solution. VR has been shown to be significantly "much more enjoyable" and capable of voluntarily driving higher physiological exercise intensity compared to conventional 2D screen-based exercises (Barbour et al., 2024). Another study confirmed that pediatric patients using VR for gait rehabilitation demonstrated significantly "increased" levels of engagement compared to conventional physical therapy sessions (Ammann-Reiffer et al., 2022). The addition of gamification elements such as points, narratives, and progressive challenges (Elor et al., 2022) has been shown to significantly extend the duration for which patients are willing to perform rehabilitation tasks (Ota et al., 2023). Patients reported that VR is "more engaging than traditional exercises" and that they "would practice more often" if they had access to such a system (Ríos-Hernández et al., 2021).

However, VR and gamification alone are not enough. A critical shortcoming repeatedly identified in the literature is the "lack of haptic feedback" (Ammann-Reiffer et al., 2022). Without the sensation of physical touch, interactions in the virtual world feel incomplete and unnatural. Study participants who used hand tracking reported that "reaching into objects felt strange" and "unnatural" (Coox et al., 2024). The failure to replicate this "feeling of touch" prevents virtual interactions from feeling "similar to real-world interactions" (Laine & Suk, 2024). In a significant case study, a gamified VR training system was actually rated as having poor usability because 15 out of 17 participants complained about the "lack of tactile and force feedback." The researchers concluded that this lack of haptic feedback "drastically hindered the experience" that users expected (Turchet et al., 2025).

The integration of haptic feedback, therefore, becomes the third essential and inseparable component. Haptic feedback serves to bridge the gap between the virtual world and physical sensations, which is crucial for

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motor recovery and perception. A user-centered design study involving patients, therapists, and engineers concluded that the combination of "Visuals, Sound, and Force (Haptic) Feedback" is the most critical feature desired in rehabilitation systems, while visuals alone were rated as the least effective (Boriboon et al., 2024). Clinically, the addition of haptic guidance has been shown to significantly improve movement accuracy (Jiang et al., 2022) and movement smoothness (Camardella et al., 2023) compared to visual feedback alone. Haptic feedback has even been identified as a crucial need to help patients overcome their "fear of pain" when moving after surgery (Jiang et al., 2022).

When motivation (from gamification) and visual immersion (from VR) fall short due to a lack of physical sensation, haptic feedback serves as a third pillar that ties the system together and enhances realism. Systems that rely solely on VR and gamification have proven to be incomplete (Turchet et al., 2025); meanwhile, systems that rely on haptics and gamification without VR immersion (Elmanowski et al., 2023) lack the psychological benefits of distraction and presence (Ammann-Reiffer et al., 2022). Therefore, this study focuses on investigating how the use of a rehabilitation system that integrates all three components gamification, virtual reality, and haptic feedback can serve as an effective tool to optimize motor and psychological recovery in accident trauma victims.

2. Method

The research methodology employed a Systematic Literature Review (SLR) approach. This approach was chosen to comprehensively identify, evaluate, and synthesize relevant research evidence to answer the main research question: How can the use of a rehabilitation system that integrates gamification, virtual reality, and haptic feedback serve as an effective tool to optimize motor and psychological recovery in victims?

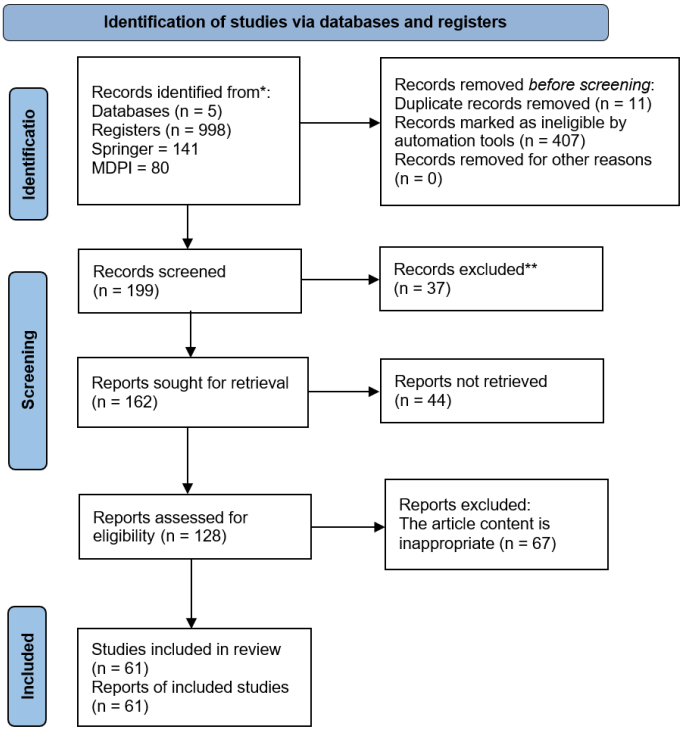

Figure 1. PRISMA

This SLR process is divided into three main stages, namely: Data Search Strategy. Data collection was conducted through a systematic search of several major digital scientific databases that were found to be relevant. These databases include: IEEE Xplore, ACM Digital Library, SpringerLink, ScienceDirect (Elsevier), MDPI (Multidisciplinary Digital Publishing Institute), JMIR (Journal of Medical Internet Research), Frontiers Media, and PLoS (Public Library of Science). The search was limited to articles published between 2015 and 2025 to ensure the relevance and recency of the technology. The main search keywords were combined using Boolean operators (AND/OR) based on the core components of the research question. Articles were selected based on predetermined criteria to filter search results and ensure the relevance of the studies.

(("Virtual Reality" OR "Augmented Reality" OR "Immersive") AND ("Gamification" OR "Exergame" OR "Serious Game") AND ("Haptic Feedback" OR "Tactile Feedback" OR "Force Feedback") AND ("Rehabilitation" OR "Therapy" OR "Motor Recovery" OR "Stroke" OR "Trauma")).

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Inclusion Criteria: Articles that discuss at least two of the three core components (VR, gamification, haptics) in the context of physical, motor, or psychological rehabilitation. Articles published in English (which were subsequently analyzed and synthesized in Indonesian). Articles with a primary study design (e.g., feasibility studies, controlled trials/RCTs, usability studies, case studies, and prototype development). Full-text articles that are accessible. Exclusion Criteria: Articles that are purely reviews, meta-analyses, or research proposals (since this study is a review). Articles not related to the context of health, therapy, or rehabilitation.

3. Results and Discussion

3.1. Results

Table 1 summarizes the psychological impacts of Virtual Reality (VR) and gamification in rehabilitation programs. The findings highlight their contributions to improving patient engagement, adherence to therapy, long-term motivation, and the reduction of pain and anxiety during the recovery process.

Table 1. Psychological Impacts of VR and Gamification

Context	Key Findings	Study
Increased Engagement	VR-based rehabilitation was reported as significantly more enjoyable and encouraged higher training intensity.	Barbour et al.
Increased Engagement	Therapists reported higher levels of patient engagement compared with conventional physiotherapy.	Ammann-Reiffer et al.
Improved Adherence	Gamification (Mdn = 330 s) significantly increased exercise duration compared with the control group (Mdn = 112 s).	Ota et al.
Improved Adherence	High adherence rates (>90%) were maintained over eight weeks, exceeding the typical novelty effect.	Elor et al.
Long-Term Motivation	Motivation was associated with patients' perceptions that the system genuinely contributed to their recovery.	Feingold-Polak et al.
Reduced Pain and Anxiety	VR served as an effective distraction tool for burn injury patients and individuals with chronic pain.	Coox et al.
Reduced Pain and Anxiety	The intervention was described as highly engaging and effective in reducing anxiety symptoms.	Kulkarni & Weir

Table 1 shows that VR and gamification have a measurable impact on motivation, engagement, and compliance. The findings indicate that VR and gamification provide substantial psychological benefits in rehabilitation settings. These technologies enhance patient engagement and adherence by creating enjoyable and interactive therapy experiences. In addition, they help sustain long-term motivation and reduce pain and anxiety, which are important factors influencing recovery outcomes. Overall, the evidence suggests that integrating VR and gamification can improve both patient participation and the effectiveness of rehabilitation programs.

Table 2 presents evidence regarding the limitations of rehabilitation systems that rely solely on visual and auditory feedback, highlighting the importance of haptic feedback in enhancing user experience, immersion, and therapeutic effectiveness. The studies summarize user perceptions and usability challenges associated with the absence or insufficiency of tactile feedback.

Table 2. The Need for and Limitations of Haptic Feedback

Context	Key Findings	Study
VR Interaction (Visual/Audio Only)	Therapists explicitly identified the lack of haptic feedback as a major limitation of the rehabilitation system.	Ammann-Reiffer et al.
Hand Tracking (Without Haptics)	Interactions were perceived as less realistic due to the absence of tactile sensory stimulation.	Laine & Suk
Standard Controller Vibration	Low usability scores (SUS = 55.12) were reported; 15 of 17 participants complained about the absence of adequate tactile or force feedback, which significantly reduced the user experience.	Turchet et al.
Hand Tracking (Without Haptics)	Participants described interactions as unnatural and unfamiliar because no tactile feedback was provided.	Coox et al.
Standard Controller Vibration	Conventional vibration feedback was considered too weak; 57% of participants reported feeling little or no haptic sensation.	Kamínska et al.
User-Centered Design Survey	Participants identified the combination of visual, auditory, and haptic feedback as the most critical feature, while visual-only feedback was rated as the least effective.	Boribon et al.
VR-CBT (Visual Only)	Researchers explicitly recommended the addition of haptic feedback to increase immersion and user engagement.	Kulkarni & Weir

Table 2 shows why haptics are needed. The findings demonstrate that haptic feedback plays a crucial role in creating realistic and immersive rehabilitation experiences. Systems that rely only on visual and auditory

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feedback often result in lower usability, reduced realism, and decreased user satisfaction. Several studies emphasized that the integration of tactile or force feedback enhances immersion, interaction quality, and overall therapeutic effectiveness. These results suggest that haptic feedback is an essential component for the development of more effective VR-based rehabilitation systems.

Table 3 summarizes key findings related to hardware design and user interaction in VR-based rehabilitation systems. The studies identify successful design features, common limitations, user preferences, and considerations for adapting rehabilitation technologies to different patient populations.

Table 3. Hardware Design and Interaction Findings

Context	Key Findings	Study
Gamification Failure	Gamification systems may be ineffective when perceived as boring, childish, or when rewards are considered random and not performance-based.	Tobler-Ammann et al.
Interaction Preference	Most participants (78.5%) preferred hand tracking over controllers because it felt more natural and realistic.	Juan et al.
Interaction Limitations	Standard controllers were considered unsuitable for training fine motor movements, such as finger and hand extension exercises.	Rojo et al.
Interaction Limitations	Although preferred by users, hand tracking still faced technical issues, including occlusion and tracking failures.	Coox et al.
Therapist Requirements	Clinicians preferred managing patient data through companion applications (mobile or desktop apps) rather than directly using VR headsets.	Duval et al.
Population Personalization	Existing systems may not be suitable for patients with cognitive impairments or intellectual disabilities.	Coox et al.; Gentilozzi et al.
Population Personalization	Older adults may prefer numerical visualizations rather than gamified elements and may require lighter haptic feedback.	Kojić et al.; Huang et al.

Table 3 shows what worked and what didn't in the rehabilitation design. The findings indicate that successful rehabilitation systems require a balance between engaging interactions, practical clinical use, and user-specific adaptation. While hand tracking is generally preferred because of its natural interaction, technical limitations remain a challenge. Furthermore, gamification must be carefully designed to match user expectations and abilities. The results also emphasize the importance of personalization, as different patient groups and clinicians have distinct needs that should be considered during system development.

3.2. Discussion

An analysis of the existing literature shows that the integration of these three components VR, gamification, and haptics is not merely complementary but rather an essential synergy. Each component plays a specific role in overcoming the two main barriers to rehabilitation: (1) psychological barriers (low motivation, boredom, anxiety, and pain) and (2) physiological barriers (lack of proprioceptive feedback and accurate motor guidance). Psychological Foundation: The Synergy of VR and Gamification as Motivational Drivers The greatest obstacle in long-term rehabilitation is a crisis of motivation (Rodriguez et al., 2022). The combination of VR and gamification directly addresses these psychological issues. VR as a Distraction and Engagement Booster: Immersive VR environments have been shown to be “far more enjoyable” than 2D exercises, encouraging participants to voluntarily exercise at higher intensities (Barbour et al., 2024). VR serves as an effective distraction tool, particularly for patients with burns and chronic pain (Coox et al., 2024), and is capable of reducing anxiety symptoms (Kulkarni & Weir, 2024). Therapists explicitly observed that VR “increases patient engagement” compared to conventional physical therapy (Ammann-Reiffer et al., 2022). Gamification as a Driver of Adherence: While VR provides the environment, gamification provides the purpose. Mechanisms such as narrative (Han et al., 2025), progression (Elor et al., 2022), and social competition (Ota et al., 2023) significantly extend exercise duration and reduce boredom. Even specific gamification strategies such as “Loss and Avoidance” (risk of failure) have been shown to objectively increase physical exertion, as measured by heart rate and calories burned (Han et al., 2025).

Patients reported that gamified systems made them “want to practice more often” (Ríos-Hernández et al., 2021). However, the findings also clearly indicate that motivation and visual immersion alone are not enough. The most significant shortcoming in realism repeatedly identified in pure VR rehabilitation systems is the “lack of haptic feedback” (Ammann-Reiffer et al., 2022). Without the sensation of touch, virtual interactions feel “unnatural” and “strange” (Coox et al., 2024). The failure to provide this “sense of touch” results in interactions that do not feel “similar to real-world interactions” (Laine & Suk, 2024). The impact of this shortcoming is devastating for the adoption of such systems. A study testing a gamified VR surgical simulator found poor usability, with 15 out of 17 surgeons complaining about the “lack of tactile and force feedback.” The researchers concluded that this lack of haptic feedback “drastically hindered the expected experience” (Turchet et al., 2025). This demonstrates that for serious motor rehabilitation, physical feedback is not a luxury, but a necessity. This is where haptic feedback serves as a crucial third pillar. Findings indicate that haptics are a key component for translating virtual intent into real-world motor learning. A user-centered design study involving various stakeholders (therapists, patients, engineers) concluded that the combination of “Visuals, Audio, and Force

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Feedback (Haptic)" is the most critical feature desired in rehabilitation systems, while visuals alone were rated as the least effective (Boriboon et al., 2024). Measurably, the addition of haptic guidance was shown to significantly improve movement accuracy (Jiang et al., 2022) and movement smoothness (Camardella et al., 2023) compared to visual feedback alone. Haptics serve as an anchor to reality. The combination of immersive VR and haptic stimulation has been shown to significantly enhance users' sense of embodiment (Du et al., 2021). Synchronization between VR visuals and haptic sensations (such as bubbles in water) has been shown to create a bodily illusion, which drastically enhances the sense of presence (Montoya et al., 2023). Psychomotor Function: Haptics also bridges psychological gaps. Haptic guidance has been identified as a crucial need to help patients overcome their "fear of pain" when performing post-surgical movements (Jiang et al., 2022). Haptic feedback (such as resistance from a robot) can even induce motor adaptation (visuomotor plasticity) passively, without the participant being aware of it (Wilf et al., 2021).

The most effective integrated synergy and system design challenge is one that does not treat the three components separately, but rather integrates them into a single cohesive feedback loop. Successful systems use haptics as part of the gamification itself. For example, haptics serves as corrective feedback (vibration when deviating from the path) (Duval et al., 2022), affirmative feedback (a brief vibration upon success) (Prahm et al., 2025), or feedback as a reward (a "tickling" bubble sensation as a reward) (Montoya et al., 2023). This integration is not without challenges. The literature highlights several critical design pitfalls: gamification must be meaningful. Systems that are "boring," "childish," or use random, non-performance-based rewards will fail completely and be ignored by patients (Tobler-Ammann et al., 2017). Simpler designs that focus on clear goals (e.g., "reaching the green circle") have proven to be more preferred (Kungwengwe & Evans, 2020). Standard vibration feedback on commercial VR controllers is often "too weak" and not prominent enough, so that 57% of participants did not even notice it (Kamińska et al., 2022). This reinforces the case for specially designed haptic devices (e.g., force feedback, EMS, or wearables). "One size fit all" does not apply. Older adults may prefer numerical visualizations over gamification (Kojić et al., 2023) and "light" haptic feedback (Huang et al., 2025). Furthermore, this system may not be suitable for patients with severe cognitive impairments (Coox et al., 2024) or intellectual disabilities (Gentilozzi et al., 2023). There is a strong preference for "more natural" interactions using hand tracking without a controller (Juan et al., 2023). This is particularly important for patients who are physically unable to hold a controller (Górski et al., 2024). However, current hand-tracking technology still has technical limitations such as occlusion (Coox et al., 2024).

According to the literature, the use of systems that integrate VR, gamification, and haptics has proven to be a highly effective tool. VR and gamification build a psychological foundation by increasing motivation, engagement, and adherence overcoming the boredom and anxiety associated with traditional therapy. Meanwhile, haptic feedback serves as a critical motor pillar, providing realism, guidance, and embodiment that visuals alone cannot provide. The integration of these three elements creates an optimal multisensory learning environment for motor and psychological recovery.

4. Conclusion

This study aims to evaluate how the integration of Virtual Reality (VR), gamification, and haptic feedback can optimize motor and psychological recovery in trauma survivors. Findings from the literature review confirm that conventional therapy is often hampered by significant psychological challenges, including boredom, anxiety, pain, and low motivation, which lead to poor adherence. The proposed integrated system has proven effective in addressing these dual challenges through the synergy of three components. VR and gamification together successfully overcome motivational barriers. VR provides an immersive environment that is "far more enjoyable" and serves as an effective distraction from pain. Gamification provides structure, goals, and progression, which significantly extend exercise duration and increase engagement, while haptic feedback is a crucial motor component that bridges the realism gap. Without physical sensations, virtual interactions feel "unnatural" and "drastically hinder the experience". The addition of haptics has proven essential for enhancing embodiment, movement accuracy, and helping patients overcome their "fear of pain". These three components.

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Declaration of Conflicting Interests

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Data Availability

The datasets generated during and/ or analysed during the current study are available from the corresponding author on reasonable request.

Declaration on AI Use

The authors declare that no artificial intelligence (AI) or AI-assisted tools were used in the preparation of this manuscript.

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