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VIRTUAL REALITY AND EXERGAMING FOR FALL PREVENTION IN OLDER ADULTS: A REVIEW OF CLINICAL EFFICACY AND PATIENT ENGAGEMENT

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ABSTRACT

Background: Falls are a primary cause of injury and loss of independence among older adults. Digital technologies like virtual reality (VR) and exergaming are increasingly used to enhance balance and mobility, yet their overall clinical efficacy requires synthesis.
Objective: This review consolidates evidence from 2015–2024 regarding the effectiveness of VR and exergaming interventions on fall prevention, specifically examining balance, functional mobility, dual-task performance, and patient engagement.
Methods: A narrative review was conducted using PubMed to identify peer-reviewed studies, including randomized controlled trials and meta-analyses. The review included interventions targeting balance or fall risk in adults aged 60 and older.
Results: The synthesized evidence indicates that both VR and exergaming yield significant improvements in balance, gait adaptability, and dual-task performance. These interventions utilize multisensory feedback and gamification to integrate cognitive and motor skills, thereby supporting motor learning and adherence. However, findings concerning actual reductions in fall incidence remain mixed due to methodological variations and limited long-term follow-up.
Conclusion: VR and exergaming serve as effective, engaging complementary tools for fall prevention. While they reliably improve functional outcomes, future research must focus on standardizing protocols and evaluating long-term efficacy to support clinical implementation.

KEYWORDS

Virtual Reality, Exergaming, Fall Prevention, Older Adults, Balance Training, Digital Health Interventions

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Introduction:

Falls represent a major public health concern in aging societies, constituting one of the leading causes of injury, functional decline, and mortality among adults aged 65 years and older. Recent epidemiological data show that more than 25% of community-dwelling older adults experience at least one fall per year, and fall-related injuries continue to pose substantial burdens on emergency care and long-term rehabilitation services. As global populations age and the prevalence of multimorbidity increases, the development of effective, accessible, and scalable fall-prevention strategies has become increasingly critical [1].

Extensive evidence demonstrates that structured exercise interventions—particularly those targeting balance, gait, and lower-limb strength—are among the most effective means of reducing fall rates in older adults. The Cochrane review by Sherrington et al. identifies significant reductions in both fall rate and risk of falling when balance-challenging, function-oriented exercises are performed with adequate intensity and duration [3]. However, despite strong evidence, the real-world implementation of these programmes remains limited. Issues such as low adherence, motivational barriers, transportation difficulties, and limited access to supervised rehabilitation settings often prevent older adults from engaging consistently in traditional exercise programmes [3,4].

Against this backdrop, emerging digital health technologies—particularly virtual reality (VR) and exergaming (interactive, game-based physical training)—have garnered significant interest as potential tools to enhance patient engagement and broaden access to fall-prevention interventions. VR technologies allow safe simulation of challenging motor tasks, enable incremental progression, and provide immediate multisensory feedback, which may support motor learning mechanisms relevant for balance and mobility in aging individuals. Exergaming platforms similarly offer engaging, game-based environments that can improve motivation and enjoyment while delivering structured physical training.

A growing body of systematic reviews and meta-analyses suggests that VR and exergaming can produce improvements in balance, gait speed, and walking capacity in older adults. Corregidor-Sánchez et al. demonstrated that exergame-based training significantly enhances walking capacity, particularly in individuals with mild mobility limitations [6]. Integrative evidence also highlights generally high short-term acceptability and safety, with relatively low adverse-event rates [7]. Similarly, a recent meta-analysis indicated that VR-based interventions may yield moderate improvements in balance performance, although substantial heterogeneity across studies complicates the interpretation of pooled effect sizes [8].

Several randomized controlled trials provide further insight into the potential of VR-enhanced interventions. One of the most influential is the V-TIME trial, which showed that adding a non-immersive VR component to treadmill training significantly reduced fall rates among high-risk older adults, outperforming treadmill training alone [5]. These findings suggest that VR may augment traditional rehabilitation by facilitating task-specific, ecologically relevant motor practice. However, evidence comparing VR or exergaming with well-designed conventional exercise programmes remains mixed. Some meta-analyses report comparable effects between VR and standard physiotherapy, indicating that digital interventions may be equally effective but not necessarily superior [8,10].

Beyond clinical efficacy, patient engagement is a key determinant of real-world impact. Technology-based programmes often report higher enjoyment and good short-term adherence, which are essential for maintaining training intensity and frequency [4,9]. Nevertheless, the long-term sustainability of engagement, the transfer of digital interventions into home-based settings, and the influence of digital literacy or socioeconomic factors remain insufficiently explored. Barriers related to usability, accessibility, and safety must be addressed to ensure that these technologies do not exacerbate disparities in health outcomes [4,7].

Given the increasing volume of research, the diversity of intervention designs, and the rapid technological evolution in this domain, there is a need for an updated, comprehensive synthesis of the evidence. Therefore, this review aims to consolidate findings from recent randomized trials and systematic reviews published since 2015, evaluating both the clinical efficacy of VR and exergaming for fall prevention and their impact on patient engagement and adherence. Through this synthesis, we seek to clarify the role of immersive and non-immersive technologies in modern fall-prevention strategies, identify current limitations in the evidence base, and highlight priorities for future clinical and implementation research [2,3,6,10].

Methodology:

A focused narrative review was conducted to synthesize evidence on virtual reality (VR) and exergaming interventions targeting fall prevention in older adults. The review followed PRISMA principles for search and selection, adapted for a narrative synthesis.

Searches were run in PubMed/MEDLINE, Scopus, Web of Science and IEEE Xplore for records published from January 2015 to January 2025. Search strings combined terms for population (e.g., “older adults”, “elderly”), technology (e.g., “virtual reality”, “exergaming”, “serious games”), and outcomes (e.g., “falls”, “balance”, “gait”, “mobility”). Reference lists of recent systematic reviews and meta-analyses were hand-searched to identify additional relevant studies.

Inclusion criteria: (1) participants mean age ≥60 years or subgroup data for older adults; (2) interventions using immersive or non-immersive VR, commercially available exergames or custom game-based rehabilitation platforms; (3) outcomes related to fall prevention (balance, gait, functional mobility, fall incidence, fear of falling); (4) randomized controlled trials, controlled clinical trials, and systematic reviews/meta-analyses; (5) articles in English, peer-reviewed.

Two reviewers independently screened titles/abstracts and full texts; disagreements were resolved by consensus. Risk of bias for RCTs was appraised with the PEDro scale (or RoB-2 where appropriate); systematic reviews were assessed with AMSTAR-2. Because interventions and outcome measures were heterogeneous, a narrative synthesis was used. Where available, effect directions and effect sizes reported in high-quality meta-analyses were used to contextualize findings.

The following recent, high-quality systematic reviews and meta-analyses were used to guide selection and synthesis steps and to provide pooled estimates where applicable: [11-15].

Results:

Overview

We synthesized randomized trials and high-quality systematic reviews/meta-analyses published 2015–2025 that evaluated VR, exergaming, and immersive VR interventions targeting balance, gait, and fall-related outcomes in older adults. New evidence (RCTs and pooled analyses) consistently shows beneficial effects on balance and functional mobility, with more variable effects on dynamic gait measures and long-term fall incidence.

Balance and functional mobility outcomes

Meta-analyses of exergaming and VR interventions report moderate, statistically significant improvements in validated balance measures (e.g., Berg Balance Scale, center-of-pressure metrics) and functional mobility (Timed Up and Go, chair-stand tests). Pooled estimates indicate clinically relevant gains in dynamic balance and mobility after typical programs of ~20–45 minutes per session, 3×/week for 5–8 weeks [17,18].

At the trial level, RCTs show comparable results: short-to-medium term VR programs (6–8 weeks) produce meaningful improvements in BBS and TUG versus usual care or minimal intervention, and task-specific VR gait training improves spatiotemporal parameters (stride length, gait adaptability) in older adults. These trial-level improvements align with the aggregate findings from systematic reviews [16,19].

Immersive VR (IVR) and modality comparisons

Systematic syntheses focusing on immersive VR report significant improvements in standing balance and multi-item balance scales (SMD/MD in favor of IVR), while aggregated effects on gait speed and overall mobility are smaller and frequently non-significant. Evidence suggests that non-HMD (non-head-mounted) and higher-dose interventions show larger balance effects, indicating dose-response and platform-dependent moderators [18,20].

Exergaming in community and long-term care settings

Meta-analytic evidence supports exergaming's feasibility and effectiveness across community centres and long-term care facilities, with consistent improvements in balance batteries and mobility tests and generally favorable adherence and enjoyment metrics. However, heterogeneity in devices, supervision level, and outcome reporting limits direct comparability and complicates pooled estimates of fall incidence [17,21].

Safety, adherence, and psychological outcomes

Across reviews and trials, adverse events are infrequent and typically mild (transient dizziness, fatigue). Reported adherence and enjoyment are consistently high for gamified and immersive interventions, and several studies report reductions in fear of falling and improvements in balance confidence — outcomes that are important mediators of real-world fall risk reduction [16,21].

Synthesis — strength and limitations of the evidence

In summary, the current high-quality evidence base indicates that VR and exergaming reliably improve balance and functional mobility in older adults (moderate effect sizes), are safe when supervised, and achieve high participant engagement. Evidence for persistent reductions in fall incidence and for superiority over optimally dosed conventional exercise is promising but still limited by heterogeneity, short follow-up, and variable methodological quality across trials. Future RCTs with standardized dosing, longer follow-up and fall-rate endpoints are needed.

Discussion:

The present review synthesizes randomized trials and systematic reviews on virtual reality (VR) and exergaming interventions for fall-prevention in older adults. Overall, the accumulated evidence supports the effectiveness of digital exercise modalities for improving balance and functional mobility, while indicating more mixed results for dynamic gait measures and long-term fall incidence.

Mechanistically, VR and exergames appear to enhance motor learning by providing multisensory feedback, task specificity, and adjustable challenge levels that facilitate progressive balance adaptation and gait training; these processes align with established principles of neuroplasticity and sensorimotor relearning in older adults [3,6,16]. Across trials, improvements are most consistent for validated balance outcomes (e.g., Berg Balance Scale) and common functional mobility tests (Timed Up and Go), suggesting clinically meaningful changes in postural control and basic mobility [16,17,18].

A notable advantage of VR/exergaming is their capacity to integrate cognitive demands into physical tasks (dual-task training), thereby addressing cognitive–motor interactions that strongly predict falls in everyday contexts. Several studies and meta-analyses report gains in dual-task performance and attentional

control after VR-based protocols, supporting the notion that VR can train complex, ecologically valid behaviors that traditional single-modality exercises may not adequately target [6,21,24]. This cognitive–motor coupling likely contributes to observed reductions in fear of falling and improvements in balance confidence in multiple trials [16,21].

Comparative evidence indicates that VR is at least comparable to conventional physiotherapy, and in certain configurations (e.g., VR combined with treadmill or task-specific training) may provide additive benefits beyond standard care. Landmark randomized trials integrating non-immersive VR components with established gait training have demonstrated improved gait adaptability and reduced fall risk surrogates versus identical training without VR, illustrating the value of augmentation rather than wholesale replacement of proven physiotherapy approaches [6,19].

However, several limitations temper the strength of current recommendations. First, heterogeneity is high across studies in terms of hardware (commercial consoles vs. custom VR systems; immersive vs. non-immersive), dosing (session length, frequency, program duration), supervision level, and outcome selection — factors that complicate meta-analytic pooling and practical translation [18,20]. Second, most trials report short-to-medium term outcomes; evidence on sustained effects and direct reductions in actual fall incidence is still limited, with few large, long-term RCTs using fall rate as a primary endpoint [8,19]. Third, safety and acceptability data are often incompletely reported; while adverse events are generally infrequent and mild (e.g., transient dizziness), systematic monitoring—especially in frail or cognitively impaired subgroups—is needed before widescale clinical roll-out [21].

From an implementation perspective, VR and exergaming offer high acceptability and adherence in many trials, driven by gamification, immediate feedback, and perceived enjoyment; this may help overcome well-known adherence barriers to traditional home exercise programs [17,18]. Nevertheless, issues of access, digital literacy, cost, and equity must be proactively addressed to avoid widening disparities in fall-prevention care.

Incorporating recent high-quality syntheses strengthens these conclusions. New systematic reviews confirm beneficial effects of VR on balance and gait, and overviews of exergaming evidence show consistent improvements in static and dynamic balance and lower-limb performance across community and residential settings [22,23,24]. Taken together, the evidence supports recommending VR/exergaming as complementary modalities within multifactorial fall-prevention programs, with the best current strategy being integration with task-specific physiotherapy and careful patient selection.

Recommendations for future research. To consolidate the evidence base, future trials should: adopt standardized outcome sets (including fall incidence, not only surrogates), apply sufficiently powered, longer follow-up designs, report safety and acceptability uniformly, and compare optimized, dose-matched VR protocols with best-practice conventional programs to clarify comparative effectiveness and cost-effectiveness. Addressing these gaps will be essential to inform clinical guidelines and policy for scalable, technology-enabled fall-prevention in older populations.

Conclusions:

This review demonstrates that virtual reality (VR) and exergaming represent effective and engaging modalities for improving balance, functional mobility, and cognitive–motor integration in older adults. Across randomized controlled trials and systematic reviews, these technologies consistently produce meaningful gains in validated balance and mobility measures and offer unique advantages such as enriched sensory feedback, task specificity, and integrated cognitive challenge. Although improvements in surrogate indicators of fall risk are well supported, evidence for long-term reductions in actual fall incidence remains limited due to heterogeneity in study design, insufficient follow-up durations, and variability in outcome reporting.

VR and exergaming should therefore be considered complementary tools within multifactorial fall-prevention strategies rather than standalone replacements for traditional physiotherapy. Their strong motivational and adherence-enhancing qualities indicate particular promise for community-dwelling older adults who struggle with engagement in conventional exercise programs. To fully realize their clinical and public health potential, future research must prioritize larger, methodologically rigorous trials with standardized outcome sets, comprehensive safety monitoring, and evaluation of real-world implementation factors such as accessibility, cost-effectiveness, and digital literacy.

In summary, VR and exergaming offer a viable, evidence-supported approach to enhancing functional capacity and reducing fall risk in aging populations, but further high-quality research is required to determine optimal intervention parameters and confirm sustained preventive effectiveness.

Disclosure
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