

Effect of Virtual-Reality-Based Rehabilitation on Balance and Functional Mobility Following Lower-Limb Orthopaedic Injury

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Abstract:

Balance deficits and reduced functional mobility are common and clinically important consequences of lower-limb orthopaedic injury and surgery. Virtual reality (VR) and exergaming platforms are increasingly used to deliver engaging, feedback-rich exercise, yet their effect on balance and mobility outcomes remains debated. This structured narrative review synthesises evidence from systematic reviews, meta-analyses and key randomised controlled trials (RCTs) of VR-based rehabilitation after ankle injury, anterior cruciate ligament reconstruction (ACLR), total knee arthroplasty (TKA) and mixed lower-limb conditions. The more recent source reviews included 6 to 15 RCTs each. In ankle injury, a pooled analysis of four trials reported a small-to-moderate benefit for overall balance (standardised mean difference [SMD] 0.36, 95% CI 0.01–0.71), driven by static rather than dynamic balance. After TKA, reviews agree that VR improves pain and function, but findings for postural control and Timed Up and Go performance are inconsistent. Evidence after ACLR is promising but of low certainty. Across conditions VR was usually superior to or at least comparable with conventional rehabilitation, with no adverse events reported in ankle trials. Methodological quality was frequently poor to fair, samples were small, and follow-up was short. VR is best viewed as an engaging adjunct to, rather than a replacement for, conventional rehabilitation. Larger, adequately powered and standardised trials are needed.

Keywords: Virtual Reality; Exergaming; Rehabilitation; Balance; Functional Mobility; Orthopaedic Injury; Ankle; Anterior Cruciate Ligament; Knee Arthroplasty.

1. Introduction

Injuries and surgical procedures affecting the lower limb—ankle sprains, ligament ruptures, fractures and joint replacement—are among the most frequent reasons for orthopaedic and physiotherapy care. Ankle sprains alone are very common in the general and athletic populations [1]. Beyond pain and swelling, these conditions disrupt the sensorimotor system: proprioception, muscle strength, reaction time and neuromuscular control are all impaired, and static and dynamic balance deteriorate [2]. Because upright balance depends on the integration of sensory information and coordinated motor responses [3], residual deficits can persist long after tissue healing, limiting walking, stair negotiation and return to sport or work, and raising the risk of re-injury and chronic instability [2].

Conventional rehabilitation—progressive strengthening, range-of-motion work and balance training—is effective, but it is repetitive, can be perceived as monotonous, and depends on sustained adherence. Non-adherence to physiotherapy is a well-documented problem [4], and tedious home programmes are one plausible contributor [5]. Technology that makes exercise more engaging while delivering immediate performance feedback is therefore attractive.

Virtual reality (VR) places users in computer-generated environments with which they can interact in real time. VR systems range from fully immersive head-mounted displays to non-immersive “exergames” played on consoles and balance boards [6]. In neurological rehabilitation, VR has accumulated substantial evidence, including after stroke [7], where it has been associated with improvements in walking speed, balance and mobility [8]. Interest in orthopaedic applications has grown rapidly, but an early systematic review concluded that VR was not clearly superior to conventional exercise across orthopaedic conditions [9]. Since then, condition-specific reviews of ankle injury [5], anterior cruciate ligament reconstruction (ACLR) [10], total knee replacement [11]–[13] and mixed lower-limb populations [14] have appeared, with results that are not always aligned.

This paper integrates that literature with a specific focus on two clinically meaningful outcome domains—balance and functional mobility—following lower-limb orthopaedic injury or surgery. The objectives are to (i) summarise the conceptual rationale for VR-based rehabilitation, (ii) synthesise the strength and consistency of the evidence by injury type, (iii) derive practical implications for clinicians, and (iv) identify priorities for future research.

2. Background and Conceptual Framework

2.1 Balance and functional mobility after injury

Balance is commonly divided into static control (maintaining a posture) and dynamic control (maintaining stability during movement or perturbation). Clinical and laboratory trials most often quantify them with computerised balance platforms and stability indices [5]. Functional mobility reflects the ability to move safely in daily life and is frequently captured by performance tests such as the Timed Up and Go (TUG) [15] and by gait parameters such as speed, cadence and step length [16]. Table 1 lists the measures used in the reviewed trials. Impairments in the two domains are related but not interchangeable: dynamic balance, for example, depends on factors beyond sensory feedback, including ankle range of motion [17], which may help explain why interventions can change static balance without changing mobility tests.

Table 1. Outcome domains and measures used in the reviewed trials

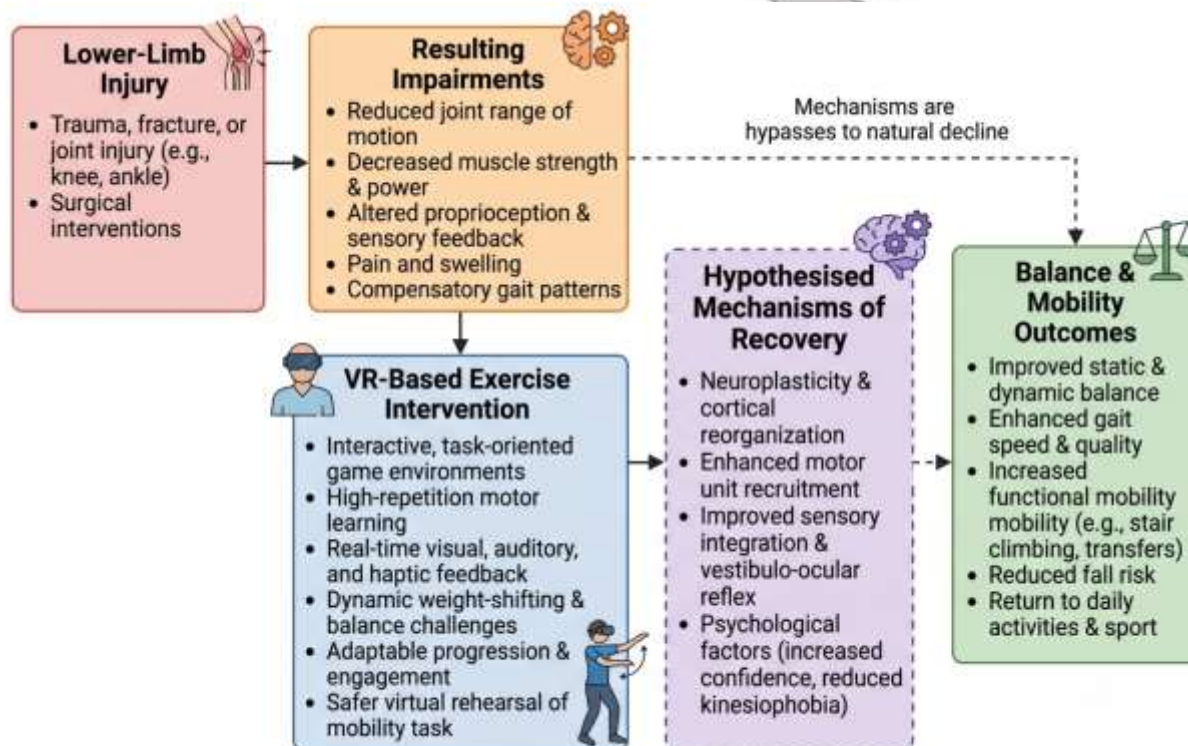
Domain	Typical measures	Comment
Static / dynamic balance	Computerised balance platforms and stability indices (e.g., limits of stability, overall stability index) [5]; Berg Balance Scale [12]	Laboratory measures are precise but not always clinically available.
Functional mobility	Timed Up and Go [15], [12]; gait speed, cadence, step length [16]	Captures daily-life performance; often insensitive in young, active patients.
Patient-reported function and stability	Foot and Ankle Ability Measure, Cumberland Ankle Instability Tool [5]; WOMAC and Hospital for Special Surgery knee score [12]	Reflect perceived benefit and complement performance tests.
Pain and strength	Visual analogue or numeric pain scales; isokinetic dynamometry [5], [12]	Secondary outcomes in most trials.

2.2 VR modalities used in orthopaedic rehabilitation

Most orthopaedic trials use commercially available, non-immersive systems rather than head-mounted displays. In the ankle-injury literature, eight of ten randomised trials used the Nintendo Wii Fit Plus, with other studies using Xbox Kinect or a visual-feedback balance trainer [5]. Reviews of knee-replacement rehabilitation likewise identify the Wii Balance Board as the most frequently used device [11]. Trials after ACLR have employed VR balance training over 8–12 weeks, and the degree of immersion has been proposed as a possible modifier of response [10]. This predominance of low-cost, non-immersive technology is important when interpreting the evidence, because results may not generalise to immersive systems.

2.3 Proposed mechanisms

Figure 1 summarises a conceptual model of how VR may influence outcomes. VR provides task-specific, repeatable movement practice with immediate feedback and graded difficulty, and it can motivate patients to attempt challenging movements within a safe environment [5]. Enjoyment and novelty are associated with sustained engagement in physical activity [18], which could translate into higher training dose and better adherence. These mechanisms are largely hypothesised and extrapolated from neurological rehabilitation [7]; few orthopaedic trials test them directly.



Mechanisms are hypothesised (dashed arrows indicate hypothesised pathways).

Figure 1. Conceptual framework linking lower-limb injury, resulting impairments, VR-based exercise and balance/mobility outcomes. Mechanisms are hypothesised.

3. Review Methods

3.1 Design and scope

This is a structured narrative review. It does not constitute a new systematic review or a new meta-analysis and was not prospectively registered. Where appropriate, the transparency principles of the PRISMA 2020 statement [19] guided how sources and findings are reported.

3.2 Source identification

Targeted searches of the biomedical literature and citation tracking were used to identify systematic reviews, meta-analyses and RCTs evaluating VR or exergaming for adults after lower-limb orthopaedic injury or surgery (ankle, knee ligament, fracture, arthroplasty). Priority was given to recent reviews (2019–2025) and to the primary trials on which they depend. Studies in neurological populations were used only to provide context.

3.3 Outcomes of interest

The primary outcomes were static and dynamic balance and functional mobility (TUG, gait speed and related gait parameters). Secondary outcomes were pain, patient-reported function, muscle strength, adherence or enjoyment, and adverse events.

3.4 Appraisal and synthesis

Methodological quality was taken from the source reviews, which used tools such as the Downs and Black checklist [20], the PEDro scale and the Cochrane risk-of-bias tool [14]. Pooled estimates are reported exactly as published and were not recalculated. Findings were synthesised narratively by injury type, and consistency across reviews was judged qualitatively.

4. Evidence Synthesis

4.1 Overview of the evidence base

Table 2 summarises the principal reviews, and Figure 2 shows the number of RCTs each contains. The evidence base is modest: individual reviews pooled between six and fifteen trials, most with small samples. Reviews for ankle injury, ACLR and knee replacement are now available, whereas fractures and other lower-limb injuries are poorly covered.

Table 2. Principal systematic reviews of VR-based rehabilitation in lower-limb orthopaedic conditions

Review	Population / evidence	Principal conclusion
Gumaa & Youssef [9]	All orthopaedic conditions	Not superior to conventional exercise overall; only four ankle trials, with mixed results (as described in [5]).
Blasco et al. [11]	TKR; 6 trials	Balance-oriented VR may beat standard therapy for balance limitations; no advantage for function, pain or satisfaction.
Peng et al. [12]	TKA; 8 RCTs (7 pooled)	Improved pain and function but not postural control; no significant difference in TUG.
Elaraby et al. [5]	Ankle; 10 RCTs, 394 participants	Significant pooled effect on overall and static balance; dynamic balance not significant; quality mostly poor to fair.
Tunç et al. [14]	Lower extremity; 12 RCTs, PEDro ≥ 7	VR superior or comparable to conventional care for balance and strength; roughly equivalent for pain.
Shaheen et al. [13]	TKR; 15 RCTs, 1,046 participants	Pooled benefit for dynamic balance, and a borderline reduction in pain (95% CI touching zero).
Du et al. [10]	ACLR; 6 RCTs, 464 patients	Possible benefit for knee function, strength, proprioception and pain; low-quality evidence; immersion may matter.

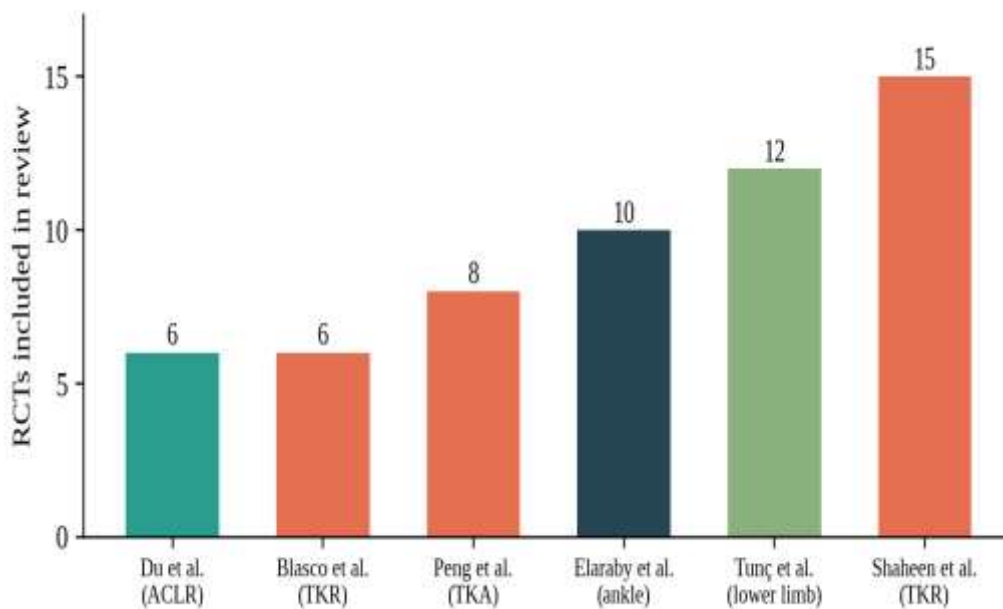


Figure 2. Number of RCTs included in each source review (colour indicates condition: teal = ACLR, orange = knee replacement, dark blue = ankle, green = mixed lower limb).

4.2 Ankle injuries

The most detailed ankle evidence comes from ten RCTs enrolling 394 participants with functional ankle instability or lateral ankle sprain; seven trials originated in South Korea [5]. Four trials were pooled. VR produced a significant effect on overall balance (SMD 0.36, 95% CI 0.01–0.71) with low heterogeneity ($I^2 = 17\%$) [5]. As shown in Figure 3, the effect was concentrated in static balance (SMD 0.57), whereas the dynamic-balance estimate was small and its confidence interval spanned zero [5]. Only two of ten trials were rated good quality, and no adverse events were reported [5].

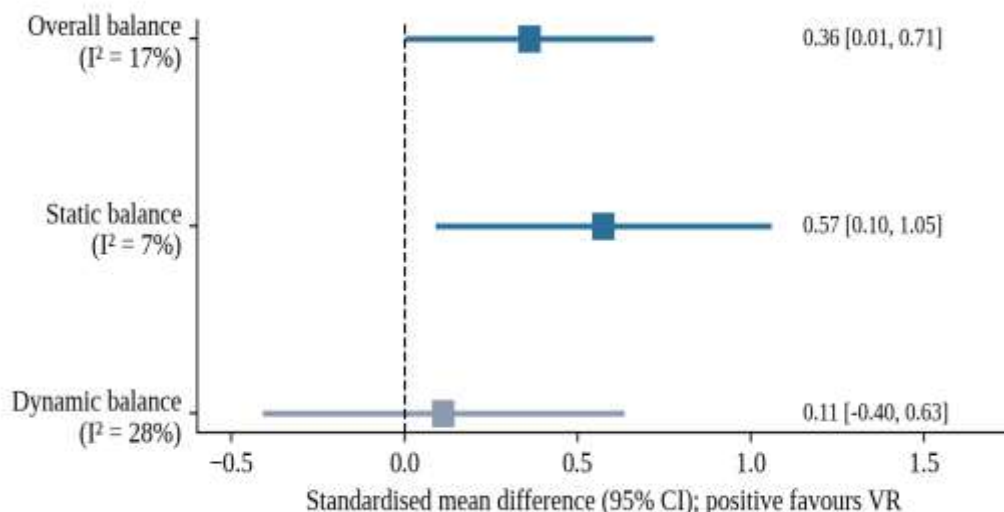


Figure 3. Pooled effects of VR versus conventional physiotherapy or no treatment on balance after ankle injury (values redrawn from the meta-analysis in [5]).

Table 3 lists representative trials. Home-based Wii Fit balance training in 90 patients with acute ankle sprain improved gait speed, cadence and step length, but improvements were similar in the physiotherapy and no-exercise groups [16]; self-reported function likewise improved in all groups without a clear VR advantage [21]. In functional ankle instability, a VR programme produced greater gains than conventional exercise in overall static and mediolateral dynamic balance [22], a visual-feedback balance trainer improved limits of stability [23], and an Xbox Kinect programme improved stability indices in previously injured athletes while a no-exercise control did not [24]. However, in a small pilot trial VR and traditional rehabilitation did not differ between groups [25].

Table 3. Representative RCTs of VR-based rehabilitation after ankle injury (data from the review in [5])

Trial	Population	VR system	Dose	Main finding
Punt et al. [16], [21]	Acute ankle sprain, n = 90	Home-based Wii Fit	30 min, 2×/wk, 6 wk	Gait and function improved in all groups; no clear superiority over physiotherapy or no exercise.
Kim & Heo [22]	Functional ankle instability, n = 21	Wii Fit Plus	20 min, 3×/wk, 4 wk	Greater improvement than conventional exercise in overall static and mediolateral dynamic balance.
Kim et al. [25]	Functional ankle instability, n = 20	Wii Fit Plus	20 min, 3×/wk, 4 wk	Ankle strength improved in some directions in both groups; no significant between-group difference.
Nam et al. [23]	Functional ankle instability, n = 28	Visual-feedback balance trainer	30 min, 3×/wk, 8 wk	Limits of stability improved in the VR group; instability scores improved in both groups.
Vernadakis et al. [24]	Previously injured athletes, n = 63	Xbox Kinect	24 min, 2×/wk, 10 wk	Stability indices improved in VR groups, not in no-exercise control.

4.3 Anterior cruciate ligament reconstruction

A recent meta-analysis of six RCTs (464 patients) tested 8–12 weeks of VR balance training after unilateral ACLR and suggested advantages for knee function, lower-limb strength, proprioception and pain, with immersion level potentially influencing outcome [10]. Conclusions are nevertheless limited by low-quality evidence [10]. Direct evidence for balance and mobility endpoints is therefore less certain than for strength and function, and further trials with standardised balance measures are needed.

4.4 Total knee arthroplasty and replacement

Knee-replacement populations are older and the rehabilitation goals differ, but they provide the largest body of evidence. An earlier review of six trials suggested that balance-oriented VR may overcome balance limitations better than standard therapy, whereas VR showed no advantage for function, pain or satisfaction [11]. A subsequent meta-analysis of eight trials reached a partly opposite conclusion—VR improved pain and function but not postural control, and TUG did not differ significantly [12]. The most recent and largest synthesis (15 RCTs, 1,046 participants) reported favourable pooled effects on dynamic balance and a borderline reduction in pain [13]. The divergence between reviews probably reflects different trial sets, outcome measures, device types and postoperative timing rather than a true contradiction, and it illustrates that conclusions on balance are sensitive to how it is measured.

4.5 Mixed lower-limb and fracture populations

A review restricted to randomised trials of high methodological quality (PEDro ≥ 7) examined lower-extremity VR across foot, ankle, knee and hip conditions and concluded that VR typically produced superior or comparable results to conventional treatment for balance and muscle strength, with roughly equivalent effects on pain [14]. Evidence for fractures is thin. A small feasibility study of Wii Fit as an adjunct to physiotherapy after lower-limb fracture explored safety and sample-size requirements [26], and exergaming has been examined for static postural control in people with a history of lower-limb injury [27]. These studies support feasibility but cannot establish effectiveness.

4.6 Functional mobility

Functional mobility outcomes show a less consistent picture than balance. After TKA, pooled TUG performance did not differ between VR and conventional rehabilitation [12]. After ankle sprain, gait parameters improved with Wii Fit training but not more than with conventional therapy or no exercise [16]. Taken together, VR rarely appears to impair mobility recovery, but there is little evidence that it accelerates it beyond what conventional rehabilitation achieves. Part of this may reflect the short duration of most programmes and ceiling effects in younger patients.

4.7 Adherence, enjoyment and safety

One motivation for VR is adherence. Estimates cited in the ankle literature suggest that roughly one in ten patients miss physiotherapy sessions, one in five do not complete recommended exercises, and many are non-adherent to prescribed programmes [4]. Xbox Kinect balance training was reported to be more enjoyable than traditional programmes [24], and enjoyment has been proposed as a predictor of adherence [18]. However, adherence was rarely a primary outcome, so this benefit remains plausible rather than demonstrated. No adverse events were reported in any of the ten ankle trials [5].

5. Discussion

5.1 Interpretation of findings

Across injury types, VR-based rehabilitation was generally at least as effective as conventional rehabilitation for balance, with a small-to-moderate advantage in some comparisons, particularly static balance after ankle injury [5] and dynamic balance after knee replacement [13]. Evidence that VR improves functional mobility specifically is weaker [12]. Three observations help reconcile the mixed findings. First, outcomes differ: static balance, dynamic balance and mobility tests capture different constructs, and dynamic performance may require longer or different training and depends on factors such as ankle mobility [5], [17]. Second, programmes are heterogeneous in content, with some emphasising strength and others balance, and trials comparing the two found different patterns of benefit [5]. Third, the reviews themselves differ in inclusion criteria, which alters the trials pooled.

5.2 Clinical implications

Current evidence supports VR as an adjunct to, not a replacement for, usual rehabilitation. Trials generally delivered sessions of 20–30 minutes, two to three times per week, for four to ten weeks (Table 3), which provides

a pragmatic starting dose. Clinicians should match the game or task to the target impairment—balance-specific games for balance deficits—and should record both static/dynamic balance and a mobility measure such as the TUG at baseline and follow-up. Home-based delivery is feasible [16], but patient age, technological literacy and prior experience influence usability, and clinicians need training to apply the systems effectively [5]. Given the absence of reported adverse events in ankle trials [5], the safety profile is reassuring, although supervision is advisable after surgery or in older adults.

Figure 4 outlines a simple four-step pathway for integrating VR into a rehabilitation plan. It is a conceptual aid derived from the dose ranges and outcome measures reported in the trials above, and the pathway itself has not been tested in a trial.

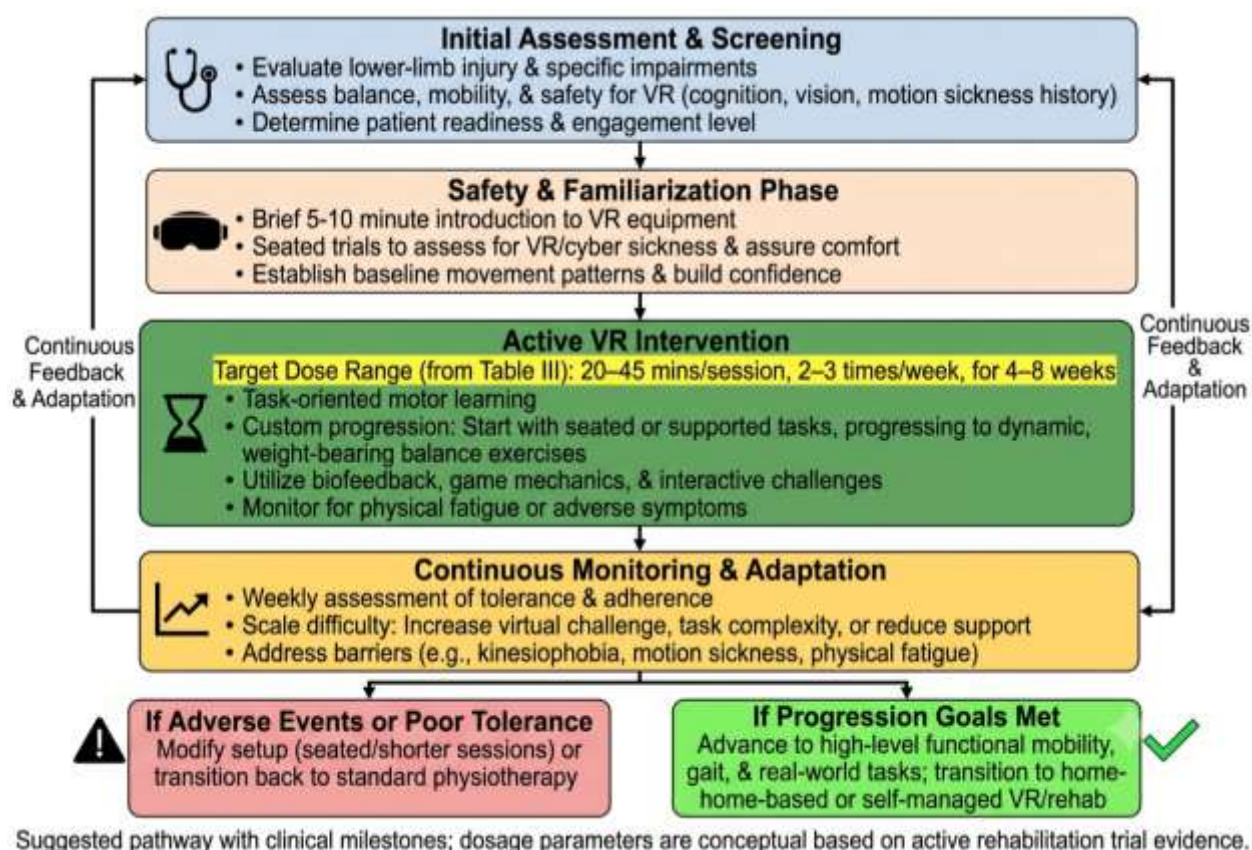


Figure 4. Suggested pathway for integrating VR into lower-limb rehabilitation (conceptual; dose range taken from the trials in Table III).

5.3 Limitations of the evidence

Several weaknesses limit confidence. Samples were small and rarely powered formally, and quality ratings were frequently poor to fair, partly because participants cannot be blinded to VR [5]. Trials were geographically clustered—seven of ten ankle trials came from South Korea [5]—and some authors contributed several studies. Outcomes and devices varied widely, follow-up was short, and the certainty of evidence for ACLR was rated low [10]. Most studies used non-immersive consumer systems, so conclusions may not extend to immersive VR. Finally, available appraisal tools were not designed for VR trials, which may under-rate their quality [5].

5.4 Limitations of this review

This narrative review relied on published reviews and selected trials rather than a registered, exhaustive search, so some studies may have been missed. Pooled estimates were not recalculated, source reviews overlap in the trials they include, and sign conventions differ between meta-analyses, so effect sizes should not be compared directly

across conditions. The conclusions should be read as an evidence-informed synthesis, not as a definitive quantitative estimate.

6. Future Research Directions

Priorities include (1) adequately powered, multicentre RCTs with pre-registered protocols; (2) standardised core outcome sets combining static and dynamic balance with mobility tests such as the TUG and gait speed; (3) longer follow-up to determine whether gains persist and translate into return to sport or work; (4) head-to-head comparisons of immersive and non-immersive systems [10]; (5) dose-response studies to define the optimal frequency and duration; (6) trials in under-studied groups such as fractures [26]; (7) direct measurement of adherence and cost-effectiveness; and (8) development of quality-appraisal tools suited to VR interventions [5]. Tele-rehabilitation formats, already shown to be feasible at home [16], merit particular attention.

7. Conclusion

Virtual-reality-based rehabilitation is a safe and engaging option that generally performs as well as, and sometimes better than, conventional rehabilitation for balance after lower-limb orthopaedic injury, with the clearest signal for static balance after ankle injury and growing evidence for dynamic balance after knee replacement. Evidence for improved functional mobility is limited and inconsistent, and the overall certainty is constrained by small, short and methodologically weak trials. VR should currently be used as a complement to supervised conventional rehabilitation, with outcomes monitored. Rigorous, standardised trials are needed before it can be recommended as a stand-alone treatment.

References

- [1] B. R. Waterman, B. D. Owens, S. Davey, M. A. Zacchilli, and P. J. Belmont, "The epidemiology of ankle sprains in the United States," *J. Bone Joint Surg. Am.*, vol. 92, pp. 2279–2284, 2010, <https://doi.org/10.2106/JBJS.I.01537>.
- [2] Y.-J. Hung, "Neuromuscular control and rehabilitation of the unstable ankle," *World J. Orthop.*, vol. 6, no. 5, pp. 434–438, 2015, <https://doi.org/10.5312/wjo.v6.i5.434>.
- [3] F. B. Horak, "Postural orientation and equilibrium: What do we need to know about neural control of balance to prevent falls?," *Age Ageing*, vol. 35, suppl. 2, pp. ii7–ii11, 2006, <https://doi.org/10.1093/ageing/afl077>.
- [4] S. F. Bassett and H. Prapavessis, "A test of an adherence-enhancing adjunct to physiotherapy steeped in the protection motivation theory," *Physiother. Theory Pract.*, vol. 27, pp. 360–372, 2011, <https://doi.org/10.3109/09593985.2010.507238>.
- [5] A. E. R. Elaraby, M. Shahien, A. M. Jahan, M. Etoom, and A. H. Bekhet, "The efficacy of virtual reality training in the rehabilitation of orthopedic ankle injuries: A systematic review and meta-analysis," *Adv. Rehabil. Sci. Pract.*, vol. 12, Art. no. 11795727231151636, 2023, <https://doi.org/10.1177/11795727231151636>.
- [6] P. Cipresso, I. A. C. Giglioli, M. A. Raya, and G. Riva, "The past, present, and future of virtual and augmented reality research: A network and cluster analysis of the literature," *Front. Psychol.*, vol. 9, Art. no. 2086, 2018, <https://doi.org/10.3389/fpsyg.2018.02086>.
- [7] K. E. Laver, B. Lange, S. George, J. E. Deutsch, G. Saposnik, and M. Crotty, "Virtual reality for stroke rehabilitation," *Cochrane Database Syst. Rev.*, vol. 11, Art. no. CD008349, 2017, <https://doi.org/10.1002/14651858.CD008349.pub4>.
- [8] D. Corbetta, F. Imeri, and R. Gatti, "Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: A systematic review," *J. Physiother.*, vol. 61, no. 3, pp. 117–124, 2015, <https://doi.org/10.1016/j.jphys.2015.05.017>.
- [9] M. Gumaa and A. Rehan Youssef, "Is virtual reality effective in orthopedic rehabilitation? A systematic review and meta-analysis," *Phys. Ther.*, vol. 99, pp. 1304–1325, 2019, <https://doi.org/10.1093/ptj/pzz093>.
- [10] C. Du, N.-M. Gu, T.-C. Guo, and A.-F. Liu, "Efficacy of virtual reality balance training on rehabilitation outcomes following anterior cruciate ligament reconstruction: A systematic review and meta-analysis," *PLoS ONE*, vol. 20, no. 1, Art. no. e0316400, 2025, <https://doi.org/10.1371/journal.pone.0316400>.

- [11] J. Blasco, C. Igual-Camacho, M. Blasco, V. Antón-Antón, L. Ortiz-Llueca, and S. Roig-Casasús, "The efficacy of virtual reality tools for total knee replacement rehabilitation: A systematic review," *Physiother. Theory Pract.*, vol. 37, no. 6, pp. 682–692, 2021, <https://doi.org/10.1080/09593985.2019.1641865>.
- [12] L. Peng et al., "Virtual reality-based rehabilitation in patients following total knee arthroplasty: A systematic review and meta-analysis of randomized controlled trials," *Chin. Med. J.*, vol. 135, no. 2, pp. 153–163, 2022, <https://doi.org/10.1097/CM9.0000000000001847>.
- [13] A. A. M. Shaheen et al., "Efficacy of virtual reality-based rehabilitation following total knee replacement: A systematic review and meta-analysis of randomized control trials," *Bull. Fac. Phys. Ther.*, vol. 30, no. 1, 2025, <https://doi.org/10.1186/s43161-024-00246-y>.
- [14] H. Tunç, M. K. Bakar, S. Özden, G. Leblebici, and D. Tarakçı, "The effect of virtual reality applications on treatment outcomes in lower extremity rehabilitation: A systematic review," *Adv. Rehabil.*, vol. 38, no. 3, pp. 43–57, 2024, <https://doi.org/10.5114/areh.2024.143256>.
- [15] D. Podsiadlo and S. Richardson, "The timed "Up & Go": A test of basic functional mobility for frail elderly persons," *J. Am. Geriatr. Soc.*, vol. 39, no. 2, pp. 142–148, 1991, <https://doi.org/10.1111/j.1532-5415.1991.tb01616.x>.
- [16] I. M. Punt, S. Armand, J. L. Ziltener, and L. Allet, "Effect of Wii Fit exercise therapy on gait parameters in ankle sprain patients: A randomized controlled trial," *Gait Posture*, vol. 58, pp. 52–58, 2017, <https://doi.org/10.1016/j.gaitpost.2017.06.284>.
- [17] M. C. Hoch, G. S. Staton, and P. O. McKeon, "Dorsiflexion range of motion significantly influences dynamic balance," *J. Sci. Med. Sport*, vol. 14, pp. 90–92, 2011, <https://doi.org/10.1016/j.jsams.2010.08.001>.
- [18] N. Lakicevic, A. Gentile, S. Mehrabi, et al., "Make fitness fun: Could novelty be the key determinant for physical activity adherence?," *Front. Psychol.*, vol. 11, Art. no. 577522, 2020, <https://doi.org/10.3389/fpsyg.2020.577522>.
- [19] M. J. Page et al., "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," *BMJ*, vol. 372, Art. no. n71, 2021, <https://doi.org/10.1136/bmj.n71>.
- [20] S. H. Downs and N. Black, "The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions," *J. Epidemiol. Community Health*, vol. 52, no. 6, pp. 377–384, 1998, <https://doi.org/10.1136/jech.52.6.377>.
- [21] I. M. Punt, J. L. Ziltener, D. Monnin, and L. Allet, "Wii Fit exercise therapy for the rehabilitation of ankle sprains: Its effect compared with physical therapy or no functional exercises at all," *Scand. J. Med. Sci. Sports*, vol. 26, pp. 816–823, 2016, <https://doi.org/10.1111/sms.12509>.
- [22] K. J. Kim and M. Heo, "Comparison of virtual reality exercise versus conventional exercise on balance in patients with functional ankle instability: A randomized controlled trial," *J. Back Musculoskelet. Rehabil.*, vol. 32, pp. 905–911, 2019, <https://doi.org/10.3233/BMR-181376>.
- [23] S. M. Nam, K. Kim, and D. Y. Lee, "Effects of visual feedback balance training on the balance and ankle instability in adult men with functional ankle instability," *J. Phys. Ther. Sci.*, vol. 30, pp. 113–115, 2018, <https://doi.org/10.1589/jpts.30.113>.
- [24] N. Vernadakis, V. Derri, E. Tsitskari, and P. Antoniou, "The effect of Xbox Kinect intervention on balance ability for previously injured young competitive male athletes: A preliminary study," *Phys. Ther. Sport*, vol. 15, pp. 148–155, 2014, <https://doi.org/10.1016/j.ptsp.2013.08.004>.
- [25] K. Kim, B. Choi, and W. Lim, "The efficacy of virtual reality assisted versus traditional rehabilitation intervention on individuals with functional ankle instability: A pilot randomized controlled trial," *Disabil. Rehabil. Assist. Technol.*, vol. 14, pp. 276–280, 2019, <https://doi.org/10.1080/17483107.2018.1429501>.
- [26] S. M. McPhail, M. O'Hara, E. Gane, P. Tonks, J. Bullock-Saxton, and S. S. Kuys, "Nintendo Wii Fit as an adjunct to physiotherapy following lower limb fractures: Preliminary feasibility, safety and sample size considerations," *Physiotherapy*, vol. 102, pp. 217–220, 2016, <https://doi.org/10.1016/j.physio.2015.04.006>.
- [27] J. Sims, N. Cosby, E. N. Saliba, J. Hertel, and S. A. Saliba, "Exergaming and static postural control in individuals with a history of lower limb injury," *J. Athl. Train.*, vol. 48, pp. 314–325, 2013, <https://doi.org/10.4085/1062-6050-48.2.04>.