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REVIEW

Virtual reality training and balance and gait in Parkinson's disease in Latin America: a systematic review

Entrenamiento con realidad virtual y equilibrio y marcha en la enfermedad de Parkinson en América Latina: una revisión sistemática

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ABSTRACT

Introduction: Balance and gait impairments are among the most disabling features of Parkinson's disease, and virtual reality training is increasingly offered to treat them, but the evidence generated in Latin America has not been synthesised. Methods: This systematic review followed PRISMA 2020. Five sources were searched for reports published from 2012 to 2024 in English, Spanish and Portuguese. Prospective studies of virtual reality or exergame training in Parkinson's disease, conducted in Latin America and reporting balance or gait outcomes, were included. Results: The review included 33 studies with 549 participants, 32 from Brazil and 1 from Chile: eight randomized trials, six non-randomized comparative studies and 19 uncontrolled before-after studies. Of 23 studies measuring balance, 19 reported improvement after training, and of 20 measuring gait or mobility, 11 did. Among 9 comparisons with an active control, 7 showed similar effects. No randomized trial had low risk of bias, and all uncontrolled studies were at critical risk. Conclusions: Studies from Latin America show that virtual reality training is feasible and is followed by better balance scores, but they offer no evidence of superiority over conventional rehabilitation. The certainty of the evidence is very low, and randomized trials with adequate samples, blinded assessment and common outcomes are required in Spanish-speaking countries.

Keywords: Parkinson disease; virtual reality; postural balance; gait; Latin America.

RESUMEN

Introducción: Las alteraciones del equilibrio y de la marcha figuran entre las manifestaciones más incapacitantes de la enfermedad de Parkinson y se tratan cada vez más con realidad virtual, pero la evidencia generada en América Latina no se ha sintetizado. Métodos: Revisión sistemática según PRISMA 2020 con cinco fuentes, informes de 2012 a 2024 en inglés, español y portugués. Se incluyeron estudios prospectivos de realidad virtual o videojuegos activos en la enfermedad de Parkinson, realizados en América Latina, con desenlaces de equilibrio o marcha. Resultados: Se incluyeron 33 estudios con 549 participantes, 32 de Brasil y 1 de Chile: ocho ensayos aleatorizados, seis comparativos no aleatorizados y 19 antes-después sin control. De 23 estudios que midieron equilibrio, 19 informaron mejoría, y de 20 que midieron marcha o movilidad, 11. En 9 comparaciones con control activo, 7 mostraron efectos similares. Ningún ensayo tuvo bajo riesgo de sesgo y los estudios sin control tuvieron riesgo crítico. Conclusiones: Los estudios de América Latina muestran que el entrenamiento con realidad virtual es factible y se acompaña de mejores puntuaciones de equilibrio, pero no aportan evidencia de superioridad frente a la rehabilitación convencional. La certeza es muy baja y se requieren ensayos aleatorizados con muestras adecuadas, evaluación enmascarada y desenlaces comunes en países hispanohablantes.

Palabras clave: enfermedad de Parkinson; realidad virtual; equilibrio postural; marcha; América Latina.

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INTRODUCTION

Parkinson's disease affected 6.1 million people worldwide in 2016, up from 2.5 million in 1990, according to the estimates of the Global Burden of Disease 2016 Parkinson's Disease Collaborators. (1) In Latin America, Llibre-Guerra et al.(2) estimated a prevalence of 2.0% among 11,613 adults aged 65 years or older from six countries, and Kim et al.(3) pooled 17 studies into a prevalence of 472 per 100,000 inhabitants. In the same older cohorts, Kim and colleagues (4) linked Parkinson's disease to incident dependency and to mortality, which underlines the need for effective rehabilitation in the region.

Among the motor features of the disease, postural instability and gait disturbance stand out. Silva et al.(5)noted that impaired postural control and functional mobility limit daily activities and raise the occurrence of falls, and that postural control responds poorly to dopaminergic replacement although physiotherapy can improve it. Dockx et al.(6)described virtual reality as a rehabilitation tool that may optimise motor learning in a safe environment and replicate real-life scenarios, and noted that most trials used commercially available devices.

Several syntheses have weighed that promise. Dockx et al.(6) included eight trials with 263 participants and found that virtual reality and physiotherapy may have similar effects on gait and balance, with low-quality evidence. Lei et al.(7) pooled 16 randomized trials with 555 participants and reported a small advantage for balance function, a larger one for step and stride length, and no effect on gait speed. Harris et al.(8) found only two Parkinson's disease studies for their balance analysis, and Juras et al.(9) reported that most controlled trials of virtual reality for balance carried a high risk of bias through small samples and missing randomization or blinding. None of these abstracts describes a separate analysis of studies conducted in Latin America.

That omission matters because regional studies are often published in Portuguese or Spanish and may escape English-language syntheses. What those studies found, and how reliable it is, remains unanswered. Two features of the regional evidence justify a separate synthesis. First, the clinical setting differs from that of the trials pooled elsewhere, since regional studies may be run in university clinics or public services, where consoles, staff time and participant recruitment follow local constraints. Second, the language of publication changes who can read the reports, and a review that gathers them in English can return them to the international discussion. This systematic review therefore aimed to synthesise published studies conducted in Latin America on virtual reality training for balance and gait in people with Parkinson's disease, asking whether the training improves balance and gait compared with conventional rehabilitation, with global evidence reserved for comparison in the Discussion.

METHODS

Protocol and reporting

The review followed the PRISMA 2020 statement of Page et al..(10)

Eligibility criteria

The population was people with a diagnosis of Parkinson's disease of any stage. The intervention was training with virtual reality or active video games (immersive or non-immersive, commercial consoles or purpose-built systems) as the main component of the programme. Comparators could be conventional physiotherapy, other exercise, no intervention or none, so that single-group designs were eligible. Eligible outcomes were any measure of balance (clinical scales, functional tests or posturography) or of gait and mobility (walking tests, gait speed or the Timed Up and Go test).

Eligible designs were prospective intervention studies with quantitative outcomes: randomized trials, non-randomized controlled studies, uncontrolled before-after studies and case series. The study had to be conducted in Latin America, meaning that participants were recruited and trained in a Latin American country, whatever the affiliation of the authors or the language of the report. Reports published from 2012 to 2024 in English, Spanish or Portuguese were considered, including journal articles and proceedings papers. Reviews, protocols without results, cross-sectional and diagnostic studies, interventions combined with brain stimulation, studies reporting only game scores, cognition or quality of life, and duplicate reports of the same cohort were excluded. Reports without a DOI were eligible when a stable and accessible publisher address existed, because the regional literature includes journals and proceedings that do not assign DOIs, and a

missing identifier says nothing about the quality of a study. Single-group designs were kept for the same reason: most regional reports are before-after series, and excluding them would have left a handful of trials and hidden the shape of the literature.

Information sources and coverage

Scopus, PubMed, Crossref, OpenAlex and Semantic Scholar were searched for reports published between 2012 and 2024. Because regional reports may carry Portuguese or Spanish titles and abstracts, searches were run in English, Spanish and Portuguese, and a further Scopus query restricted by affiliation country to Latin American nations was added. Reference lists were not screened by hand and no trial registers were searched. Regional literature databases were not queried directly, so the coverage of Latin American journals depends on their indexing in the five sources.

Search strategy

The main Scopus query was TITLE-ABS-KEY("Parkinson" AND ("virtual reality" OR exergam OR "video game*" OR kinect OR "nintendo wii" OR "wii fit") AND (balance OR gait OR postural OR equilibrium)) AND PUBYEAR > 2011 AND PUBYEAR < 2025. Parallel queries combined Parkinson with "realidad virtual", "realidade virtual", videojuego, jogos, Wii, Kinect, equilíbrio, equilibrio and marcha, and the PubMed queries used the corresponding MeSH terms and country affiliation filters. The searches returned 2,294 records, of which 525 came from Scopus, 478 from PubMed, 700 from Crossref, 374 from OpenAlex and 217 from Semantic Scholar.

Regional scope and missing information

The regional criterion was applied to the place where participants were recruited and trained, which was read from the affiliations, the ethics statements and the setting described in each report. Reports whose setting could not be established from the available text were assessed on the affiliations of the authors and are flagged in the tables when the city was not stated. When a report omitted a datum, such as the number of participants or the platform, the datum was recorded as not stated and no value was inferred from other reports.

Data extraction

For each study the reviewer recorded the setting, design, number of participants with Parkinson's disease, platform, training dose, comparator, balance and gait outcomes and the result reported by the authors. Extraction followed the same assisted procedure and drew only on the report; authors were not contacted, and no value was imputed. The outcome of each study was classified for balance and for gait or mobility as improved, unchanged or mixed, using the authors' own statement of change, and as not measured when the report gave no result for that domain. Comparisons were coded separately for active controls, such as conventional physiotherapy or another exercise, and for passive controls, such as no intervention. Studies are identified by the first author and year throughout.

Risk of bias

Randomized trials were appraised with RoB 2 of Sterne et al.,(11)and non-randomized and uncontrolled studies with ROBINS-I of Sterne and colleagues.(12)Domains that the available report did not allow to judge were labelled as lacking information, and no study could be rated at low risk on that basis. Uncontrolled before-after studies lack a comparison group and were therefore rated at critical risk of confounding by definition.

Synthesis and certainty

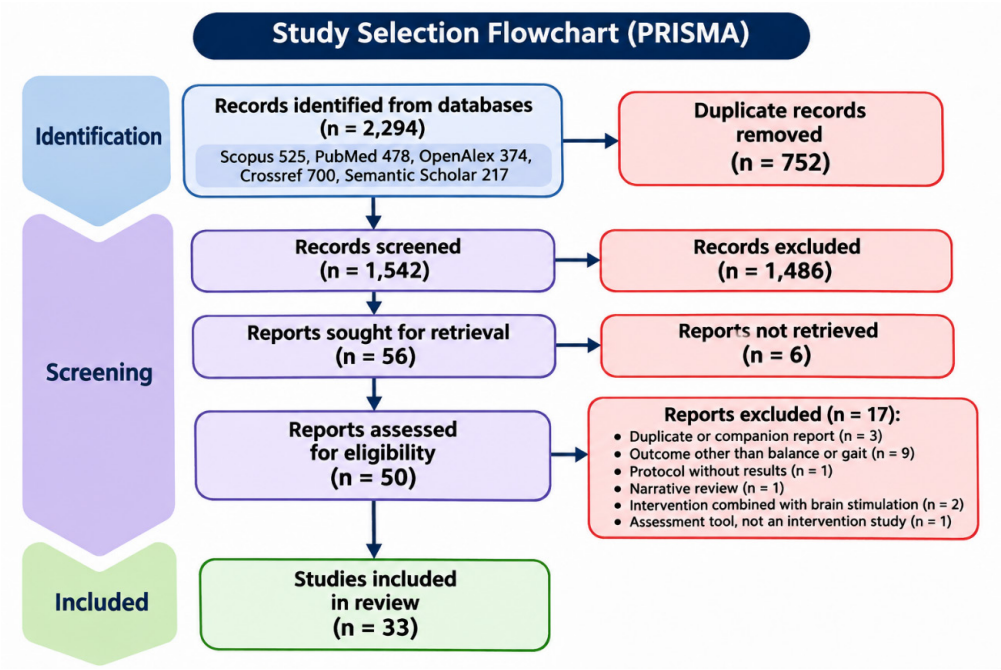
The synthesis was narrative and organised by outcome. The direction of change was taken as the authors reported it, within groups and between groups, and was classified as improved, unchanged or mixed. No pooled estimate was calculated, because the studies used different balance and gait measures, most reports did not give standard deviations by group, and 19 of the studies had no control arm. The certainty of the evidence was judged qualitatively following the GRADE approach of Guyatt et al.,(13)considering risk of bias, inconsistency, indirectness, imprecision and publication bias, without a formal summary-of-findings table. All counts were computed from the extraction records with a script that is reproducible from those records.

RESULTS

Selection and characteristics of the studies

After the removal of 752 duplicates, 1,542 records were screened and 1,486 were excluded on title and abstract. Of the 56 reports sought, 6 could not be retrieved or verified and 50 were assessed, of which 17 were excluded: nine measured outcomes other than balance or gait, three duplicated a cohort already included, and five were a protocol, a review, an assessment tool or an intervention combined with brain stimulation. The remaining 33 studies formed the review. The six reports not retrieved were not excluded on eligibility grounds and are treated as not verifiable (Figure 1).

Figure 1. Flow of records through the review.



Brazil contributed 32 studies and Chile one, and no eligible study from another country was found, although searches in Spanish and a Scopus query restricted by Latin American affiliation countries were run. Publication years ran from 2012 to 2024, with 22 of the studies appearing from 2018 onwards. Eight were randomized trials, six were non-randomized comparative studies and 19 were uncontrolled before-after studies or case series (Table 1, Table 2).

The studies enrolled 549 participants with Parkinson's disease, and one study did not state its sample size. The median sample was 10.50 participants, with a range from 2 to 62, and 15 of the 32 studies that reported a sample enrolled fewer than ten people. Platforms were the Nintendo Wii in 17 studies, the Xbox Kinect in 7 and both consoles in one; two studies used head-mounted immersive systems and 6 used other or unspecified platforms, among them the PlayStation 3. Programmes lasted from a single session to 12 weeks. Randomized trials were the largest, with a median of 33 participants, and 4 of the eight trials enrolled 30 people or more, against a median of 6 in the uncontrolled studies. São Paulo contributed 8 of the studies, which points to a concentration of research groups in one city rather than a national sample. Full texts were available for 17 studies, and the other 16 were assessed on their abstracts. Three included reports had no DOI (those of Galeote and Cecato,(14) de Andrade et al.(15) and Almeida (16)), and the report of Bacha et al.(17) carried a DOI that Crossref did not hold; all four were included through stable publisher addresses.

Where the number of sessions was stated, programmes comprised from 1 to 20 sessions, with a median of 12; ten sessions were used in 8 studies, 12 in 3 and 14 in 6. Among reports that gave duration in weeks, the longest programme ran for 12 weeks. Sessions lasted from 20 to 60 minutes when the length was given.

The outcome measures were heterogeneous. The Berg Balance Scale appeared in 12 studies and the Timed Up and Go in 12, the 10-m walk in 8, the 6-minute walk in 4, the Mini-BESTest or the full BESTest in 4, force-platform or baropodometric measures in 4, the Tinetti scale in 2

and the Dynamic Gait Index in 2.

Table 1. Characteristics of the randomized and non-randomized comparative studies.

Study	Setting	Participants with PD (n)	Virtual reality intervention	Comparator	Balance and gait outcomes
(5)	São Paulo	38	Kinect Adventures games, 14 sessions of 60 min, twice weekly	Physiotherapy protocol based on the European guideline	Mini-BESTest (primary); posturography; Timed Up and Go (TUG)
(18)	Porto Alegre	23	Ten sessions over 5 weeks of tightrope-walking balance training in immersive VR (20 min per session)	Psychoeducation without exercise	TUG; 10MWT; mobility smoothness
(19)	Salvador	45	Nintendo Wii alone, or Wii plus conventional exercises, 50 min twice weekly for 2 months	Conventional exercises	Balance; gait; functional mobility; quality of life
(20)	Chile	8	Six weeks of multicomponent training based on Nintendo Wii	Traditional training	TUG; 10-m walk test; Short Physical Performance Battery
(21)	Salvador	62	Kinect Adventures exergames, 8 weeks	Functional training; stationary bicycle	6-minute walk test (6MWT, primary); 10-m walk test (10MWT); sitting-rising test
(22)	São Paulo	37	Gait training with Xbox games	Treadmill gait training; conventional training	6MWT; gait variables; heart rate
(23)	Curitiba	20	Exergaming, 12 weeks	Conventional exercise	Berg Balance Scale; 6MWT; fatigue; PDQ-39
(24)	Brazil	29	Ten sessions of exercises with virtual reality	Exercises without virtual reality	Pain (primary); Berg Balance Scale; 10MWT
(25)	Londrina	40	One 50-min session each of augmented reality, virtual reality and neurofunctional physiotherapy, 7 days apart	Neurofunctional physiotherapy (same participants)	Force-platform postural control; Trail Making Test
(26)	São Paulo	40	Ten one-hour sessions, twice weekly, with four immersive games	No training	TUG; 10MWT; 30-s walk with single and dual task; cognition
(27)	Brasília	8	Ten sessions of six Xbox 360 Kinect games over 5 weeks	Eight healthy older adults (same training)	TUG; 10MWT; Berg Balance Scale; cognition
(28)	Brasília	27	Ten sessions of four games on Nintendo Wii or on Xbox Kinect	No intervention	Single- and dual-task gait tests; cognition; anxiety; quality of life
(29)	Brazil	11	Twelve Wii Fit sessions	Twelve kinesiotherapy sessions (same participants)	TUG; Berg Balance Scale; 10MWT; falls efficacy
(30)	São Paulo	16	Eight sessions of Wii Fit training, follow-up session at 60 days	Eleven healthy older adults (same training)	Game scores; functional reach test (transfer)

Note: PD = Parkinson's disease; TUG = Timed Up and Go; 10MWT = 10-m walk test; 6MWT = 6-minute walk test; PDQ-39 = Parkinson's Disease Questionnaire; UPDRS = Unified Parkinson's Disease Rating Scale; BESTest = Balance Evaluation Systems Test. Setting shows the city or, when not stated, the country.

Risk of bias

None of the 33 studies reached a low risk of bias. The eight randomized trials were rated as having some concerns, since allocation concealment and outcome masking could not be confirmed from the available reports, and three of them stated that assessors were blinded. The six non-randomized comparative studies were rated at serious risk, mainly through confounding, and two reported blinded assessment. The 19 uncontrolled studies were rated at critical risk, and only one of them mentioned a blinded evaluator (Table 3).

Table 2. Characteristics of the uncontrolled before-after studies and case series.

Study	Setting	Participants with PD (n)	Virtual reality intervention	Comparator	Balance and gait outcomes
(31)	Brazil	2	Wii Fit and Wii Fit Plus, twice weekly for 10 weeks	None	Mini-BESTest; TUG; Falls Efficacy Scale; PDQ-39
(32)	Belém	2	Thirty-minute sessions twice weekly for 5 weeks	None	Dynamic Gait Index; Freezing of Gait Questionnaire; UPDRS
(17)	São Paulo	10	Fourteen one-hour sessions, twice weekly, with Kinect Adventures	None	Force-platform centre-of-pressure area and velocity; limits of stability
(33)	Brazil	7	Ten sessions with the Nintendo Wii console	None	10MWT; satisfaction scale
(34)	Fortaleza	2	Six weeks, twice weekly, with three Wii Fit games	None	Baropodometry (static balance); gait analysis
(35)	Brazil	3	Fourteen sessions with the Nintendo Wii	None	Berg Balance Scale; Functional Reach Test; TUG
(36)	Curitiba	16	Nintendo Wii balance games (Tightrope Walk, Ski Slalom and others) with Wii Balance Board	None	Berg Balance Scale; Dizziness Handicap Inventory; SF-36
(37)	Brazil	6	Fifteen virtual reality sessions	None	Tinetti scale; PDQL
(38)	Brazil	Not stated	Three single 25-min sessions with a different game each	None	Posturography; Berg Balance Scale and TUG at baseline
(39)	Brazil	9	Twenty sessions of 50 min with Wii Fit Plus, twice weekly	None	Berg Balance Scale
(40)	São Paulo	4	Wii Fit Plus games	None	Berg Balance Scale; Functional Independence Measure
(14)	Jundiaí	13	Fourteen sessions, twice weekly, with five Nintendo Wii games	None	Berg Balance Scale; TUG
(15)	Brazil	4	Wii Fit exercises targeting balance	None	Mini-BESTest
(41)	São Paulo	7	Kinect Adventures, 14 sessions of 60 min, three times weekly	None	6MWT; Balance Evaluation Systems Test (BESTest); Dynamic Gait Index; PDQ-39
(42)	Brazil	15	Fourteen sessions of 40 min, twice weekly, with Wii Fit Plus	None	Biomechanical gait analysis (stride length, speed); UPDRS III
(43)	Brazil	6	Eighteen 30-min sessions of Wii Sports boxing and tennis	None	Trunk mobility; Berg Balance Scale; PDQ-39
(44)	São Paulo	30	Wii Fit Plus training (aerobic, balance and plus exercises)	None (two trained groups, with and without freezing of gait)	TUG; UPDRS III; freezing questionnaire
(16)	Torres	3	Ten 30-min sessions, twice weekly, with Kinect Adventures	None	Tinetti scale
(45)	Curitiba	6	Twelve sessions, twice weekly, with four Wii Fit games	None	Berg Balance Scale; TUG; functional reach; Borg scale

Note: PD = Parkinson's disease; TUG = Timed Up and Go; 10MWT = 10-m walk test; 6MWT = 6-minute walk test; PDQ-39 = Parkinson's Disease Questionnaire; UPDRS = Unified Parkinson's Disease Rating Scale; BESTest = Balance Evaluation Systems Test. Setting shows the city or, when not stated, the country.

Table 3. Risk of bias by study design.

Design	Tool	Studies	Overall judgement	Blinded assessment reported
Randomized trial	RoB 2	8	Some concerns	3
Non-randomized comparative study	ROBINS-I	6	Serious	2
Uncontrolled before-after study or case series	ROBINS-I	19	Critical	1

Note: RoB 2 = Cochrane risk-of-bias tool for randomized trials, version 2; ROBINS-I = Risk Of Bias In Non-randomised Studies of Interventions.

Balance

Silva et al.(5)carried the largest trial that measured balance as its primary outcome. They ran-

domized 38 patients in São Paulo to Kinect Adventures games or to a physiotherapy protocol based on the European guideline, and both groups improved on the Mini-BESTest after 14 sessions, with no difference between them. Santos et al.(19)observed the same pattern in 45 patients allocated to the Nintendo Wii alone, to conventional exercises or to both: all groups improved, and only the effect size favoured the combination.

Ribas et al.(23)randomized 20 patients in Curitiba to exergaming or conventional exercise and found better Berg Balance Scale scores after 12 weeks of exergaming ($p = 0.033$), a gain that had disappeared at 60 days. D'Alencar et al.(24)allocated 29 older adults to exercises with or without virtual reality, and balance on the Berg scale improved in both arms.

Among non-randomized comparisons, Araújo et al.(25)exposed 40 patients in Londrina to one session each of augmented reality, virtual reality and neurofunctional physiotherapy, and postural control on a force platform improved after all three modalities without differences between them. Ramos et al.(29) gave 11 patients 12 kinesiotherapy sessions and 12 Wii Fit sessions and reported no statistical differences in Berg, Timed Up and Go or walking variables, although most patients preferred the console. De Melo Cerqueira et al.(27)likewise found no motor improvement in eight patients after ten Kinect sessions, while cognitive scores rose. Mendes et al.(30)followed 16 patients through eight Wii Fit sessions and found that they learned and retained seven of ten games over 60 days, showed learning deficits on three games with high cognitive demand, and transferred motor ability to a functional reach task.

Pompeu et al.(41)opened the uncontrolled reports with seven patients whose Balance Evaluation Systems Test scores improved after 14 Kinect Adventures sessions, and no adverse events occurred. Severiano et al.(36)observed 16 patients in Curitiba and found better Berg scores after training, significant for the Ski Slalom game ($p < 0.05$). Galeote and Cecato(14)trained 13 older adults in Jundiaí with five Nintendo Wii games over 14 sessions, and mean Berg scores rose from 49.52 to 52.77 points ($p = 0.002$).

Smaller series pointed the same way. Nogueira et al.(39)reported gains in the stationary tests and the transfer items of the Berg scale in nine patients after 20 Wii Fit Plus sessions, and Ramos et al.(37)recorded better static and dynamic Tinetti scores in six patients trained on the PlayStation 3 ($p < 0.0013$). Loureiro et al.(45)found higher Berg ($p = 0.0277$) and lateral functional reach scores in six patients, and da Silva et al.(43)found higher Berg scores ($p = 0.02$) together with greater trunk mobility.

The smallest series were descriptive. De Freitas et al.(40)reported a mean Berg score that moved from 38.25 to 49 points in four patients, Maffei et al.(35)recorded Berg gains of two, seven and three points in three patients, and de Oliveira et al.(31)observed improvement or maintenance of Mini-BESTest scores in two patients. De Andrade et al.(15)and Almeida(16)described improvement in postural stability and in Tinetti scores in four and three patients, and Almeida and Belchior(34) described a smaller baropodometric support surface in two patients.

Two reports were mixed. Costa et al.(38)measured posturography after three single 25-minute sessions and found a significant change only in mediolateral amplitude with eyes closed and feet together ($p = 0.043$). Bacha et al.(17)found that the limits of stability increased in ten patients after 14 Kinect Adventures sessions, whereas centre-of-pressure area and velocity did not change. Balance improved in 19 of the 23 studies that measured it, did not change in two and gave mixed results in two.

Gait and mobility

De Melo et al.(22)ran the gait trial with the clearest contrast, in which 37 patients were randomized to conventional training, treadmill training or Xbox gait training. The virtual reality and treadmill groups walked farther on the 6-minute walk test and faster than the control group, with no difference between them, and heart-rate gains were not maintained at 30 days. Ferraz et al.(21) randomized 62 patients in Salvador to functional training, bicycle exercise or Kinect Adventures, and all three groups improved on the 6-minute walk test without differences between groups. The abstract credits a gain in gait speed on the 10-m walk test to the exergaming group alone, but the printed p value of 0.11 does not support significance.

Other randomized trials were less favourable or smaller. Gómez-Álvarez et al.(20)randomized eight participants in Chile, and the Wii group improved on the Timed Up and Go and sit-to-stand tests while the traditional group improved only on the former. Santos et al.(19)and D'Alencar et al.(24)reported gait gains in all arms, and Ribas et al.(23)found no difference between groups on the 6-minute walk. Schuch et al.(18)randomized 23 patients in Porto Alegre to ten sessions of tightrope walking in a smartphone headset or to psychoeducation, and mobility smoothness on the Timed

Up and Go did not change, while walking duration on the 10-m test fell in both groups.

Among non-randomized comparisons, Alves et al.(28)allocated 27 patients in Brasília to the Nintendo Wii, the Xbox Kinect or no intervention, and only the Wii group improved on single-task and dual-task gait tests. Rocha et al.(26)compared 20 patients trained with a Samsung Gear VR headset with 20 untrained controls and found no interaction effect, although the trained group walked faster after training and at 30 days ($p < 0.005$ and $p < 0.001$). De Melo Cerqueira et al.(27) and Ramos et al.(29)found no gait change.

The uncontrolled studies were more favourable, with improvement in 6 of the 9 that measured gait or mobility. Pompeu et al.(41)reported better 6-minute walk and Dynamic Gait Index scores in seven patients, and Gonçalves et al.(42)found greater stride length and speed in 15 patients after 14 Wii Fit Plus sessions. In a thesis summary, Gonçalves(44)trained 30 patients with and without freezing of gait and reported better gait performance in both groups. Galeote and Cecato(14)recorded a shorter Timed Up and Go, from 15.39 to 14.12 seconds ($p = 0.048$), and de Oliveira et al.(31) and Almeida and Belchior(34)described better Timed Up and Go scores and higher walking speed, respectively, in two patients each.

Three uncontrolled reports found no clear change. Souza et al.(33)measured the 10-m walk in seven patients before and after ten Wii sessions and found no significant difference ($p = 0.187$), although satisfaction reached 4.8 of 5. De Oliveira et al.(32)combined virtual reality with a treadmill in two patients with freezing of gait and found no significant change on the Dynamic Gait Index ($p = 0.684$) or the freezing questionnaire ($p = 0.776$). Loureiro et al.(45)did not list the Timed Up and Go among the tests with significant differences. In all, 11 of the 20 studies that measured gait or mobility reported improvement, 6 reported none and 3 were mixed.

Results by design and platform

Study design shaped how favourable the results looked. In the 8 randomized and 6 non-randomized comparative studies, balance improved in 6 of the 8 that measured it and gait or mobility improved in 5 of the 11. In the 19 uncontrolled studies, balance improved in 13 of 15 and gait or mobility in 6 of 9.

By platform, the Nintendo Wii studies reported improved balance in 12 of 13 and improved gait or mobility in 7 of 10. The Xbox Kinect studies reported improved balance in 3 of 5 and improved gait or mobility in 3 of 4. The remaining 9 studies, which used both consoles, headsets, the PlayStation 3 or unspecified systems, reported improved balance in 4 of 5 and improved gait or mobility in 1 of 6.

The journals in which the studies appeared also differed from the usual sources of reviews. Of the 33 included reports, 18 appeared in sources that Scopus did not index, and 15 in indexed journals.

Other findings

Five studies reported results outside balance and gait that bear on tolerability. Silva et al.(5) described high rates of safety and adherence, Pompeu et al.(41)and Schuch et al.(18)recorded no adverse events, and no participant withdrew from the trial of Schuch and colleagues. Souza et al.(33)reported a mean satisfaction of 4.8 of 5, and Rocha et al.(26)rated the usability of the headset as excellent.

Cognitive outcomes moved more readily than motor ones in two controlled studies of Kinect and headset training. De Melo Cerqueira et al.(27)found gains on the Montreal Cognitive Assessment and the Frontal Assessment Battery in patients and healthy controls alike, although the frontal gain was not retained in the patients at follow-up. Rocha et al.(26)observed better working memory and attention in the trained group at both assessments, and Alves et al.(28)found lower anxiety and better memory and attention in the Wii group.

Comparison with control interventions

Nine studies compared virtual reality with an active control, and in seven the effects were similar. De Melo et al.(22)found superiority over conventional gait training but equivalence with the treadmill, and Ribas et al.(23)left the balance comparison unclear. Three studies used a passive control. Alves et al.(28)found an advantage for the Wii but not for the Kinect, and Schuch et al.(18) and Rocha et al.(26)found no advantage over no exercise.

Certainty of the evidence

The certainty was judged very low for both outcomes. Randomized trials carried some con-

cerns, the studies were small and imprecise, outcome measures and programmes differed, and 19 of the 33 studies had no comparison group. Within-group improvement was reported in 19 balance results and 11 gait results, but the evidence for an advantage over comparators was weak.

DISCUSSION

The studies conducted in Latin America indicate that virtual reality training is followed by better balance scores in most reports, yet the controlled comparisons show no advantage over conventional rehabilitation, and the certainty of this evidence is very low. That pattern fits the Cochrane review of Dockx et al.,(6)which found that virtual reality and physiotherapy may have similar effects on gait and balance, with a standardised mean difference of 0.34 (95% CI -0.04 to 0.71) for balance. The regional trials of Silva et al.,(5)Santos et al.(19)and D'Alencar et al.(24)reproduce it, since each found improvement in both arms and no between-group difference.

Gait gave a more varied picture, and here the regional findings partly echo and partly depart from the pooled estimates. Lei et al.(7)reported benefit for step and stride length but not for gait speed, and de Melo et al.(22)found longer walking distance and faster gait speed against conventional training. The discrepancy may reflect the comparator, since most trials pooled by Dockx et al. compared virtual reality with physiotherapy, whereas the control in this trial received conventional training whose content the abstract does not specify. Ferraz et al.(21)observed gains in all three arms, including bicycle exercise, which suggests that supervised exercise in general improves walking capacity in this population.

The two studies with immersive headsets found no benefit over controls, and their authors offer reasons that the data support. Schuch et al.(18)concluded that ten to twenty minutes of smartphone-based training were not enough to change mobility smoothness, and Rocha et al.(26) reported that the trained group improved on its own but did not surpass untrained controls. Alves et al.,(28)working with non-immersive consoles, found an advantage for the Wii over no intervention but none for the Kinect, so the platform alone does not decide the outcome. Just as Mendes et al.(30)showed that learning depends on the cognitive demand of each game, Freitas et al.(46) later found that people with Parkinson's disease learned tasks with high postural demand and retained them for a month.

Retention deserves attention, since several gains faded. Ribas et al.(23)saw the balance benefit disappear at 60 days, and de Melo et al.(22)saw heart-rate gains vanish at 30 days, which suggests that maintenance sessions may be needed after a short course. De Melo Cerqueira et al.(27)observed that cognitive scores rose without motor change, a dissociation that their design cannot explain. Along the same lines, the small series of Pompeu et al.(41)and Galeote and Cecato(14)found balance gains of the kind that uncontrolled designs tend to produce, and these gains cannot be separated from practice, attention and natural fluctuation.

Dose offers a further angle on the gait results. The regional programmes ran for a median of 12 sessions, and Dockx et al.(6)reported interventions lasting between 4 and 12 weeks; the longest regional programme, of 12 weeks, matches the upper limit of that range, so brief exposure alone is an unlikely explanation for the lack of advantage over comparators. The exceptions are the single-session designs of Araújo et al.(25)and Costa et al.,(38)which can test immediate effects only and cannot be compared with courses of 14 or 20 sessions.

A plausible mechanism for the within-group gains is task-specific practice with immediate visual and auditory feedback, which Dockx et al.(6)proposed as the route by which virtual reality may optimise motor learning. The regional data are compatible with that account but cannot test it: Freitas et al.(46)showed that patients learned and retained postural tasks inside the games, while the transfer to untrained tasks was shown only for a functional reach test by Mendes et al.(30) and for gait distance by de Melo et al..(22)Whether game scores predict better balance outside the game remains open, and a trial that pairs game performance with an independent balance measure at the start and the end would answer it.

Selection of games is a practical consequence. Mendes et al.(30)found learning deficits on the three games that required decision-making, response inhibition or divided attention, and de Melo Cerqueira et al.(27)found cognitive but not motor gains after six commercial Kinect games. Programmes built on games with a high motor and low cognitive demand may therefore suit patients with executive impairment, whereas dual-task games may be reserved for those who can sustain them, although no included study compared the two approaches.

Measurement choices also colour the findings. Galeote and Cecato(14)began at a mean Berg score of 49.52, near the upper end of that scale, so a gain of three points in a group already close

to the ceiling may carry little functional meaning, and Costa et al.(38) found a change in only one of many posturographic conditions. Studies with instrumented measures, such as Bacha et al.,(17) showed gains in limits of stability without changes in sway, which suggests that training may enlarge the usable stability margin rather than reduce spontaneous oscillation.

The venues of publication matter for anyone repeating this search. One eligible report appeared in a psychology journal,(14)two in proceedings volumes,(15,16) and several in physiotherapy journals published in Portuguese, so a search confined to neurology or rehabilitation titles would have missed them. Restricting a review to reports with a DOI would have removed at least three of these studies, which is why the criteria here rested on content and on a stable publisher address.

The regional context also shapes what these studies can tell. Brazil accounts for 32 of the 33 studies, and the only Chilean trial enrolled eight people, so the findings cannot be extended to the Spanish-speaking countries where Llibre-Guerra et al.(2) and Kim et al.(3) located a considerable disease burden. Kim and colleagues (4) linked Parkinson's disease to dependency and mortality in six regional countries, which raises the stakes of accessible rehabilitation options. Commercial consoles dominated, with the Wii in 17 studies and the Kinect in 7, so the regional findings concern low-technology implementations that may be feasible in clinics with limited equipment, although feasibility does not establish effect.

The pattern by design in the Results confirms that caution. Comparative studies produced fewer positive findings than uncontrolled series, which is the direction expected when a control group absorbs the effect of practice and attention, and the platform counts are too small and too confounded by design to indicate that one console works better than another. Because 18 of the 33 reports lay outside Scopus, a review confined to that database would have missed most of the regional evidence, which supports searching several sources and reading the regional literature directly.

Within-group improvement deserves caution because 19 of 23 balance results and 11 of 20 gait results were positive, yet 19 studies had no comparison group. Practice effects, attention to participants and spontaneous fluctuation of motor symptoms can each raise scores after a supervised programme, as the equal gains in the conventional arms of Silva et al.(5)and Santos et al.(19) illustrate. For that reason the before-after gains of the small series are best read as feasibility signals.

Safety is the point on which the regional reports and the Cochrane review agree most clearly. Dockx et al.(6)found no reported adverse events with virtual reality and no difference in exercise adherence between arms, and Silva et al.,(5)Pompeu et al.(41)and Schuch et al.(18)describe the same tolerability with Kinect and smartphone headset systems. Because patients also expressed a preference for the console in the series of Ramos et al.(29)and rated satisfaction highly in that of Souza et al.,(33)virtual reality may suit programmes in which adherence is the main obstacle, a hypothesis that no included study tested directly.

Several limitations qualify these conclusions, and each has a corresponding remedy. Full texts were unavailable for 16 studies, so risk-of-bias domains rested on abstracts, and contacting the authors of these reports would settle allocation concealment and masking. Reports from the research groups of Pompeu and of Gonçalves may share participants, as Freitas et al.(46)report for a sub-study registered under the same trial identifier as the trial of Silva et al.,(5)and clarifying overlap with the authors would prevent double counting. Searches did not cover LILACS, PEDro or SciELO directly, and querying them would add regional reports, while six reports could not be retrieved.

The heterogeneity of outcomes prevented pooling, and a common core set, such as the Berg Balance Scale or Mini-BESTest, the Timed Up and Go and the 10-m walk with means and standard deviations by group, would allow meta-analysis. Reviews of controlled trials, such as that of Juras et al.,(9)also warn that small samples and absent blinding inflate effects, and nearly all the regional studies share those weaknesses. Harris et al.(8)identified only two Parkinson's disease studies for their balance analysis, so the regional literature gathered here is larger, though not yet more reliable.

The strengths of the review lie in its separate regional focus, in the inclusion of eligible reports regardless of DOI or language, and in counts that can be regenerated from the extraction records. Those strengths do not compensate for the quality of the primary studies, and the conclusions should be read with the very low certainty in mind.

For practice, the evidence supports using commercial virtual reality as an adjunct or an alternative to conventional exercise when patients prefer it, as Ramos et al.(29)found, because effects were similar and the studies that described safety, such as those of Pompeu et al.(41)and Schuch et al.,(18)reported no adverse events. For health services in the region, the immediate implication is that a physiotherapist who already owns a console can use it within a supervised programme without expecting more than conventional exercise would give, whereas an investment made

solely in expectation of better balance outcomes is not supported by these data. For research, the priority is multicentre randomized trials in Spanish-speaking countries with registered protocols, blinded assessors, sample sizes calculated on a balance outcome, follow-up beyond 60 days and a head-to-head comparison of console-based and immersive systems.

CONCLUSIONS

Searches of five sources identified studies from Brazil and Chile only, most of them small and uncontrolled, and they describe virtual reality training with commercial consoles as the dominant approach in the region. Balance scores improved after training in most studies that measured them, but randomized and controlled comparisons showed effects similar to conventional rehabilitation. Gait and mobility results were more variable, and an advantage over a control group appeared in only a minority of the comparative studies. The risk of bias was never low and the certainty of the evidence is very low, so virtual reality may be offered as an alternative to conventional exercise without claims of superiority, pending adequately powered trials in the region.

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