

Review

Virtual Reality Applications for Balance Rehabilitation and Efficacy in Addressing Other Symptoms in Multiple Sclerosis—A Review

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Abstract: (1) Background: Since multiple sclerosis (MS) is a neurological pathology known for its disabling effects across many domains, the introduction of virtual reality (VR) usage has been attempted, as it represents a new method of approach to rehabilitation and treatment of chronic neurological pathologies. Encouraging research has explored the use of video game consoles and VR-assisted Robot-Assisted Gait Training (RAGT) to address balance disturbances in this population. (2) Methods: The search involved two databases, Web of Science and PubMed, utilizing a selection of terms including “Virtual reality”, “Multiple sclerosis”, “Balance”, and “Rehabilitation”. Two reviewers initiated and performed the search for articles, subsequently selecting and extracting data from the studies. The PEDro scale was the tool for evaluating the quality of the articles that we introduced in our research. (3) Results: After rigorous scanning, nine articles remained eligible for our study. VR interventions, particularly compared to standard balance training, consistently improved balance in multiple sclerosis. Robotic-assisted technology with 2D VR yielded superior results in balance rehabilitation. VR interventions had varied effects on walking speed. They have shown promise in decreasing the risk of falls and improving patients’ daily lives while reducing fatigue in multiple sclerosis. (4) Conclusions: VR offers comparable or superior benefits to classical exercise and no intervention for balance but does not significantly improve functional mobility. However, it shows the potential to improve quality of life and fatigue in MS patients. Investigation of VR alongside RAGT is important to be performed with larger sample sizes and comprehensive results are needed to fully understand its efficacy in MS rehabilitation.

Keywords: balance; multiple sclerosis; rehabilitation; gait; quality of life; fatigue; risk fall; virtual reality

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1. Introduction

Multiple sclerosis (MS) is a well-known, chronic, disabling, and progressive pathology diagnosed in approximately 2.8 million people worldwide [1]. MS is among the top causes of disability when we refer to young people, with an estimated incidence ranging from 1.1 to 4 per 100,000 people globally [2]. The disease is characterized by an autoimmune, inflammatory, and demyelinating process that affects the brain and spinal cord. This process leads to progressive loss of neurons and axons. Symptoms vary depending on the location of the lesion [3]. Gait disorders such as reduced speed and stride length, gait asymmetry, and balance disorders are disabling aspects of people living with MS. The risk of falling among these patients results in a low quality of life and reduced independence in activities of daily living (ADL) [4]. Therefore, improving walking ability is a main objective for rehabilitation. Various studies carried out for the rehabilitation of patients with central motor neuron disease have shown that classic rehabilitation programs based on physical therapy [5] and physiotherapy can have very good results on spasticity [6] and

can improve motor function and even walking ability, therefore improving autonomy [7]. In addition to traditional physiotherapy and rehabilitation techniques, the use of various new technologies presents a promising way to achieve a comprehensive treatment of MS [8]. Among these innovations, virtual reality (VR) methods have already emerged as potentially valuable tools for addressing various neurorehabilitation challenges [9]. VR can be successfully utilized as a standalone treatment method as well as in conjunction with other technologies [10,11]. VR facilitates interaction within a simulated environment closely resembling the real world, offering multisensory feedback training that could enhance rehabilitation outcomes. Human balance control relies on integrating inputs from multiple sensory systems, including visual, vestibular, and proprioceptive signals, into a complex mechanism of continual adjustment and recalibration [12]. Consequently, incorporating multisensory augmented reality techniques may prove particularly effective in addressing balance impairments associated with MS [10]. Studies using VR in adults with MS have highlighted the existence of possible benefits. Although these patients present numerous symptoms, the latest systematic reviews about the use of VR in people with MS focus only on the rehabilitation of symptoms such as balance and gait disorders [13]. Although gait rehabilitation cannot be separated from balance disorder rehabilitation [14], this review focuses primarily on observing the relationship between VR and the rehabilitation of balance disorders in patients with MS. However, it also aims to investigate the effects that VR may have on other symptoms of multiple sclerosis. This is one of the reasons why we have not limited our research to a specific type of virtual reality. The beneficial effect of using VR in different ways is well known, whether we are talking about the results of exergaming in several rehabilitation programs with promising results [15,16], or robotic technology that is used in association or not with VR [17,18]. Various virtual reality programs have been implemented both in clinical settings and at home for gait and balance retraining, aiming to increase adherence to rehabilitation treatment. The use of VR technology has attracted even more attention following the COVID-19 pandemic, which has affected both medical professionals [19] and patients by limiting access to rehabilitation services and diminishing the results they have already achieved [6]. The results remain controversial [20]. These are some reasons to pursue the objectives of the present study, mainly to summarize the evidence of VR interventions in recent years for the rehabilitation of balance and gait in patients with multiple sclerosis and, secondarily, to determine the effects of VR on other symptoms of MS.

2. Materials and Methods

2.1. Review Method

This study follows and meets the standards of the essential elements of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) [21].

2.2. Search Strategy

The searches were carried out in the following databases, Pubmed and Web of Science, and they were carried out on 19 February 2024. Search terms included the keywords “multiple sclerosis”, “balance”, “rehabilitation”, and “virtual reality” and were used as keywords in the title and abstract. The PICOS strategy [22] was followed during the preliminary search. The included patients were subjects diagnosed with multiple sclerosis (MS), both men and women; intervention—rehabilitation using a form of virtual reality (VR); comparison—intervention group compared with another type of exercise program—either conventional exercise or another type of VR; outcome—balance, postural control, trunk, and/or lower limb coordination, functional mobility, quality of life, cognitive functions, fatigue, Fall Risk; study design—randomized clinical trials (RCTs) (without group limitation) that used VR (immersive and non-immersive) were included. Review and meta-analysis papers, case reports, pilot studies, validation studies, and feasibility studies were excluded. Also, all research that did not have the text published in full and that was not written in English was excluded. Irrelevant to the research were the studies on people with balance

disorders other than those caused by MS or other neurological conditions, which were excluded from the paper.

2.3. Selection Process

The results obtained from the search were entered into Mendeley Desktop software, version 1.19.8, to remove duplicates. The same program was used to organize the references. The selection process was carried out by two independent reviewers (E.B.B; V.I.T). The analysis and selection of eligible studies were initially performed by evaluating the titles and abstracts. Then, the potentially eligible studies were studied in full text. Articles that did not meet the eligibility criteria were not included in the research. The quality of the studies included in the research was evaluated using the PEDro scale [23], composed of 11 criteria (where item 1 is not scored) for evaluating the external and mainly internal validity of randomized controlled trials (Table 1).

Table 1. The quality of the RCT studies included in the review paper.

Section/Theme	Calabro et al. [18]	Russo et al. [17]	Ozdogor et al. [24]	Yazgan et al. [25]	Molhemi et al. [26]	Lazano-Quilis et al. [27]	Gutierrez et al. [28]	Dogan et al. [29]	Eftekharsadat et al. [30]
1	YES	YES	YES	YES	YES	YES	YES	YES	YES
2	YES	YES	YES	YES	YES	YES	NO	YES	YES
3	YES	-	NO	NO	YES	YES	-	YES	NO
4	YES	YES	YES	YES	YES	YES	YES	YES	YES
5	NO	NO	NO	NO	NO	NO	NO	NO	YES
6	NO	NO	NO	NO	YES	NO	NO	NO	NO
7	YES	YES	NO	YES	YES	NO	YES	YES	YES
8	YES	YES	YES	YES	YES	NO	YES	YES	NO
9	YES	YES	NO	YES	-	UNCLEAR	-	YES	NO
10	YES	YES	YES	YES	YES	YES	YES	YES	YES
11	YES	YES	YES	YES	YES	YES	YES	YES	-
Total score	8/10	7/10	5/10	7/10	8/10	5/10	6/10	8/10	5/10

3. Results

3.1. Study Selection

A total of 149 articles were generated in the database searches. Duplicates were eliminated, leaving 113 articles, which were checked by title and abstract according to the PICO model [22]. Sixteen studies were fully reviewed according to the eligibility criteria. Seven were excluded: two because they were retrospective studies, three because they did not present results of interest after reading the full text, and another two articles because they did not present an intervention of interest (Table 2). Finally, nine articles were included, as can be seen in Figure 1 (diagram).

Table 2. Reasons for article exclusion.

Articles Excluded after Title and Abstract Screening Phase	(n = 113)
Review papers	43
Meta-analysis papers	2
Case reports	2
Pilot studies	11
Validation studies	1
Feasibility studies	3
Book chapters	3
Studies on other neurological conditions	11
Studies on balance disorders other than those caused by multiple sclerosis	22
Not intervention of interest	14
Language different than English	1
Articles excluded after full-text screening phase	(n = 9)
Full-text unavailability	2
Retrospective studies	2
Not intervention of interest	2
Not outcome of interest	3

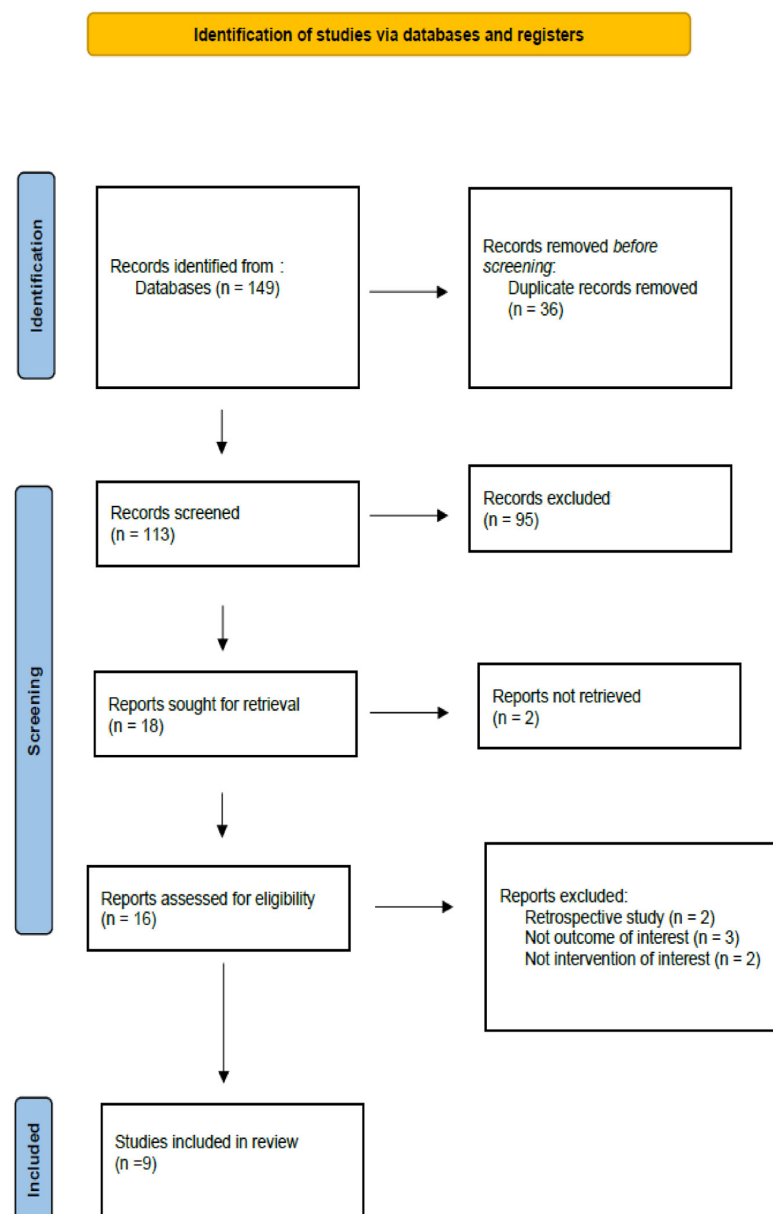


Figure 1. PRISMA flow diagram.

3.2. Main Characteristics of Included Studies

A total of 392 participants diagnosed with multiple sclerosis were evaluated in the nine studies included in the research. The studies accepted as eligible were published in the following period, 2013–2024. Of the nine studies presented, one used Nintendo Wii games as a rehabilitation intervention [25], six used games—four from Microsoft Kinect [24,26–28], and one used a non-immersive game. VR system called USE IT [29]. Only one study evaluated the effectiveness of the Biodex Balance system [30]. Regarding the interventions in the comparison group, there were a multitude of options that were addressed by the researchers in their articles; some researchers created control groups where no exercises were performed, while others used classic balance rehabilitation exercises or combinations of rehabilitation programs. No significant differences in intervention location were observed in the control group, with only one study using telerehabilitation. Robotic-assisted gait training (RAGT) combined with virtual reality technology is applied in two RCTs. The first study compared it with traditional therapy [17], while the other study compared RAGT equipped with VR to RAGT without VR [18]. We have extracted the most important data and characteristics from the studies so that they can be consulted in Table 3.

Table 3. Characteristics of the randomized controlled trials.

Article and Nationality	Study Group	EDSS	Intervention	Comparison	Outcome Measurement	Main Findings
Calabro et al., 2017 Italy [18]	40 participants EG: n = 20; robotic-assisted gait training + virtual reality (RAGT + VR) CG: n = 20; RAGT	4–5.5	RAGT using the Lokomat device, 40 min/session, 5 days/week, for 8 weeks.	RAGT + VR compared to RAGT without	BBS; TUG; COPE	Significant improvements in balance and positive coping orientation in the RAGT + VR group compared to the CG.
Russo et al., 2017, Italy [17]	45 participants EG: n = 30; robotic training using Lokomat-Pro CG: n = 15; traditional rehabilitation training.	3–5.5	EG: 6 weeks; 60 min/session, 3 times/week, then 12 weeks of traditional training. (CG): 18 weeks	Comparison between robotic training followed by traditional training (EG) and traditional rehabilitation training alone (CG).	TBS; EDSS; FIM; TUG; MMSE; HRSD	CG showed improvement only in TUG, and EG significantly improved in all outcomes. CG improved significantly in all outcomes from T1 to T2 and only EG in TUG. From T2 to T3, no significant differences emerged for both groups.
Ozdogar et al., 2020 Turkey [24]	60 participants G1: Video-based exergaming group n = 21; G2: n = 19 Conventional rehabilitation group (G3): Control group n = 20.	2–5	(G1) using a game console (Microsoft Xbox One and Kinect motion sensor) with Kinect Sports Rivals game for 8 weeks, 45 min per session, once a week. (G2) balance, arm, and core stability exercises for 8 weeks, 45 min per session, once a week	Comparison between G1 and control group evaluated at baseline and after 8 weeks, with no intervention during the study period.	ABC; STST; T25FW, MSWS-12, SSST; N-HPT; BDI, MFIS, MusiQOL curl-up test	Significant improvements in arm functions in both groups. Leg function and balance-related outcome measures improved significantly in both groups. MusiQOL and MFIS scores significantly improved in G2. Cognitive functions significantly improved in G1 and G2, except for the SDMT in G2. The G3 underperformed at T25FW and SSST. The BDI score improved significantly in G1.

Table 3. Cont.

Article and Nationality	Study Group	EDSS	Intervention	Comparison	Outcome Measurement	Main Findings
Yazgan et al., 2019 Turkey [25]	47 Participants G I-Nintendo Wii Fit n = 16; G II- Balance Trainer n = 16; G III n = 15;	2.5–6	G I and II exergaming programs 2 × 60 min sessions/week for 8 weeks. GI (Nintendo Wii Fit) used games such as Penguin Slide, Ski Slalom, Table Tilt, Heading, and Balance Bubble. G II used games including Collect Apples, Paddle War, Outline. G III did not undergo any exercise program.	Comparison of the effects of training with two exergaming systems, Group I and Group II, on balance, function, fatigue, and quality of life.	BBS; TUG; 6MWT; FSS; MusiQOL	Significant improvements in BBS, TUG, 6MWD, FSS, and MusiQOL in the GI compared to the CG. Both GI AND G II groups showed significant improvement in all parameters evaluated, while the G III showed significant improvement only in BBS. GI (Nintendo Wii Fit) demonstrated superior improvements in BBS, TUG, 6MWD, FSS, and MusiQol compared to the G III. G II (Balance Trainer) also showed superior improvements in BBS, TUG, FSS, and MusiQol compared to the control group. G I registered superior improvements in BBS and MusiQol compared to G II.
Lazano-Quilis et.al., 2014, Spain [27]	11 Participants (TG): n = 6, trial group -RemoviEM therapy (CG): n = 5	-	TG: performed virtual rehabilitation exercises during the last 15 min of each one-hour session. CG received traditional physiotherapy.	The effectiveness of RemoviEM therapy on balance rehabilitation compared to standard rehabilitation	BBS; TBS; SLB; 10 MW; TUG	Significant time effects were noted for several balance measures, including BBS, TBS, right leg SLB test, and 10 MW. A significant group effect was detected only for TUG. Significant group-by-time interactions were observed for BBS and SLB test right foot.
Molhemi et al., 2020, Iran [26]	39 Participants VR IG: (n = 19); Xbox360 with Microsoft's Kinect CG: (n = 20) Conventional rehabilitation	<6	VR IG used Xbox360 with Microsoft's Kinect. Exergames included Light Race, Stack'em up, 20,000 leaks, which were matched to conventional exercises in each category. 5 min warm-up, then 30 min exercise/18 sessions/3 times/week—6 weeks.	Evaluation of the effectiveness of balance training based on VR versus conventional programs on reducing the risk of falling and improving balance.	BBS; DTC; TUG; 10 MW; MSWS-12; ABC; FES-I	MSWS-12, BBS, TUG, 10 MW registered no significant differences. The number of falls was significantly lower in the IG at the follow-up assessment. At the level of body structure and function, no significant differences were observed post-intervention in limits of stability measures.

Table 3. Cont.

Article and Nationality	Study Group	EDSS	Intervention	Comparison	Outcome Measurement	Main Findings
Gutierrez et al., 2013, Spain [28]	50 Participants EG; n = 24; telerehabilitation treatments; Xbox360 console with Microsoft Kinect. CG; n = 23; physiotherapy treatment	3–5	EG—40 sessions, four sessions/week. Duration increased gradually based on individual patients' fatigue levels up to 20 min/session/10 weeks. CG—twice a week, 40 min/session.	Potential improvement in balance and postural control using a VR-telerehabilitation program compared to the conventional treatment.	CES; BBS; TT; MCT	Significant increase in CES percentage from pre- to post-intervention in the EG but not in the CG; significant improvement in MCT response time in the EG, indicating quicker recovery following an unexpected disturbance. No significant improvement was observed in the CG. Both BBS and TT scores showed significant improvements in the EG, while significant improvements were only observed in BBS for the CG.
Dogan et al., 2022, Turkey [29]	34 Participants EG-(V-TOCT): Virtual Reality Supported Task-Oriented Circuit Training; n = 17 CG: Mobile Application-Based Telerehabilitation (TR); n = 17	2–5.5	EG-V-TOCT: Supervised exercise program using a non-immersive VR system “USEIT” in a clinical environment: 8 weeks, 3 sessions/week TR: Home-based exercise program delivered via a mobile application (Fizyo); 8 weeks, 3 sessions/week; 60 min/session.	Comparisons were made between the TR and V-TOCT groups to determine any differences in the effectiveness of the interventions.	TIS; K-ICARS; evaluation at baseline and after eight weeks of treatment.	The V-TOCT resulted in greater improvements in dynamic balance and coordination compared to the TR intervention. Both the TR and V-TOCT interventions led to statistically significant improvements in trunk impairment and ataxia severity. Significant improvements were observed in upper limb function in both intervention groups.
Eftekharsadat et al., 2015 Iran [30]	30 participants IG; n = 15 received postural stability training (PST) CG; n = 15 received no intervention	-	IG: pts using the Biodex Balance System SD for 20 min per session, twice a week for 12 weeks. CG: no intervention for 12 weeks.	Both within-group and between-group comparisons were conducted to evaluate the effectiveness of the intervention.	BBS; TUG; romberg test; FRi; OSi	No significant changes in BBS scores between groups. Significant improvement in TUG time in the IG compared to the CG. Significant improvement in OSi and FRi in the IG compared to the CG.

EG: experimental group; CG: comparison group; IG: intervention group; RAGT: robotic-assisted gait training; TR: telerehabilitation; PST: postural stability training; VR: virtual reality; EDSS: Expanded Disability Status Scale; HDRS: Hamilton Depression Rating Scale; BBS: Balance Berg Scale; TBS: Tinetti Balance Scale; SLB: Single Leg Balance; FIM: Functional Independence Measure; ABC: Activities-specific Balance Confidence Scale; TT: Tinetti Test; COPE: Coping orientation to Problem Experienced; MMSE: Mini Mental State Examination; CES: Composite Equilibrium Score; MCT: Motor Control Test; TUG: Time up and Go; T25FW: Timed 25 Foot Walk; 6MWT: Six-minute walking test; 10MWT: 10-Meter Walk Test; SSST: Six Spot Step Test; STST: sit-to-stand test; N-HPT: Nine-Hole Peg Test; MSWS-12: Multiple Sclerosis Walking Scale-12; FSS: Fatigue Severity Scale; MusiQoL: Multiple Sclerosis International Quality of Life Questionnaire; MFIS: Modified Fatigue Impact Scale; QoL: quality of life; TIS: Trunk Impairment Scale; K-ICARS: International Cooperative Ataxia Rating Scale; FES-I: Falls Efficacy Scale—International; FRi: Fall Efficacy Scale—International; OSi: overall stability index.

4. Analysis of the Main Objectives

4.1. Functional Balance

When it comes to assessing balance, this comparison was only feasible in three studies with groups that received no intervention [24,25,30]. In the study by Eftekharsadat et al., changes in the Balance Berg Scale (BBS) score were not identified between groups ($p > 0.05$). In the study by Yazgan et al., changes in all measures were superior in the Nintendo Wii Fit group compared to the no-intervention group, which only had an improvement in BBS ($p = 0.028$), although this could not also be demonstrated by changing the functional parameters as in the intervention groups. No significant differences were recorded between the intervention group and the control group in the study by Ozdogar et al. VR training was compared with standard balance retraining programs, and significant differences in balance improvement in favor of the VR group were observed in three studies [25,27,28]. Significant differences in BBS between the studied groups were obtained by Lozano-Quilis et al. ($p < 0.001$), Gutierrez et al. ($p < 0.001$), and Yazgan et al. ($p < 0.001$) in favor of the intervention group. Ozdogar et al. [24] reported that balance-related outcomes were significantly better in video-based exergaming and conventional rehabilitation groups but with no differences between groups ($p < 0.05$). Molhemi et al. [26] reported the same results when assessing balance with the BBS and the Activity-Specific Balance Confidence Scale (ABC) and found no differences between groups. When it comes to balancing rehabilitation using robot-assisted technology together with 2D VR, the results obtained were superior for all measurements compared to the control groups in the two studies selected in our research [17,18]. In the study by Russo et al., the control group failed to maintain the results and Tinetti Balance Scale (TBS) values worsened between T2 and T3 assessment. In the study by Calabro et al., the differences between RAGT + VR and CG recorded very small improvements (<0.2) for BBS, even though pre-post rehabilitation analysis within the group favored RAGT + VR. ($p = 0.8$)

4.2. Postural Control

Four out of the nine studies included in our review assessed postural balance using different evaluation scales. None of the studies used the same method for evaluating postural balance [26–28,30]. The overall stability index (OSI) was used to calculate the individual stability of participants in Eftekharsadat et al., and they obtained significant improvement in the intervention group ($p = 0.005$). Quilis et al. used the Single Leg Balance test (SLB) at the start and at the end of the rehabilitation period for evaluation, which revealed a significant time effect of the SLB test on the right foot ($p = 0.041$). Significant group-by-time interaction was observed for the SLB test right foot ($p = 0.033$). For studying postural control [28], Gutierrez et al. used two tests, one considered a very important Sensory Organisation Test (SOT) and the Motor Control Test (MCT). The Composite Equilibrium Score (CES) is a part of SOT, which quantifies the overall postural stability or center of gravity (COG). Following the analysis of the Composite Equilibrium Score (CES), which represents percentages from pre- to post-intervention, notable differences were noted within the EG. Specifically, an increase of 8.21 points pre-treatment to the post-treatment evaluation was described ($p < 0.001$). In contrast, the same test did not yield significant results for the CG ($p = 0.123$). Additionally, in the same study, the Motor Control Test (MCT) evaluation between baseline and post-intervention revealed significant differences for the EG ($p = 0.005$). No significant differences were found in this concern for the CG. One study utilizes Directional Control (DCL) to assess the ability to control the direction of body sway, and it is the only study that did not obtain significant results between groups after the intervention [26].

4.3. Risk Fall Assessment

Only two studies aim to evaluate the risk of falls in patients with MS [26,30]. One study assesses the self-reported number of falls during the past three months recorded at baseline with the Fall Efficacy Scale-International (FES-I). Additionally, fall history during

the intervention and three-month follow-up were determined using a fall diary. FES-I and the number of fallers showed no significant differences between the groups in both post-intervention and follow-up [26]. The other study utilizes the Fall Risk test (FRT) using the Biodex Balance System protocol to evaluate the effectiveness of balance training intervention. In the Fall Risk test, the platform is unstable, and the subject's sway is used to calculate the Fall Risk index (FRi). The intervention group had significantly better FRi changes during the study period compared to the control group ($p > 0.002$) [30].

4.4. Functional Mobility

The Time up and Go (TUG) test was the most preferred test to quantify functional mobility. Significant differences in favor of the control group for the TUG test ($p = 0.027$) were observed in the Lazano-Quilis et al. study. While in favor of the VR group, significant differences were reported for TUG ($p < 0.001$) by the study of Eftekharsadat et al. Also, after treatment, TUG changes ($p = 0.005$) were found to be superior in Yazgan et al. Group I of patients, compared to group III and group II, proved to be superior to group III, TUG ($p = 0.011$). Effect sizes were very small and nonsignificant between groups for TUG ($p = 0.3$) in the Calabro et al. study favoring RAGT + VR. In the experimental group, the study conducted by Russo et al. yielded better results for all measurements, including the TUG test. The same happened for the control group. Analyzing the progression over time, from T1 to T2, the control group shows better results in all measurements, while the experimental group maintains improved results only for the TUG test. The study by Molhemi et al. showed no significant differences in TUG both post-intervention and during the follow-up. Two studies did not provide assessments of functional mobility [28,29].

4.5. Walking Speed

For the evaluation of walking speed, different tests were used, the 10-meter Walking Test (10 MW) was the most used. The only study where CG was superior in walking speed assessed with a Timed 25-Foot Walk (T25FM) is the one Ozdogar et al. conducted and registered a significantly decreased performance ($p < 0.05$). Compared with conventional balance training, significant differences between groups were observed in one study in favor of VR intervention [25]. After, the treatment changes in the Six-minute walking test (6MWD) were found to be superior ($p = 0.008$) by Yazdagan et al. compared with the CG (no intervention). Two studies [26,27] used 10 MW to assess the walking ability of patients, and the results showed improvement over time post-intervention, but no significant group-by-time improvement was detected, which suggested that both groups improved similarly. Five studies did not aim to evaluate the walking speed of the patients included in their research [17,18,28–30].

4.6. The Effectiveness of VR on Fatigue and Quality of Life

Quality of life is assessed in two studies, and the scale used is the common Multiple Sclerosis International Quality of Life Questionnaire (MusiQoL). In the study by Yazgan et al., post-treatment assessments using the MusiQoL scale ($p < 0.001$) were found to be superior in the Nintendo Wii Fit group compared to the no-intervention group. As for the group that performed balance training, it turned out to be superior to the group without intervention ($p = 0.004$). The same superior results compared to the group without any intervention could also be observed regarding fatigue ($p < 0.001$). This was estimated using the Fatigue Severity Scale (FSS) [25]. When Ozdogar et al. evaluated the participants, MusiQoL scores showed a significant improvement in the conventional rehabilitation group ($p < 0.05$). Regarding the measurements of psychosocial status in the control group, no significant changes were observed ($p > 0.05$). Fatigue was assessed using the Modified Fatigue Impact Scale (MFIS), and the improvement in scores mirrored that of the quality of life assessment [24].

4.7. Limitations and Effectiveness of Virtual Reality

Patients often respond positively to VR rehabilitation due to its engaging and enjoyable nature, sense of control, personalized approach, feedback mechanisms, safety features, and innovative appeal. But not all patients may respond equally to VR interventions, as individual preferences, abilities, and cognitive impairments can influence treatment effectiveness [10]. Additionally, some patients may experience side effects such as motion sickness or cybersickness, which can limit the duration and intensity of VR sessions [31]. In this review, however, no adverse reactions were reported by the researchers, and there were no dropouts due to any difficulties encountered in the use of VR technology devices. Still, one notable advantage of VR compared with other therapies is its ability to provide personalized rehabilitation programs in order to prevent the effectiveness of the treatment. Through customizable scenarios and feedback mechanisms, therapists can adjust the intensity and difficulty of tasks to match the patient's abilities, facilitating gradual progress and improving treatment outcomes. Moreover, VR offers a safe environment for patients to practice activities that may be challenging, especially for people with MS or who otherwise find such activities inaccessible in their lives, such as walking on uneven terrain or navigating obstacles [32]. Also, traditional rehabilitation exercises can be repetitive and monotonous, leading to low adherence rates. VR addresses this issue by providing interactive and enjoyable activities that capture the patient's attention. By making therapy sessions more engaging, VR increases motivation and encourages patients to adhere to their treatment regimen. VR platforms can incorporate cognitive training exercises specifically designed to target cognitive impairments commonly associated with MS, such as attention, memory, processing speed, and executive function. These exercises can be adapted to the individual's cognitive abilities and progressively adjusted to challenge their cognitive skills, promoting cognitive improvement over time [10,32]. Although it closely matches the treatment outcomes for balance disorder rehabilitation compared to other traditional rehabilitation methods, VR technology used in the rehabilitation of MS patients provides concurrent benefits for other symptoms faced by MS patients and contributes overall to improving the quality of life of these patients.

5. Discussion

This comprehensive analysis of nine randomized controlled trials offers a succinct overview of the impact of VR interventions on individuals with MS, comparing them to conventional or no interventions. Particular focus is given to key outcomes such as fatigue, balance, functional mobility, and quality of life. The conclusions drawn from all the studies analyzed indicate that VR technology accessed as a rehabilitation method for balance retraining is highly effective in improving mobility in individuals with MS. However, outcomes vary across different interventions, with some showing no improvement while others exhibit results akin to conventional exercises. Notably, in areas concerning quality of life, fatigue, and balance, VR interventions demonstrate a more pronounced improvement compared to conventional exercises. It is crucial to approach these findings with discernment, given the methodological disparities and variations in training dosage across the included studies, as well as the varying methodological quality observed in some of the studies incorporated in the review.

It is worth emphasizing that currently, VR training for MS patients has been combined with both traditional methods like conventional exercises and more advanced approaches such as robotic-assisted gait training (RAGT). To our knowledge, so far, there are no reviews that have examined the inclusion of RAGT studies alongside VR training. In our study, two randomized controlled trials (RCTs) meeting the inclusion criteria demonstrated superior outcomes in the RAGT + VR groups, which also maintained these results over longer periods compared to the control group. Even though an interesting systematic review of the use of RAGT in MS has recently been published [33], further exploration and investigation into the effects of integrating VR techniques with RAGT devices could provide valuable insights for a comprehensive review of the benefits and utilization of VR.

Our findings are similar to two other previous meta-analyses. Firstly, Casuso-Holgado et al. [13] conducted a systematic review analyzing the effectiveness of VR on balance and gait in patients with MS, revealing significant differences compared to no interventions. Second, Nascimento et al. [34] suggested that VR could induce benefits that are at least similar, if not greater, than classical exercises in MS patients. However, taking all this research into account, no decisive ideas have been concluded regarding the impact of VR on improving balance in MS patients despite the promising potential of this approach, as evidenced by findings in other chronic neurological conditions [35,36].

In this review, we found that VR can improve balance outcomes quantified with BBS compared with classical balance reeducation treatment in MS patients. We followed the evaluations performed with BBS, as it appears to be the most widely used and recommended tool for assessing balance in neurological pathologies. Interventions using Nintendo Wii or Kinect video games generally involved games or activities that require different motor and cognitive skills, such as memory or attention. Given that balanced rehabilitation consists of multiple elements, we would have appreciated it more if postural control had been assessed in all the studies we reviewed. This could have strengthened our beliefs regarding VR's capacity to rehabilitate MS patients. However, we could not identify any review in the literature that comprehensively addressed the evaluation of balance to such a degree.

The measurements performed with the TUG test showed that the groups that opted for balanced rehabilitation with VR technology did not turn out to be superior but not inferior to the groups that opted for other interventions or to the groups that did not receive the intervention. This finding does not bring new information regarding the use of VR to improve functional mobility. The same was concluded with regard to walking, which was quantified by the 10 MW and 6MWD tests. It is important to consider that the demands imposed by the selected virtual games and activities were primarily aimed at balance, so they may not be suitable for functional mobility and gait modification.

After evaluating the Fall Risk, we observed that this was conducted in only two studies among those included by us. It is crucial for MS patients to undergo holistic evaluation, especially when balance disorders are present. Additionally, VR training could enhance balance by introducing concurrent motor and cognitive tasks [37], which could also be engaged, and boosting motivation and treatment adherence [38]. Quality of life and fatigue are influenced by training with VR technology because exergames provide both visual and auditory feedback, which is often altered in MS patients. They also improve motivation and treatment adherence, which helps because repetition and observation play a vital role in motor learning, and VR could trigger neuroplastic changes in the central nervous system [39].

6. Conclusions

This analysis concludes that VR can offer similar or complex satisfaction compared to the classical approach when we focus on balance retraining. However, when it comes to functional mobility, VR, whether used alone or with conventional exercise, offers no additional benefits. On the other hand, in terms of quality of life, VR can improve different aspects of life with particular benefits in certain areas and even on the fatigue experienced by MS patients. These benefits are greater than those obtained through rehabilitation with conventional programs. Thus, this systematic review supports the effectiveness of VR in training balance disorders and in the potential for increasing the quality of life and reducing fatigue in people with MS.

Further research is needed to evaluate the effect of VR on RAGT, which has promising prospects. In addition, it is essential to approach VR technology in studies with larger batches and with an extended follow-up of subjects. Studies that promote a holistic approach to multiple sclerosis along with balance disorders could also have an important contribution to the rehabilitation of MS patients.

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