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The Effects of Virtual Reality Training on Post-Stroke Upper and Lower Limb Function: A Meta-Analysis

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HIGHLIGHTS

- Virtual reality (VR) training is gaining attention in stroke rehabilitation.
- VR training significantly improves arm motor function over conventional training.
- VR training enhances balance but not lower limb motor or gait function.

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The Effects of Virtual Reality Training on Post-Stroke Upper and Lower Limb Function: A Meta-Analysis

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ABSTRACT

This meta-analysis presents an updated comparison between virtual reality (VR) training and conventional training (CT) in post-stroke rehabilitation by incorporating recent studies based on prior meta-analyses. We searched 3 international electronic databases (MEDLINE, Embase, and the Cochrane Library) and a Korean database (KoreaMed) to identify relevant studies. Out of 5,218 studies, 30 randomized controlled trials were selected through the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. Among these, 21 focused on upper limb training and 14 on lower limb training. A subgroup meta-analysis was conducted based on the VR type. The risk of bias (RoB) was assessed using Cochrane's RoB tool. The certainty of the evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) method. The outcomes were categorized into upper limb motor function, fine motor function, and activities of daily living (ADLs) for upper limb training, and lower limb motor function, balance, and gait velocity for lower limb training. A random-effects model for the meta-analysis indicated that VR training showed significant superiority over CT in improving upper limb motor function, ADL, and balance. This study provides low- to moderate-certainty evidence supporting the superiority of VR training over CT. Clinicians and therapists should consider individual rehabilitation needs, goals, patient preferences, and available resources when selecting VR for post-stroke functional recovery.

Keywords: Virtual Reality; Randomized Controlled Trials as Topic; Recovery of Function; Stroke Rehabilitation

INTRODUCTION

Stroke is one of the leading causes of death and long-term disability globally, with numerous survivors facing severe motor impairments in their upper and lower limbs [1-3]. More than one-third of chronic stroke patients experience upper limb dysfunction, while over one-fifth have impaired walking abilities. Therefore, stroke rehabilitation is essential for restoring limb function and increasing physical independence [4,5].

Conflict of Interest
The authors have no potential conflicts of interest to disclose.

Virtual reality (VR) training employs a range of technological tools to support rehabilitation exercises. VR is defined as an interactive simulation created by computer hardware and software, which allows users to engage with environments that mimic real-world scenarios [6]. In recent years, VR training has been refined to improve therapeutic rehabilitation, aiming to achieve diverse goals through various approaches [7,8]. This training promotes functional recovery by facilitating repetitive practice of voluntary movements in the upper or lower limbs [9]. The exercises focus on training either whole tasks or specific components to strengthen functional movement. Over time, these methods have expanded to include robotic rehabilitation with electrical stimulation and task-based training using VR. The interfaces have evolved from easily accessible, commercially available non-immersive VR to more sophisticated immersive VR, which addresses spatial and temporal limitations and has further developed into augmented reality (AR) [10]. VR training serves multiple therapeutic purposes and fosters motor learning through multisensory feedback, including visual, tactile, auditory, and balance inputs, underscoring its significance in stroke rehabilitation [6,11-14]. Numerous comparative studies have assessed the effects of VR training compared to traditional therapies, and their results have been integrated into national clinical guidelines [15-18]. Additionally, systematic literature reviews and analyses are essential to further inform clinical guidelines.

Recent reviews, including meta-analyses, have limitations such as high heterogeneity [19,20] or findings that focus solely on either upper or lower limb function [21,22]. Therefore, our objective was to evaluate the impact of VR training on the recovery of both upper and lower limb function in post-stroke patients by conducting a meta-analysis that includes the latest research.

MATERIALS AND METHODS

The protocol used in this study followed the method specifically designed for meta-analysis for the development of the Clinical Practice Guideline for Stroke Rehabilitation in Korea [23].

Criteria for this review (PICO)

1) Patients (P): Adult post-stroke patients (age 18 and older, with either cerebral hemorrhage or cerebral infarction)

2) Intervention (I): VR training for post-stroke patients with disabilities in upper and lower limb function (various types of VR, including non-immersive, immersive, and AR)

3) Comparison (C): Comparisons between the effects of VR training and the effects of conventional training (CT)

4) Outcomes (O): Improvement in upper and lower limb function

4-1) Outcome domains for the upper extremity: Upper limb motor function, fine motor function

We assessed upper limb motor function using the Fugl-Meyer Assessment-Upper Extremities (FMA-UE) and measured grip strength in kilograms. Fine motor function was evaluated with the Wolf Motor Function Test (WMFT), Action Research Arm Test (ARAT), and Box and Block Test (BBT). Additionally, the measures for activities of daily living (ADLs) included in the meta-analysis were the Functional Independence Measure (FIM), Modified Barthel Index (MBI), and Barthel Index (BI).

4-2) Outcome domains for the lower extremity: Lower limb motor function, balance, and gait function

We assessed lower limb motor function using the Fugl-Meyer Assessment-Lower Extremities (FMA-LE). Balance evaluations were conducted with the Berg Balance Scale (BBS), Functional Reach Test (FRT), FMA-balance, and Timed Up and Go (TUG) test. To measure gait function, we included assessments that estimate walking speed, such as gait velocity, the 6-Minute Walk Test (6MWT), and the 10-Meter Walk Test (10MWT).

Evidence was analyzed only from randomized controlled trials (RCTs) that directly compared different forms of VR training (including non-immersive VR, immersive VR, and AR) with CT, all conducted at the same intensity and frequency.

Studies that combined VR training with other treatments—such as robotic-assisted or treadmill gait training, which involve controlling patient movements through an interface—were excluded from the meta-analysis.

Search and selection

We searched online international databases (MEDLINE, Embase, and the Cochrane Library) and a Korean database (KoreaMed). The search query was based on a review of the VR training sections in the latest clinical practice guidelines for stroke from the U.S. [15,18] and Canada [17]. The specific search terms and strategies are detailed in **Supplementary Table 1**. After a comprehensive literature search, we refined our search queries related to VR training and eliminated duplicate entries, yielding a total of 5,218 studies. Two reviewers independently screened these studies in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, as illustrated in **Fig. 1**.

Given the distinct purposes of VR training interfaces, separate meta-analyses were conducted for upper and lower limb VR training. A total of 21 studies focused on upper limb VR training, while 14 addressed lower limb VR training. Within each category, subgroup meta-analyses were performed based on different outcome measures. Participants were divided into 2 groups: those who underwent VR training and those who received CT. Outcome measures for the upper extremity included upper limb motor function, fine motor function, and ADL. For the lower extremity, the measures encompassed lower limb motor function, balance, and gait velocity. These outcomes were assessed by comparing results before and after the interventions.

Risk of bias (RoB) assessment

Two reviewers (Y.W.K. and P.J.) independently evaluated the methodological quality of the included RCTs using the Cochrane RoB 1.0 tool and resolved any disagreements by discussion.

Data extraction and transformation

The outcome measures for motor function of the upper and lower extremities were categorized into the following domains: motor function, fine motor function, balance, gait velocity, and ADL. Each domain was ranked based on a predefined list, with the highest-ranking outcome selected for the meta-analysis. Two reviewers (Y.W.K. and P.J.) conducted the meta-analysis, agreeing to use the difference between pre- and post-intervention results (delta values) for each domain. When studies did not provide delta values, the pre-intervention (baseline) and post-intervention means and standard deviations were used to calculate the mean change and standard deviation, following the formula provided in the

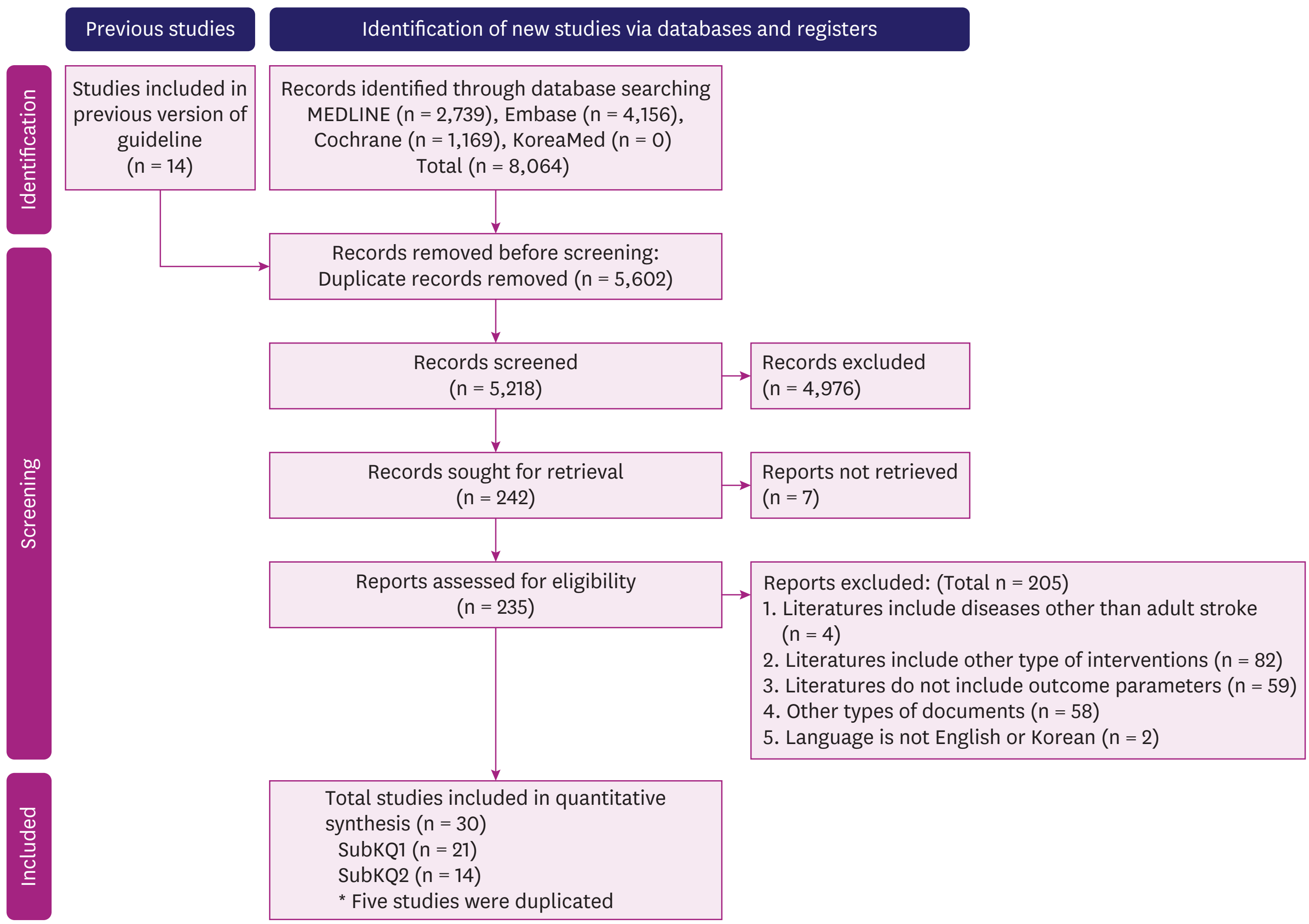

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart.

Cochrane Handbook [24]. For studies with more than one intervention group or those not presenting continuous outcomes as means and standard deviations, valid methods from the handbook were applied to convert the data into a format suitable for the meta-analysis. Studies were excluded if the outcomes required for meta-analysis could not be obtained using the aforementioned methods.

Assessment of certainty of evidence

The certainty of the evidence was evaluated using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach and rated as high, moderate, low, or very low [25]. Two reviewers independently assessed the selected RCTs for RoB, inconsistency, indirectness, imprecision, and publication bias. They then reached a consensus to assign the GRADE level of evidence based on the results of these assessments.

Statistical analysis

Review Manager Software 5.4 (Cochrane Collaboration, Oxford, UK) was utilized to analyze the evidence. Statistical significance was established at $p < 0.05$. Heterogeneity was evaluated using the I^2 statistic, with values of ≥ 50% indicating significant statistical heterogeneity. When significant heterogeneity was detected, subgroup analyses were performed. These analyses categorized VR training types into non-immersive (commercial game console, computer display) and immersive (head-mounted display) VR groups, following criteria similar to those used in Cochrane reviews [13]. In light of recent technological advancements and the growing use of immersive VR devices, we also analyzed immersive VR training, which had not been previously included in meta-analyses. Due to the variety of outcome measures, a random-effects model was employed for the meta-analysis.

RESULTS

Study selection

Following a comprehensive literature search and screening, 30 RCTs were selected from a pool of 5,218 studies using the PRISMA method [19,26-54]. Detailed information about the included studies can be found in **Supplementary Table 2**. In the study by Ögün et al. (2019) [50], patients with hemorrhagic stroke were excluded during recruitment, leading to a potential bias in patient characteristics of the recruited population and increasing heterogeneity in the meta-analysis. However, since this exclusion did not significantly impact the statistical of the results, the study was included in the meta-analysis.

Study characteristics

The RoB evaluation of the 30 RCTs included in this review is presented in **Fig. 2**. For the upper extremity, 19 RCTs were analyzed for upper limb motor function, 10 for fine motor function, and 8 for ADL. For the lower extremity, 5 were analyzed for lower limb motor function, 13 for balance, and 6 for gait velocity.

Meta-analysis for the effects of VR training

The evidence summaries and certainty of evidence according to GRADE are presented in **Table 1**. The primary outcome measures of VR training—motor function for upper and lower limbs, fine motor function, balance, and gait velocity—were considered crucial, while ADLs were deemed important but not essential. According to the GRADE approach, no significant RoB was detected across any of the outcome measures. However, inconsistencies were noted in the measures of lower limb motor function, fine motor function, and balance due to the inclusion of studies with high heterogeneity. Measures of lower limb motor function and gait velocity demonstrated imprecision, which was attributed to wide confidence intervals (CIs) resulting from small sample sizes. Publication bias, along with heterogeneity, was evident in the measures of upper limb motor function, fine motor function, and balance, although no issues of indirectness were identified.

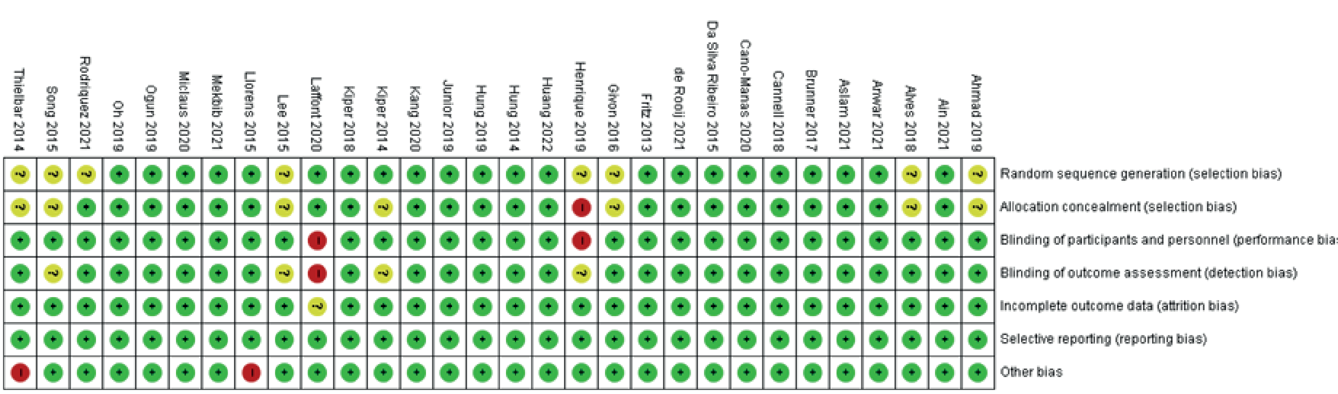

Fig. 2. Risk of Bias for included studies in the meta-analysis.

Table 1. Evidence summary and GRADE evaluations

Outcomes	Importance	No. of participants (studies)	Certainty of evidence (GRADE)	Statistical method	Effect estimate
1.1 Motor function (upper extremity)	9	790 (19)	Moderate	SMD (IV, random, 95% CI)	0.57 (0.28, 0.86)
1.1.1 Non-immersive VR		641 (15)		SMD (IV, random, 95% CI)	0.48 (0.17, 0.78)
1.1.2 Immersive VR		149 (4)		SMD (IV, random, 95% CI)	0.95 (0.26, 1.64)
1.2 Fine motor function	9	486 (10)	Moderate	SMD (IV, random, 95% CI)	0.31 (−0.15, 0.77)
1.2.1 Non-immersive VR		421 (9)		SMD (IV, random, 95% CI)	0.05 (−0.19, 0.29)
1.2.2 Immersive VR		65 (1)		SMD (IV, random, 95% CI)	2.10 (1.49, 2.72)
1.3 Activities of daily living	4	513 (8)	Moderate	SMD (IV, random, 95% CI)	0.33 (0.08, 0.58)
1.3.1 Non-immersive VR		425 (6)		SMD (IV, random, 95% CI)	0.26 (0.04, 0.48)
1.3.2 Immersive VR		88 (2)		SMD (IV, random, 95% CI)	0.54 (−0.38, 1.45)
2.1 Motor function (lower extremity)	9	225 (5)	Moderate	SMD (IV, random, 95% CI)	0.51 (−0.49, 1.52)
2.1.1 Non-immersive VR		225 (5)		SMD (IV, random, 95% CI)	0.51 (−0.49, 1.52)
2.1.2 Immersive VR		0			
2.2 Balance	9	493 (13)	Low	SMD (IV, random, 95% CI)	0.66 (0.21, 1.11)
2.2.1 Non-immersive VR		391 (10)		SMD (IV, random, 95% CI)	0.77 (0.21, 1.33)
2.2.2 Immersive VR		102 (3)		SMD (IV, random, 95% CI)	0.25 (−0.24, 0.75)
2.3 Gait velocity	8	254 (6)	Low	SMD (IV, random, 95% CI)	0.03 (−0.30, 0.35)
2.3.1 Non-immersive VR		182 (4)		SMD (IV, random, 95% CI)	0.02 (−0.27, 0.31)
2.3.2 Immersive VR		72 (2)		SMD (IV, random, 95% CI)	0.19 (−1.14, 1.51)

GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; SMD, standardized mean difference; IV, inverse variance; CI, confidence interval; VR, virtual reality.

Figs. 3-8 present the forest plots from the meta-analysis. When comparing VR training (experimental group) to control group using standardized mean difference (SMD) with 95% CIs, VR training demonstrated statistically significant improvements in motor function and ADLs of the upper extremities, as well as balance.

Motor function (upper extremity)

The meta-analysis for upper limb motor function included 19 RCTs. The outcome measures used were the FMA-UE and grip strength. The effect size calculated as the SMD was 0.57 (0.28, 0.86).

A subgroup analysis revealed that the non-immersive VR group (15 RCTs, n = 641) had an effect size (SMD) of 0.48 (0.17, 0.78), while the immersive VR group (4 RCTs, n = 149) had an effect size (SMD) of 0.95 (0.26, 1.64) (**Fig. 3**).

Fine motor function

For fine motor function, 10 RCTs were included in the meta-analysis. These trials measured WMFT, ARAT, and BBT. The effect size (SMD) was 0.31 (−0.15, 0.77).

Subgroup analysis showed that the effect size (SMD) was 0.05 (−0.19, 0.29) for the non-immersive VR group (9 RCTs, n = 421), while for the immersive VR group (1 RCT, n = 65), it was 2.10 (1.49, 2.72) (**Fig. 4**).

ADLs

Eight RCTs were included in the analysis of ADL. These studies reported results for the FIM, BI, and MBI. The effect size (SMD) was 0.33 (0.08, 0.58).

A subgroup analysis for the non-immersive VR group (6 RCTs, n = 425) showed an effect size (SMD) of 0.26 (0.04, 0.48), while the immersive VR group (2 RCTs, n = 88) had an effect size (SMD) of 0.54 (−0.38, 1.45) (**Fig. 5**).

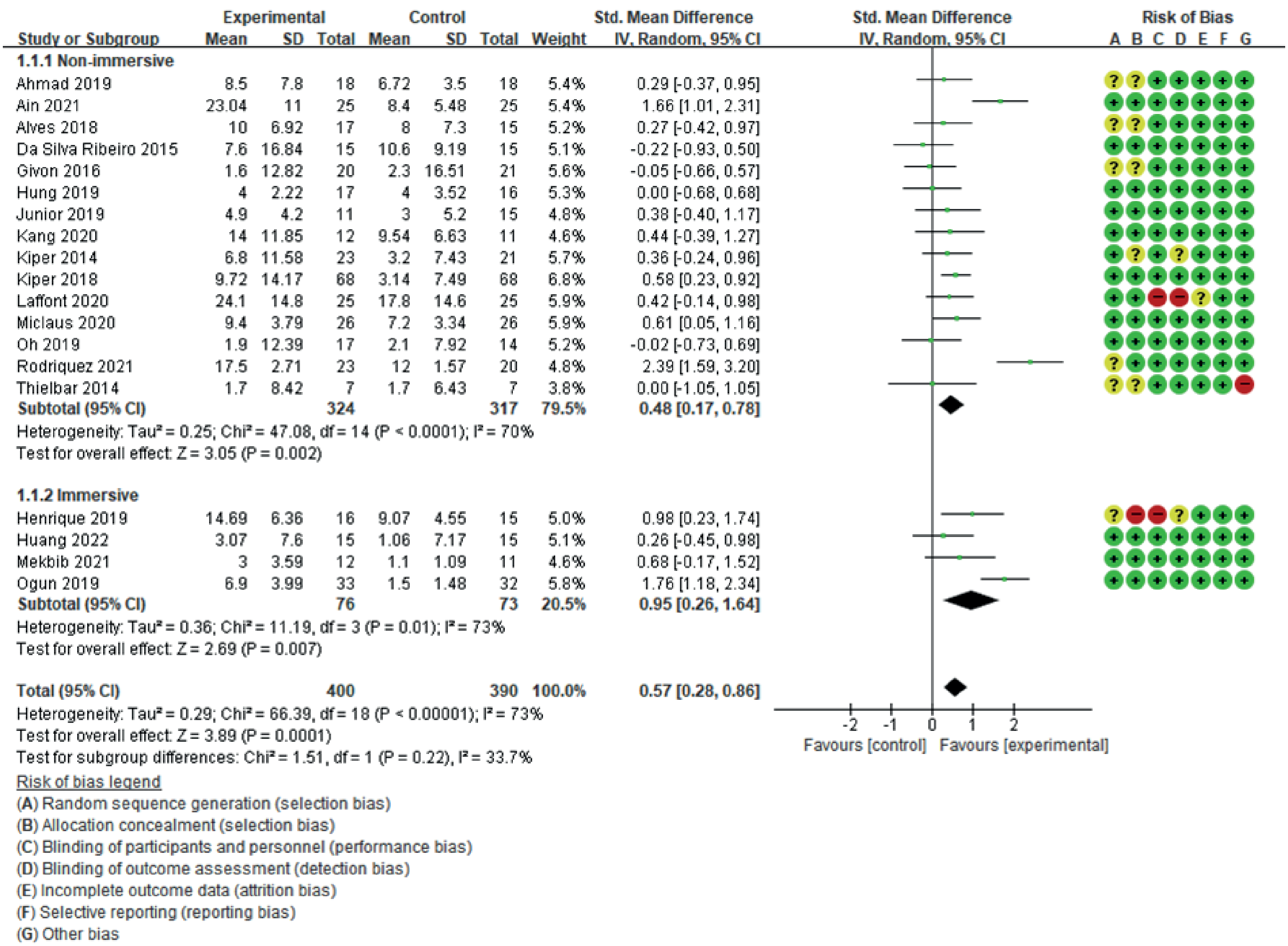

Fig. 3. Forest plot of the meta-analysis for virtual reality training: motor function of the upper extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

Motor function (lower extremity)

For lower limb motor function, the meta-analysis included 5 RCTs, which used the FMA-LE and weight balance ratio as outcome measures. The effect size (SMD) was 0.51 (−0.49, 1.52), with all studies using non-immersive VR as intervention (**Fig. 6**).

Balance

Balance was assessed in 13 RCTs, using the BBS, FRT, FMA-balance, and TUG test. The effect size (SMD) was 0.66 (0.21, 1.11).

A subgroup analysis for the non-immersive VR group (10 RCTs, n = 391) revealed an effect size (SMD) of 0.77 (0.21, 1.33), while for the immersive VR group (3 RCTs, n = 102), the effect size (SMD) was 0.25 (−0.24, 0.75) (**Fig. 7**).

Gait velocity

For gait velocity, 6 RCTs were included, measuring gait velocity, gait speed, the 6MWT, and the 10MWT. The effect size (SMD) was 0.03 (−0.30, 0.35).

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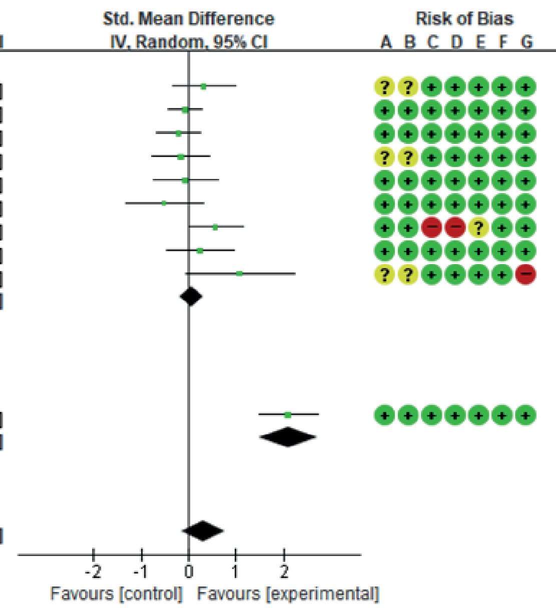
Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.2.1 Non-immersive								
Ahmad 2019	7.6	4.99	18	5.94	5.14	18	10.1%	0.32 [-0.34, 0.98]
Brunner 2017	11.9	11.15	62	12.6	4.28	58	11.8%	-0.08 [-0.44, 0.28]
Cannell 2018	7.7	8.11	35	9.5	8.68	38	11.2%	-0.21 [-0.67, 0.25]
Givon 2016	-0.1	10.14	20	1.8	12.05	21	10.3%	-0.17 [-0.78, 0.45]
Hung 2019	2.18	4.73	17	2.45	2.72	16	9.9%	-0.07 [-0.75, 0.62]
Kang 2020	8.33	7.76	12	13	9.81	11	8.9%	-0.51 [-1.35, 0.32]
Laffont 2020	15.7	16.3	25	7.4	12.2	25	10.6%	0.57 [0.00, 1.13]
Oh 2019	4.1	6.59	17	1.9	11.19	14	9.7%	0.24 [-0.47, 0.95]
Thielbar 2014	3.1	3.88	7	-3.5	7.14	7	7.1%	1.08 [-0.07, 2.22]
Subtotal (95% CI)			**213**			**208**	**89.7%**	**0.05 [-0.19, 0.29]**
Heterogeneity: Tau² = 0.04; Chi² = 11.25, df = 8 (P = 0.19); I² = 29%								
Test for overall effect: Z = 0.45 (P = 0.66)								
1.2.2 Immersive								
Ogun 2019	8.33	4.44	33	1.25	1.45	32	10.3%	2.10 [1.49, 2.72]
Subtotal (95% CI)			**33**			**32**	**10.3%**	**2.10 [1.49, 2.72]**
Heterogeneity: Not applicable								
Test for overall effect: Z = 6.73 (P < 0.00001)								
Total (95% CI)			**246**			**240**	**100.0%**	**0.31 [-0.15, 0.77]**

Heterogeneity: Tau² = 0.43; Chi² = 51.24, df = 9 (P < 0.00001); I² = 82%
Test for overall effect: Z = 1.31 (P = 0.19)
Test for subgroup differences: Chi² = 37.25, df = 1 (P < 0.00001), I² = 97.3%



Risk of bias legend
(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias

Fig. 4. Forest plot of the meta-analysis for virtual reality training: fine motor function of the upper extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

A subgroup analysis showed that the non-immersive VR group (4 RCTs, n = 182) had an effect size (SMD) of 0.02 (−0.27, 0.31), while the immersive VR group (2 RCTs, n = 72) had an effect size (SMD) of 0.19 (−1.14, 1.51) (**Fig. 8**).

DISCUSSION

This meta-analysis was designed to compare the effects of VR training with those of CT in stroke patients, drawing on recent studies and data from a Cochrane review. The findings revealed that VR training significantly outperformed CT in enhancing upper limb motor function, ADL, and balance, when administered with equivalent intensity and frequency.

The primary difference between the findings of this meta-analysis and those of earlier meta-analyses [13] relates to the scope and quality of the included studies. Previous analyses frequently included preliminary studies that employed with less rigorous methodologies or focused primarily on non-immersive VR. In contrast, this meta-analysis excluded preliminary RCTs and incorporated newer studies featuring immersive VR training.

For the meta-analysis of upper limb function, we conducted a subgroup analysis to differentiate between immersive and non-immersive VR training. Previous studies encountered analytical challenges due to small sample sizes and a limited number of RCTs focusing on immersive VR or newly developed VR technologies for rehabilitation therapy. In

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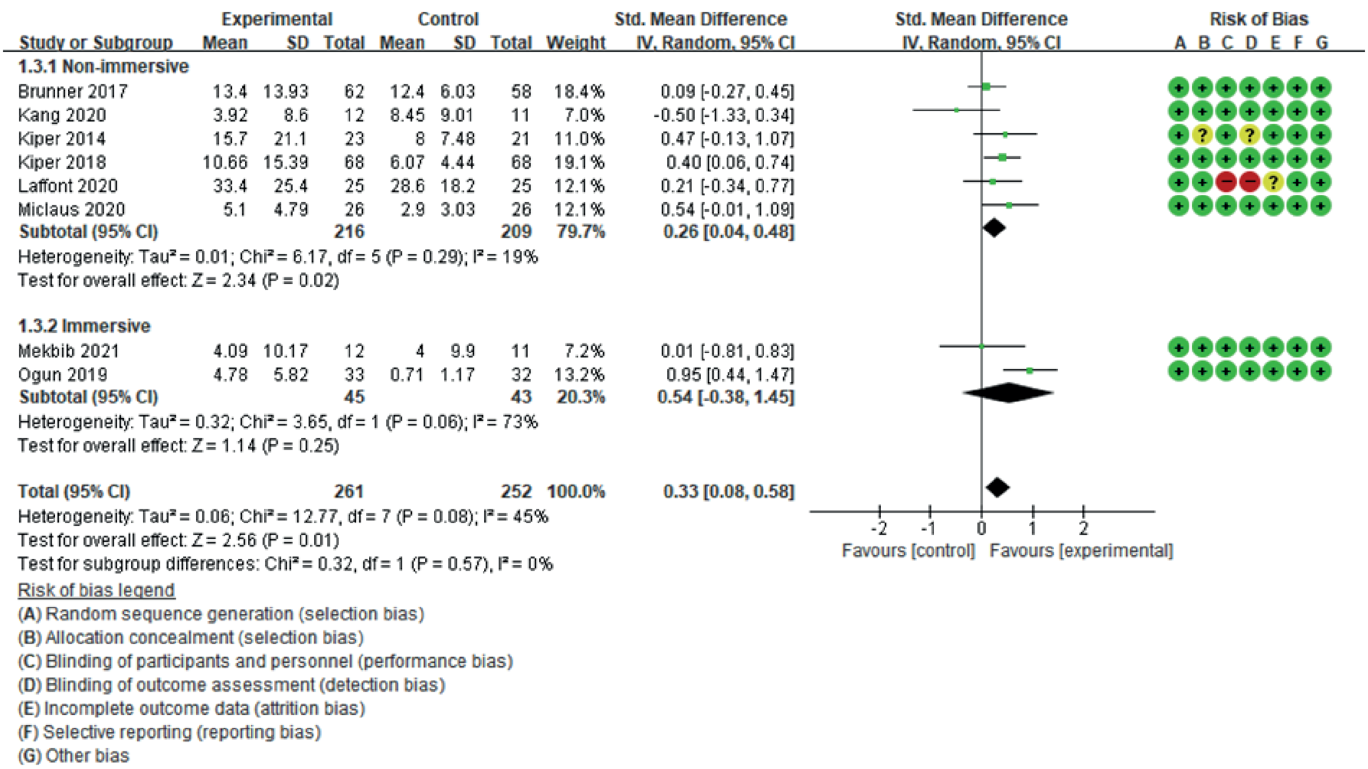

Fig. 5. Forest plot of the meta-analysis for virtual reality training: activities of daily living of the upper extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

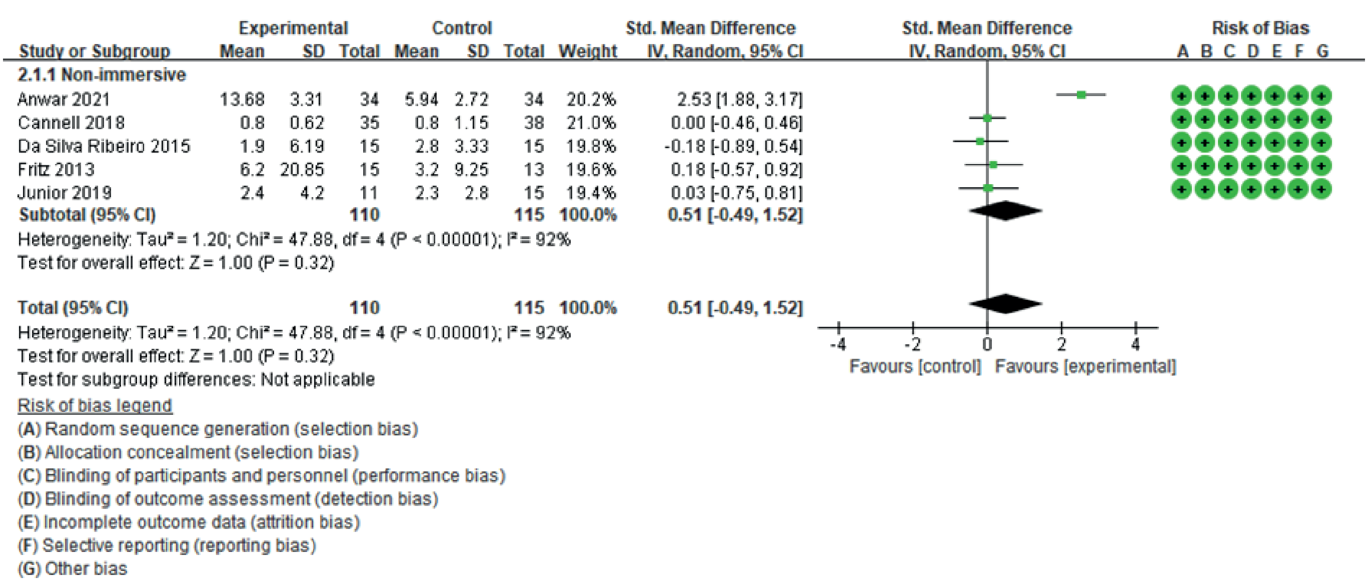

Fig. 6. Forest plot of the meta-analysis for virtual reality training: motor function of the lower extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

this meta-analysis, we performed subgroup analyses to ascertain if outcomes varied across domains based on the type of VR employed.

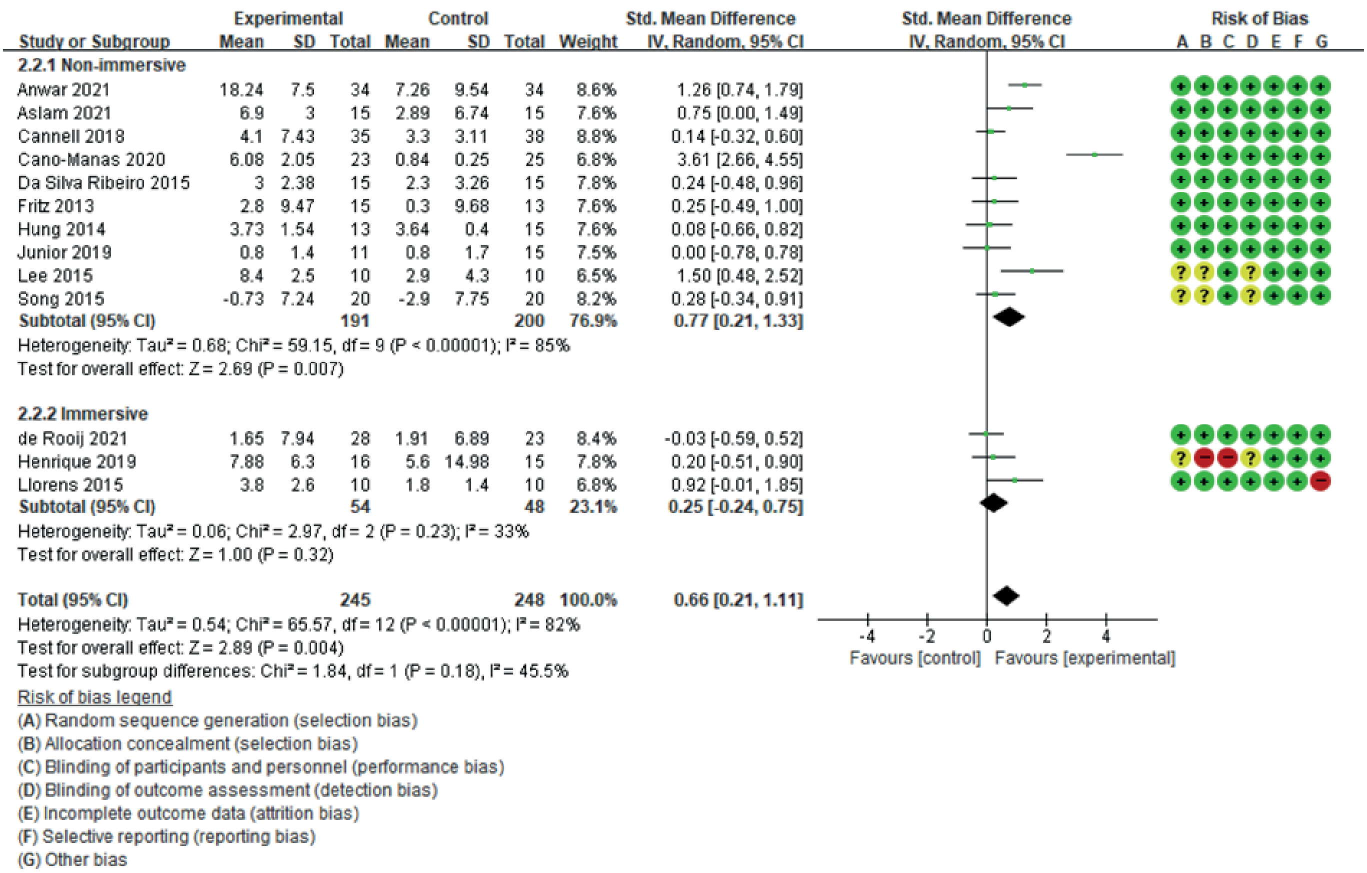

Fig. 7. Forest plot of the meta-analysis for virtual reality training: balance of the lower extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

In terms of upper limb motor function, VR training demonstrated better outcomes compared to CT, with both non-immersive and immersive VR training showing benefits. When examining fine motor function, no significant difference was found between VR training and CT overall. However, the sole study using immersive VR training, conducted by Ögün et al. (2019) [50], showed significant improvement. VR training also demonstrated better improvement in ADL performance, though this superiority was observed only in non-immersive VR training under subgroup analysis. Moreover, 2 studies found that immersive VR training did not perform significantly better than CT. Regarding stroke type, while most studies did not specify stroke subtype or exclude hemorrhagic stroke patients during recruitment, the study by Ögün et al. (2019) [50] did exclude hemorrhagic stroke patients. This exclusion led to a notable increase in heterogeneity in the meta-analysis. Nevertheless, the statistical significance of the overall results remained unaffected by this inclusion.

The review conducted by Laver et al. [13] indicated that VR training did not significantly enhance any aspects of upper limb function, with the exception of upper limb motor function. However, this meta-analysis, incorporating recent RCTs and studies on newly developed VR training methods, has shown significant improvements in upper limb motor function following VR training—improvements that were not observed in earlier meta-analyses. Specifically, recent studies have suggested through subgroup analysis that immersive VR training leads to significantly greater improvements than non-immersive VR in this domain.

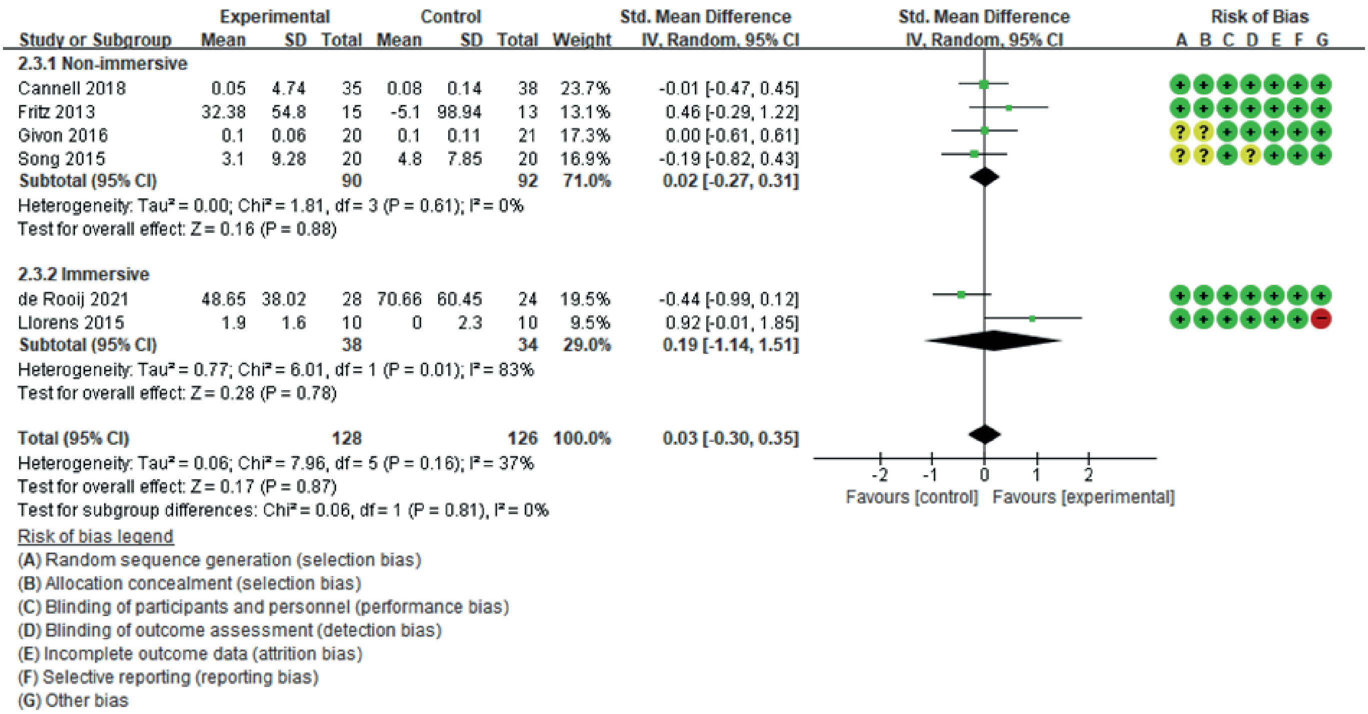

Fig. 8. Forest plot of the meta-analysis for virtual reality training: gait velocity of the lower extremity.
SD, standard deviation; Std., standardized; IV, inverse variance; CI, confidence interval.

In terms of balance, VR training was found to be more advantageous than CT. The study conducted by Cano-Mañas et al. (2020) [33] initially showed that the experimental group had significantly higher cognitive scores than the control group, indicating a bias in baseline characteristics. This bias notably increased the heterogeneity in the meta-analysis, although it did not impact the statistical significance of the results. Regarding lower limb motor function and gait velocity, the SMD for the effect of VR training included zero within the 95% CI, confirming that there was no significant difference compared to CT.

In the subgroup analysis concerning balance, immersive VR training did not show a significant difference compared to CT, and, notably, this analysis did not exhibit the heterogeneity observed in the overall analysis. In contrast, non-immersive VR training demonstrated a statistically significant advantage over CT in improving balance. For lower limb motor function, only non-immersive VR training was utilized across all studies, leaving no data available to evaluate the effectiveness of immersive VR training in this area. In terms of gait velocity, the subgroup analysis revealed no significant differences between either immersive or non-immersive VR training and CT. The study conducted by Anwar et al. (2021) [29] involved participants with an average age of 51 years, which is younger than the average age reported in previous studies. This younger cohort may have experienced a more pronounced effect from VR training, thereby contributing to increased heterogeneity in the meta-analysis. However, this variation did not affect the statistical significance of the overall results for lower limb motor function, allowing for the inclusion of this study in the analysis. Similar to the findings of the previous Cochrane review [13], this meta-analysis also determined that neither immersive nor non-immersive VR training significantly outperformed CT in enhancing lower limb function, with the exception of balance. However, balance showed a statistically significant improvement with non-immersive VR training. This

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outcome is slightly different from that of the earlier Cochrane review's meta-analysis, which only observed significant improvements in balance when VR as an additional intervention was incorporated into CT. The distinctions in this meta-analysis compared to the prior one include the incorporation of more recent studies and the omission of studies involving direct therapist intervention in VR training.

In summary, VR training has been shown to be a safe and effective intervention that offers improvements in motor function and balance for stroke patients. Its accessibility and potential for remote implementation, particularly during unique situations such as the coronavirus disease 2019 pandemic, have led to a growing interest in VR. However, there is still a need for more substantial evidence to fully affirm its safety. Additionally, potential side effects like photosensitivity seizures, nausea, and blurred vision need to be closely monitored by clinicians and therapists [55]. Despite these concerns, VR training is considered a relatively safe alternative to CT, with no additional risks expected when it is prescribed correctly and used with appropriate patients. Clinicians and therapists can decide whether to use CT or prioritize VR training based on the patient's goals, accessibility, personal interests, and any constraints related to time or space. Furthermore, VR training can be used in conjunction with CT to create a more comprehensive therapeutic strategy.

SUPPLEMENTARY MATERIALS

Supplementary Table 1

Search terms and strategies

Supplementary Table 2

Characteristics of included studies

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