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Review Article

Effect of Home-based Rehabilitation on Balance and Gait Function in Patient With Stroke: A Systematic Review and Meta-analysis

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Stroke is one of the most common disabilities experienced by the elderly in the community. However, stroke progresses to a chronic level, patients are discharged from medical institutions and eventually no longer receive therapeutic interventions at home. In this systematic review, we compared home-based rehabilitation (HBR) with comparison for patients with stroke. Literature published in Cumulative Index for Nursing and Allied Health Literature (CINAHL), Embase, Physiotherapy Evidence Database (PEDro), PubMed, and Google Scholar were reviewed. A total of 1,158 studies were initially retrieved. After reading the full texts, 11 articles were included in the systematic review. Quality assessment of the included studies was conducted using Risk of Bias (RoB) 2.0, and Egger's regression test was used to evaluate publication bias. Data analysis was performed using the R studio software (R Studio). According to the quality assessment using RoB 2.0, three studies were evaluated as low risk, two as of some concern, and three as high risk. The overall effect size was moderate (0.309). The value of the balance function was a small effect size (0.201), while the value of the gait function was a moderate effect size (0.353). The values were small and moderate effect (0.154, 0.411) for the chronic and subacute conditions, respectively. According to the Egger's regression test, no publication bias was observed. The findings of this study indicate that HBR resulted in the greatest improvement in gait function in patients with subacute stroke compared to those with chronic stroke. Therefore, the application of this intervention to patients with stroke in the community is recommended.

INTRODUCTION

Numerous studies have been conducted on the rehabilitation of patients with stroke [1-5]. Stroke is one of the most common disabilities experienced by the elderly in the community [4], patients with stroke experience balance and gait dysfunction [6]. Therefore, balance and gait problems negatively affect activities and participation, and solving these problems is the primary goal of stroke rehabilitation [7-17].

Balance is the ability to maintain a position within the limits of stability or base of support [18]. Gait after a stroke is spatiotemporally asymmetric, and static balance is correlated with gait parameters in stroke patients [19]. Therefore, in clinical practice, interventions are often performed to simultaneously improve balance and gait [20,21]. Many interventions are used in the clinic to improve balance and gait function in patients with stroke, and various guidelines have been proposed [21-23]. According to the American Heart Association/American Stroke Association, stroke rehabilitation requires a team approach involving patients and professionals, such as physical and occupational therapists and other specialists, emphasizing communication and coordination between professionals [24].

To date, interventions for the rehabilitation of patients with stroke have primarily been provided in medical centers and rehabilitation clinics, where it is difficult for experts in each field to collaborate effectively [25]. In addition, in medical institutions, patients with stroke are hospitalized and receive intensive interventions in the early stages of stroke onset [26]. However, as stroke progresses to a chronic level, patients are discharged from medical institutions and eventually no longer receive therapeutic interventions at home [25,26]. Therefore, despite the importance of rehabilitating patients with stroke in the community, they often become "rehabilitation refugees," highlighting the urgent need for appropriate interventions available after hospital discharge [27].

For these reasons, the idea of providing rehabilitation services at home has been raised, and the effectiveness of home-based rehabilitation (HBR) for patients with stroke in the community has been confirmed in various countries [2,4,7,28-30]. Previous studies have shown that HBR involves a variety of professionals such as physical therapists and occupational therapists, and has reported positive outcomes for participants [2,4,7]. However, despite these favorable results, most of the studies conducted thus far have been individual intervention studies, with a low level of evidence. Therefore, systematic reviews and meta-analyses should be conducted to combine conflicting evidence and make informed decisions.

Several qualitative studies have recently been conducted to confirm the effectiveness of HBR. Lee and Lee [31] analyzed the effectiveness of HBR for older adults after hip fracture surgery through a meta-analysis and reported more positive results for muscle strength, gait speed, and balance than in-hospital rehabilitation. Costa et al. [32] also confirmed the effectiveness of HBR in community-dwelling older adults through a meta-analysis and reported more effective results compared to a control group. However, studies on patients with stroke are lacking, and it is necessary to confirm whether the previously reported positive effects of HBR are clinically effective in patients with stroke.

The objectives of this study were as follows: (1) To conduct a systematic review and meta-analysis by categorizing studies that identified the effects of HBR on balance and gait function in patients with stroke, and (2) to propose the best protocol for applying HBR in patients with stroke.

MATERIALS AND METHODS

The procedures for this review were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [33]. The study was designed by an investigator fully trained in systematic reviews and meta-analyses and conducted by a professor of physiotherapy and a doctoral physiotherapist. In cases of disagreement, referrals were made to other researchers in the doctoral program in physiotherapy. Since this was a meta-analysis of published articles, it was exempt from Institutional Review Board review. Methodological procedures were performed after registration in the International Prospective Register of Systematic Reviews (Registration no. CRD42023445716) [34].

1. Search Strategy

This study was designed to fit the participants, intervention, comparison, and outcome criteria [35]. The participants were those diagnosed with stroke, the intervention was HBR, the comparison was conventional physical therapy, the group received no intervention or other intervention, and the outcome was the effect of HBR on balance or gait function in patients with stroke. The literature published in the English language was searched from August 2023 to September 2023 in the Cumulative Index for Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Controlled Trials, Physiotherapy Evidence Database (PEDro), PubMed, and Google Scholar (10 pages) databases. "HBR" and "Stroke" were used as keywords to minimize the number of articles that would be missed by searching with only one keyword (Figure 1).

2. Eligibility Criteria

The inclusion criteria for this study were: (1) subjects diagnosed with stroke, (2) studies comparing HBR to other therapy groups or non-intervention groups, (3) studies in which the outcome was related to balance or gait function, (4) studies published in English, and (5) randomized controlled trials (RCTs).

The exclusion criteria were as follows: (1) studies with a single experimental design and no control group; (2) non-experimental studies such as surveys, case studies, and qualitative studies; (3) gray literature (abstracts, posters) that were not peer-reviewed; (4) studies that did not provide sufficient data for effect size analysis; and (5) studies with errors in the results in the tables or figures presented.

3. Data Extraction

With the agreement of all members of the research team, author names, publication year, study participants, age, sex, onset, intervention, suppliers, duration, and outcomes were recorded for data coding. No serious adverse events related to physical activity were noted in the included studies.

4. Quality Assessment

This study was assessed using the Cochrane Risk of Bias

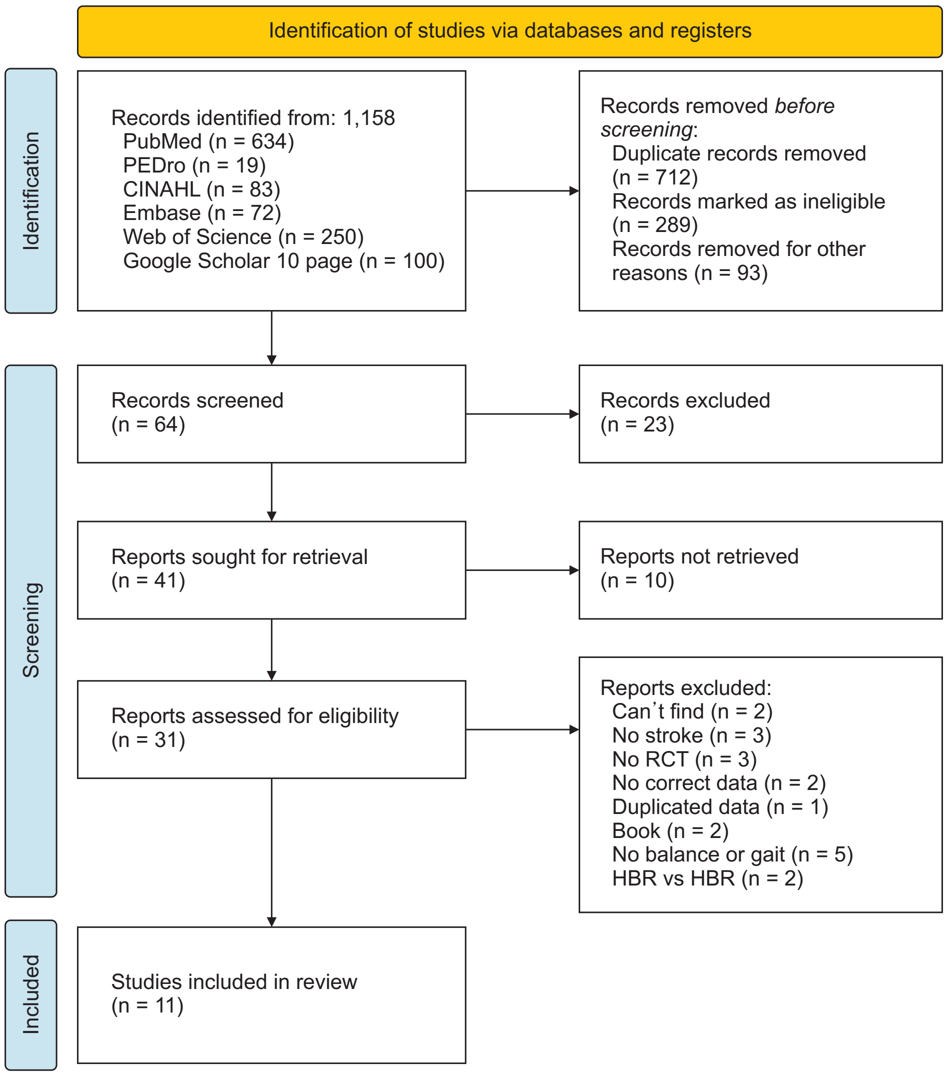

Figure 1. PRISMA flowchart. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PEDro, Physiotherapy Evidence Database; CINAHL, Cumulative Index for Nursing and Allied Health Literature; RCT, randomized controlled trial; HBR, home-based rehabilitation.

(ROB) tool for randomized trials (ver. 2.0) [36]. Two researchers independently performed quality assessments following the criteria outlined in the Cochrane Handbook of Systematic Reviews of Interventions, and any disagreements were resolved by discussion with a third researcher. The detailed domains of RoB 2.0 include: (1) randomization process, (2) deviations from intended interventions, (3) missing outcome data, (4) outcome measurements, (5) selection of reported results, and (6) overall bias.

5. Publication Bias

To check for publication bias, we visually observed the funnel plot and used the statistical test Egger's regression test to supplement the subjective aspect of the study [37]. In Egger's regression test, the intercept of the regression line is plotted, and the closer it is to zero, the smaller the publication bias. Conversely, if the intercept of the regression line increases and $p < 0.01$, the publication bias is large.

6. Data Analyses

This review analyzed the data using R studio software (R Studio). The corrected standardized mean difference (SMD) (corrected effect size) was calculated based on the SMD of Cohen's d and Hedges' g [38-40]. Cohen's d value is sample-sensitive and tends to overestimate the effect size when the sample size is small; hence, it must be corrected [38,41]. Therefore, in this study, Hedges' g value was calculated to summarize the effect size, the Z value was calculated to check the overall effect size, and the significance level was set at $p < 0.05$ [40]. The results were interpreted based on the point estimate, the criteria for analyzing the effect size are as follows: a trivial effect size has a point estimate of less than 0.1, a low effect size has a point estimate of less than 0.3, a moderate effect size has a point estimate of less than 0.8, and a large effect size has a point estimate of 0.8 or greater. Additionally, a 95% confidence interval (CI) was provided [39]. The timing criteria for the onset of symptoms were defined as follows: acute (less than 7 days), subacute (7 days to less than 6 months), and chronic (6 months or more) [42]. No studies on stroke patients in the acute stage were found.

RESULTS

1. General Characteristics of the Included Studies

The general characteristics of the studies included in this review are as follows: The literature search yielded 634 articles from PubMed, 19 from PEDro, 83 from CINAHL, 72 from Embase, 250 from the Web of Science, and 100 from Google Scholar (10 pages). The general characteristics of the selected studies were as follows: coding included study, age, sex, onset, intervention, supplier, duration, and outcome, as determined by discussions among the researchers. The balance tests included the Berg Balance Scale (BBS), activities-specificbalanceconfidence (ABC), timed up and go test (TUG), falls efficacy scale (FES), function in sitting test (FIST), and postural assessment scale for stroke (PASS). Gait function assessment included comfortable & fast gait speed, 5-meter walking test (5MWT), 10-meter walking test (10MWT), 6-minute walk test (6MWT), step activity monitor, figure of 8-walk test (F8WT), cadence, stride time, foot off and contact, step time, single support time, double support time, foot off, stride length, and step length. The distribution of sample size for balance were as follows: BBS (n = 252, 56%), ABC (n = 126, 28%), FES (n = 34, 7.56%), FIST (n = 16, 3.56%), PASS (n = 16, 3.56%), TUG (n = 6, 1.33%). For gait, gait speed included comfortable & fast walking speed, 5MWT, 10MWT, and F8WT speed. Gait endurance included 6MWT. Gait pattern included step activity monitor, F8WT step, cadence, stride time, less-affected foot off & contact, step time, single support time, double support time, stride length, and step length. The inclusion rates for each domain were as follows: gait speed (n = 477, 46.9%), gait endurance (n = 186, 18.29%), and gait pattern (n = 354, 34.81%).

2. The Results of the Quality Assessment of the Study

The quality of the 11 papers was assessed as follows: Domain 1, "bias arising from the randomization process," was rated as

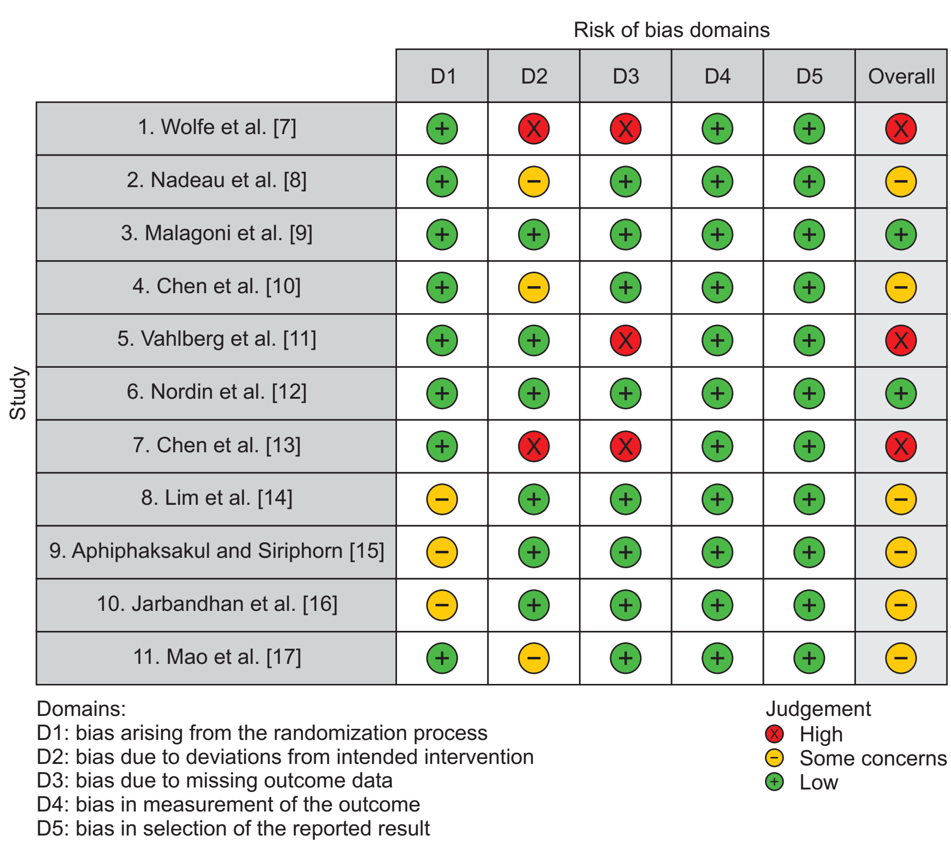

Figure 2. Results of Risk of Bias (RoB) 2.0.

"low risk of bias" for eight articles and "somewhat concerning risk of bias" for three articles. Domain 2, "bias due to changes in the intended intervention," was rated as "low risk of bias" for six studies, "somewhat concerning risk of bias" for three studies, and "high risk of bias" for two studies. For domain 3, "skewness due to exclusion of outcomes," eight articles were rated as having a "low risk of skewness" and three articles as having a "high risk of skewness." For domain 4, "bias related to outcome measures," all 11 articles were rated as having a "low risk of bias." For domain 5, "bias due to selection of reported outcomes," all 11 articles were rated as having a "low risk of bias." Finally, the overall judgment of the five domains, "overall bias," was rated as "low risk of bias" for two articles, "somewhat concerning risk of bias" for six articles, and "high risk of bias" for three articles (Figure 2) [7-17].

3. Overall Effect Size

We performed a homogeneity test on the results of all the included articles, and no heterogeneity was observed ($Q = 11.738$, $p = 0.303$, $I^2 = 14.810\%$). However, due to the inconsistent distribution of effect sizes in visual observations and the heterogeneous methodological characteristics of the included studies, we used a random-effects model to determine the overall effect size, which included balance and gait. The results showed that the overall effect size across all included studies was statistically significant at 0.309 (Hedges' g = 0.309, CI = 0.123 to 0.494, $p < 0.001$), with a moderate effect size (Figure 3) [7-17].

4. The Effect Size for Balance

The effect size for gait patterns was calculated using a random-effects model, and seven studies were included. The measures used were the BBS, ABC, TUG, FES, FIST, PASS, trunk impairment scale, mini balance evaluation systems test (Mini-BEST), and TUG. The results showed that the effect size estimate was 0.201 (Hedges' g = 0.201, CI = 0.034 to 0.367, $p = 0.018$), which was statistically significant, and a low degree of effect size was observed (Figure 4) [8-12,15,16].

Study	Variance	SE	p-value	n1	n2	Hedges' g	95% CI	Weight
1. Wolfe et al. [7]	0.094	0.307	0.049	23	20	0.603	[0.002 to 1.205]	7.4%
2. Nadeau et al. [8]	0.015	0.123	0.013	126	143	0.306	[0.065 to 0.546]	21.7%
3. Chen et al. [10]	0.072	0.268	0.755	27	27	−0.084	[−0.610 to 0.442]	9.1%
4. Malagoni et al. [9]	0.284	0.533	0.988	6	6	0.008	[−1.037 to 1.053]	2.9%
5. Vahlberg et al. [11]	0.059	0.243	0.223	34	33	0.296	[−0.181 to 0.773]	10.5%
6. Nordin et al. [12]	0.043	0.208	0.962	45	46	−0.010	[−0.417 to 0.397]	12.9%
7. Chen et al. [13]	0.035	0.187	0.000	59	62	0.748	[0.382 to 1.115]	14.6%
8. Lim et al. [14]	0.214	0.463	0.736	9	8	0.156	[−0.751 to 1.063]	3.7%
9. Aphiphaksakul and Siriphorn [15]	0.124	0.352	0.177	16	16	0.475	[−0.215 to 1.165]	6.0%
10. Jarbandhan et al. [16]	0.145	0.380	0.306	20	10	0.389	[−0.356 to 1.134]	5.2%
11. Mao et al. [17]	0.124	0.353	0.597	16	15	0.186	[−0.505 to 0.877]	5.9%
Random effects model						**0.309**	**[0.123 to 0.494]**	**100.0%**
Heterogeneity: $I^2 = 15\%$, $\tau^2 = 0.0262$, $p = 0.30$								

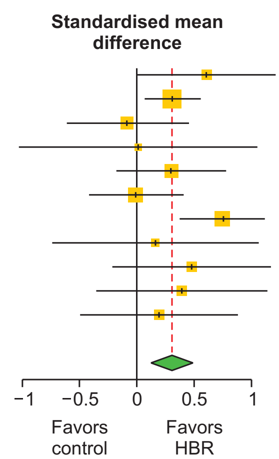

Figure 3. Overall effect size. SE, standard error; HBR, home-based rehabilitation; CI, confidence interval.

Study	Variance	SE	p-value	n1	n2	Hedges' g	95% CI	Weight
2. Nadeau et al. [8]	0.015	0.123	0.019	126	143	0.287	[0.046 to 0.527]	47.9%
3. Chen et al. [10]	0.072	0.268	0.755	27	27	−0.084	[−0.610 to 0.442]	10.0%
4. Malagoni et al. [9]	0.284	0.533	0.953	6	6	0.031	[−1.013 to 1.076]	2.5%
5. Vahlberg et al. [11]	0.059	0.243	0.298	34	33	0.253	[−0.224 to 0.729]	12.2%
6. Nordin et al. [12]	0.043	0.208	0.890	45	46	−0.029	[−0.436 to 0.379]	16.6%
9. Aphiphaksakul and Siriphorn [15]	0.124	0.352	0.177	16	16	0.475	[−0.215 to 1.165]	5.8%
10. Jarbandhan et al. [16]	0.144	0.380	0.357	20	10	0.350	[−0.394 to 1.093]	5.0%
Random effects model						**0.201**	**[0.034 to 0.367]**	**100.0%**
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 0.71$								

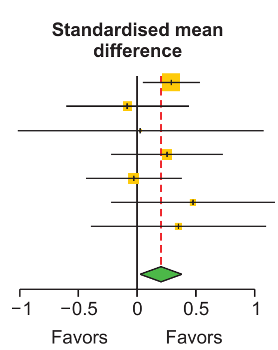

Figure 4. The effect size for the balance. SE, standard error; HBR, home-based rehabilitation; CI, confidence interval.

5. The Effect Size for Gait Function

The effect size for gait function was calculated using a random-effects model, and nine studies were included. The measurements used included a 5MWT, comfortable or fast gait speed, 6MWT, step activity monitor, F8WT, four square step test, cadence, stride time, foot off and contact, step time, single support time, double support time, foot off, stride length, step length, walking speed, and Mini-BEST gait. The results showed that the effect size estimate was 0.353 (Hedge's g = 0.358, CI = 0.153 to 0.548, $p < 0.001$), and a moderate effect size was observed (Figure 5) [7-9,11-14,16,17].

6. Effect Size Based on Onset

Subgroup analysis by onset categorized the studies as chronic or subacute. The chronic group included six studies, and the effect size was 0.154 (Hedges' g = 0.154, CI = –0.093 to 0.400, $p = 0.221$), which was not statistically significant and showed a low degree of effect size. Conversely, in the subacute groups, the effect size was statistically significant at 0.411 (Hedges' g = 0.309, CI = 0.123 to 0.494, $p < 0.001$), and a moderate effect size was observed (Figure 6) [7-17].

7. Publication Bias

Publication bias results: Egger's regression test confirmed the absence of publication bias (CI = –2.230 to 1.513, $p = 0.338$). However, the funnel plot showed some asymmetry in the visual assessment (Figure 7).

DISCUSSION

This systematic review and meta-analysis were conducted to determine the effectiveness of HBR in improving balance and

Study	Variance	SE	p-value	n1	n2	Hedges' g	95% CI	Weight
1. Wolfe et al. [7]	0.094	0.307	0.049	23	20	0.603	[0.002 to 1.205]	8.5%
2. Nadeau et al. [8]	0.015	0.123	0.010	126	143	0.315	[0.075 to 0.556]	26.7%
4. Malagoni et al. [9]	0.284	0.533	0.988	6	6	0.008	[−1.037 to 1.052]	3.2%
5. Vahlberg et al. [11]	0.059	0.243	0.163	34	33	0.339	[−0.137 to 0.816]	12.2%
6. Nordin et al. [12]	0.043	0.208	0.966	45	46	0.009	[−0.399 to 0.416]	15.2%
7. Chen et al. [13]	0.035	0.187	0.000	59	62	0.748	[0.382 to 1.115]	17.4%
8. Lim et al. [14]	0.214	0.463	0.736	9	8	0.156	[−0.751 to 1.063]	4.2%
10. Jarbandhan et al. [16]	0.145	0.381	0.260	20	10	0.429	[−0.318 to 1.175]	5.9%
11. Mao et al. [17]	0.124	0.353	0.597	16	15	0.186	[−0.505 to 0.878]	6.8%
Random effects model						**0.353**	**[0.158 to 0.548]**	**100.0%**

Heterogeneity: $I^2 = 9\%$, $\tau^2 = 0.0220$, $p = 0.36$

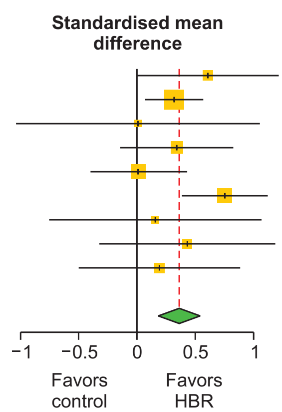

Figure 5. The effect size for the gait function. SE, standard error; HBR, home-based rehabilitation; CI, confidence interval.

Onset	Study	Variance	SE	p-value	n1	n2	Hedges' g	95% CI	Weight
Onset = chronic									
Chronic	4. Malagoni et al. [9]	0.284	0.533	0.988	6	6	0.008	[−1.037 to 1.052]	2.9%
Chronic	5. Vahlberg et al. [11]	0.059	0.243	0.223	34	33	0.296	[−0.181 to 0.773]	10.5%
Chronic	6. Nordin et al. [12]	0.043	0.208	0.962	45	46	−0.010	[−0.417 to 0.397]	12.9%
Chronic	8. Lim et al. [14]	0.214	0.463	0.736	9	8	0.156	[−0.751 to 1.063]	3.7%
Chronic	10. Jarbandhan et al. [16]	0.145	0.380	0.306	20	10	0.389	[−0.356 to 1.134]	5.2%
Chronic	11. Mao et al. [17]	0.124	0.353	0.597	16	15	0.186	[−0.505 to 0.878]	5.9%
Random effects model							**0.154**	**[−0.093 to 0.400]**	**41.2%**
Heterogeneity: $I^2 = 0\%$, $\tau^2 = 0$, $p = 0.92$									
Onset = subacute									
Subacute	1. Wolfe et al. [7]	0.094	0.307	0.049	23	20	0.603	[0.002 to 1.205]	7.4%
Subacute	2. Nadeau et al. [8]	0.015	0.123	0.013	126	143	0.306	[0.065 to 0.546]	21.7%
Subacute	3. Chen et al. [10]	0.072	0.268	0.755	27	27	−0.084	[−0.610 to 0.442]	9.1%
Subacute	7. Chen et al. [13]	0.035	0.187	0.000	59	62	0.748	[0.382 to 1.115]	14.6%
Subacute	9. Aphiphaksakul and Siriphorn [15]	0.124	0.352	0.177	16	16	0.475	[−0.215 to 1.165]	6.0%
Random effects model							**0.411**	**[0.130 to 0.692]**	**58.8%**
Heterogeneity: $I^2 = 49\%$, $\tau^2 = 0.0489$, $p = 0.10$									
Random effects model							**0.309**	**[0.123 to 0.494]**	**100.0%**

Heterogeneity: $I^2 = 15\%$, $\tau^2 = 0.0262$, $p = 0.30$
Test for subgroup differences: $\chi_1^2 = 1.82$, df = 1 ($p = 0.18$)

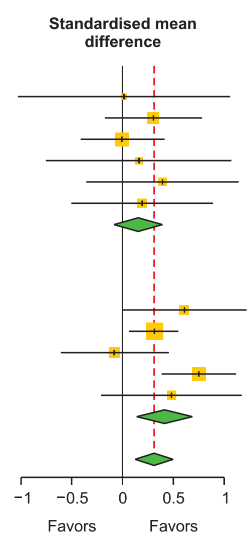

Figure 6. The effect size according to the onset. SE, standard error; HBR, home-based rehabilitation; CI, confidence interval.

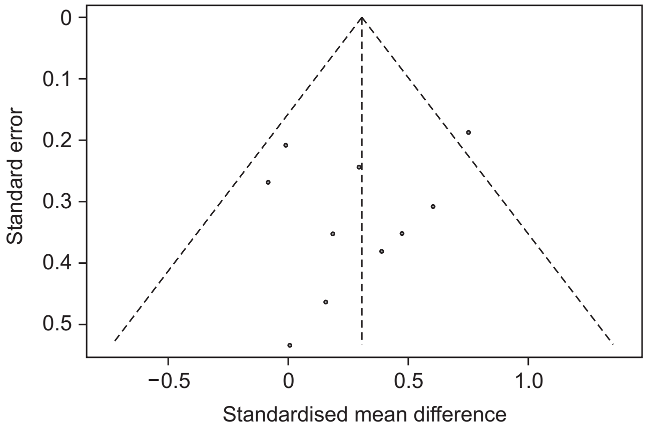

Figure 7. Funnel plot.

gait in patients with stroke. According to a previous study, the minimal clinically important difference (MCID) threshold for Hedges' g (or Cohen's d) is 0.2 [43].

The results of this study showed that the overall effect size was statistically significant (Hedges' g = 0.309, $p < 0.001$) and a moderate effect size was observed. These results suggest that HBR is an effective intervention for patients with stroke, although with modest effectiveness. However, differences were found in the designs and outcome variables of the included studies, and subgroup analyses were performed to further refine the analysis.

A small effect was observed for balance (Hedges' g = 0.201), which is slightly higher than the trivial effect of 0.2. Although the effect size is small, HBR may be more effective than other interventions in improving balance among stroke patients because this effect size was more than the MCID threshold. This observation may be attributed to the differences between home exercise and conventional rehabilitation programs performed in medical institutions, which often involve goal-directed rehabilitation rather than focusing on body structure and function [44]. According to the International Classification of Functioning, Disability and Health classification, balance, including postural control, is categorized under body function rather than activity and participation [45], therefore, potentially limiting its effectiveness as a target for goal-directed interventions in HBR. Furthermore, apart from the experimental group, HBR and control groups also received intervention programs, such as conventional rehabilitation therapy, a standard group program, and hospital-based intervention. Therefore, even the control group exhibited notable improvements in the balance of patients with stroke, indicating a moderate effect size. Despite this low effect size, we observed a positive trend in the overall effect size and a statistically significant difference. Previous studies have shown that the group that received HBR for patients with stroke did not differ significantly from the group that received other programs, such as locomotor training [14]. However, there was a minimal clinically important difference in outcomes compared with the group that received conventional care. Therefore, while the magnitude of the estimate is low, the findings of this study suggest a positive effect of HBR on balance compared with the control group, warranting its potential use in clinical practice to improve balance in patients with stroke.

A moderate effect size was observed for the gait function, which was higher than that for balance. This suggests that HBR is an effective intervention for improving gait function in patients with stroke compared with other interventions. In the literature reviewed, the healthcare providers involved were physical therapists, occupational therapists, or nurses (Table 1) [7-17]. The HBR provided to participants included continuous feedback from a medical specialist. Intervention by a rehabilitation specialist may have the advantage of increasing the effectiveness of training compared with a general intervention. In some studies, HBR has included daily walking or simple gait exercises, range of motion (ROM) exercises, stair climbing, sit-to-stand exercises, and limb muscle strengthening [8,11-14,16]. Previous studies have shown that lower limb strengthening and ROM exercises are effective in improving gait patterns [8,13,14], and daily walking or simple gait exercises are effective interventions for improving gait function by stimulating the central pattern generator through repetitive gait training [41,46]. Therefore, unlike balance, moderate effect sizes were observed for the gait function.

The differences in onset also yielded marginally different results. In patients with chronic stroke, a negligible effect size of 0.154 was found, which did not exceed the MCID, whereas in patients with subacute stroke, a moderate effect size of 0.398 was observed. This suggests that HBR is more effective in patients with relatively early stroke. These findings may be attributed to the fact that functional recovery most likely occurs in the first 3 to 6 months after a stroke [47]. Previous studies have shown that the acute phase is when the brain's neuroplasticity is most active, and intensive rehabilitation takes place [47,48]. Andrews and Bohannon [48] found that an active rehabilitation program, in addition to natural neurological recovery, sig-

Table 1. General characteristics of included studies

Study	Group	Age (mean ± SD, y)	Sex (M/F, n)	Onset	Intervention	Supplier	Duration	Outcome
Wolfe et al. [7]	Exp	72.0 ± 12.0	10/13	Subacute (3 mo)	Home-based OT, PT, and ST (not reported)	PT, OT, ST	60 min (PT 20 min + OT 20 min + ST 20 min) × 7 d × 12 wk	5-MWT CSI FAST HADS NHP MBI Motricity MMES RADL
	Con	76.0 ± 7.04	8/12		Usual community care	Not reported	7 d × 12 wk	
Nadeau et al. [8]	Exp	62.6 ± 13.3	65/61	Subacute (2 mo)	Home-based PT (progressive flexibility, range of motion, upper- and lower-extremity strength, coordination, and static, and dynamic balance exercises)	PT	90 min × 3 d × 16 wk	10-MWT 6MWT BBS FMA IADL SIS Step activity monitor
	Con	63.3 ± 12.5	74/69		Usual care	PT	90 min × 3 d × 16 wk	
Malagoni et al. [9]	Exp	62.5 ± 13.8	4/2	Chronic (74.4 ± 42.0 mo)	Home-based test in-train out program (semi-personalized walking training)	PT	210 min × 6 d × 10 wk	6MWT PF SCT TUG
	Con	70.7 ± 9.0	5/1	Chronic (81.6 ± 49.2 mo)	Standard group program (endurance, balance, muscle strength, and flexibility training)	PT	60 min × 3 d × 10 wk	
Chen et al. [10]	Exp	66.5 ± 12.1	18/9	Chronic (25.0 ± 5.6 mo)	Home-based tele-supervising rehabilitation (the portable muscle electricity biofeedback instrument) + the Bobath, PNF, and OT	PT, OT	120 min × 7 d × 12 wk	BBS CSI MBI RMS
	Con	66.2 ± 12.3	15/9	Chronic (26.9 ± 4.7 mo)	Conventional rehabilitation therapy + the Bobath, PNF, and OT	PT, OT	120 min × 7 d × 12 wk	
Vahlberg et al. [11]	Exp	72.6 ± 5.5	27/7	Chronic (12–36 mo)	Home based progressive resistance and balance training	PT	75 min × 3 d × 12 wk	6MWT 10-MWT BBS EQ-5D FES GDS-20 SPPB PASE
	Con	73.7 ± 5.3	24/9	Chronic (12–36 mo)	Regular community care	PT	12 wk	

Table 1. Continued

Study	Group	Age (mean ± SD, y)	Sex (M/F, n)	Onset	Intervention	Supplier	Duration	Outcome
Nordin et al. [12]	Exp	60.3 ± 3.4	34/11	Chronic (17.3 ± 4.1 mo)	Home-based carer-assisted program (physical activities, domestic tasks, cognitive, brain stimulating activities, and leisure activities)	PT	45–60 min × 3 d × 12 wk (physical activities) 45–60 min × 1d × 12 wk	BBS EQ-5D EQ-VAS RMI TUG
	Con	59.4 ± 3.3	36/10	Chronic (12.4 ± 2.0 mo)	Hospital-based group therapy	PT	120 min × 1 d × 12 wk	
Chen et al. [13]	Exp	55.4 ± 6.8	41/18	Subacute (3.4 ± 0.8 mo)	Conventional rehabilitation therapy + nurse-guided home-based rehabilitation (lower joint stretching, strengthening, and balance training)	Nurse	30 min × 3 d × 12 wk + 30 min × 1 d × 12 wk	10-MWT (gait speed, step size) BI FMA MAS
	Con	56.4 ± 6.1	44/18	Subacute (3.2 ± 0.8 mo)	Conventional rehabilitation therapy (strengthening the lower limb muscle groups with exercises)	Nurse	Not reported	
Lim et al. [14]	Exp	70.1 ± 6.5	5/4	Chronic (62.8 ± 8.0 mo)	Home-based rehabilitative program and tele-rehabilitative service (coordination exercises for the lower extremities and augmented feedback)	PT	30 min × 5 d × 6 wk	10-MWT (comfortable, fast) F8WT (speed, step) SF-36 PCS MCS
	Con	68.6 ± 9.1	5/3	Chronic (45.1 ± 12.1 mo)	Clinic-based exercise	PT	30 min × 5 d × 6 wk	
Aphiphaksakul and Siriphorn [15]	Exp	59.4 ± 11.1	10/6	Subacute (1.5 ± 0.6 mo)	Home-based rehabilitative program (sitting balance training and smartphone inclinometer application) + conventional rehabilitation therapy	PT	30 min × 5 d × 4 wk (home-rehabilitation program) + 30 min × 5 d × 4 wk (conventional rehabilitation therapy)	BI FIST PASS
	Con	59.4 ± 10.8	9/7	Subacute (1.3 ± 0.6 mo)	Conventional rehabilitative therapy	PT	60 min × 5 d × 4 wk	
Jarbandhan et al. [16]	Exp	61.6 ± 9.1	13/17	Chronic (> 6 mo)	Home-based physiotherapy program (stair climbing, sit-to-stand exercise, walking, and family education)	PT	70 min × 3 d × 4 wk (supervised phase) AND 70 min × 3 d × 4 wk (tele-supervised phase)	6MWT BBS DASH ESES HG UE strength
	Con	62.2 ± 9.1	9/11	Chronic (> 6 mo)	Usual community care	PT	Not reported	

Table 1. Continued

Study	Group	Age (mean ± SD, y)	Sex (M/F, n)	Onset	Intervention	Supplier	Duration	Outcome
Mao et al. [17]	Exp	54.8 ± 10.6	15/3	Chronic (≥ 12 mo)	Home-based rehabilitative program (daily walking and simple gait exercises)	PT	120 min × 7 d × 3 wk	BBS FMA-lower Vicon (3D motion)
	Con	52.3 ± 9.2	16/3	Chronic (≥ 12 mo)	Transcutaneous peroneal nerve stimulator while walking	PT	120 min × 7 d × 3 wk	

Exp, experimental group; Con, control group; OT, occupational therapy; PT, physical therapy; ST, speech therapy; 5-MWT, 5-meter walking test; CSI, Caregiver Strain Index; FAST, Frenchay Aphasia Screening Test; HADS, Hospital Anxiety and Depression Scale; NHP, Nottingham Health Profile; MBI, Modified Barthel Index; MMES, Mini-Mental State Examination; RADL, Rivermead Activities of Daily Living; 10-MWT, 10-meter walking test; 6MWT, 6-minute walking test; BBS, Berg Balance Scale; FMA, Fugl-Meyer assessment; IADL, instrumental activities of daily living; SIS, Stroke Impact Scale; PF, physical functioning; SCT, stair climb test; TUG, timed up and go test; RMS, root mean square; EQ-5D, EuroQol-5D; EQ-VAS, EuroQol-Visual Analogue Scale; GDS, Global Deterioration Scale; SPPB, short physical performance battery; PASE, Physical Activity Scale for the Elderly; RMI, Rivermead Mobility Index; BI, Bathel Index; MAS, Modified Ashworth Scale; F8WT, figure-of-8 walk test; SF-36, Short Form Survey-36; PCS, pressure core sampler; MCS, muscle condition score; FIST, function in sitting test; DASH, disabilities of the arm, shoulder, and hand; ESES, exercise self-efficacy scale; HG, handgrip strength; SD, standard deviation; M, male; F, female; PNF, proprioceptive neuromuscular facilitation; FES, falls efficacy scale; PASS, postural assessment scale for stroke; 3D, three-dimensional; UE, upper extremity.

nificantly impacted functional recovery in patients with acute stroke. However, rehabilitation in the chronic phase is often performed to provide personal care, rather than for intensive functional recovery [49]. Against this background, it is thought that the effectiveness of home training is higher in patients with subacute stroke with a relatively short onset.

Finally, in the risk of bias assessment, nine studies were rated as 'somewhat concerned' about the risk of bias or 'high risk of bias.' Despite all the included studies being RCTs, the quality assessment of the literature included indicates a risk of bias in interpreting the results, regardless of the results of the meta-analysis. Therefore, future studies should include higher-quality data. Regarding publication bias, we observed no publication bias in Egger's regression test. However, Egger's test has the disadvantage that the power decreases when the number of included studies is small; therefore, future studies should include a greater number of studies. However, this study contributes valuable insights by confirming the effectiveness of HBR centered on RCT and provides a direction for future research.

The limitations of this study are as follows. First, the number of included studies was insufficient, therefore, future research should include a larger number of studies and conduct thorough analyses. Second, balance was not categorized into dynamic or static balance, and walking was not categorized into gait patterns, gait endurance, or gait speed. Therefore, future studies should be conducted with a more detailed categorization. Third, we did not include results on the persistence of the effect. Therefore, future systematic reviews and meta-analyses should analyze the effects of follow-up. Finally, subgroup analyses should be conducted to further validate the effectiveness of HBR for patients with stroke and address the shortcomings of this study.

CONCLUSIONS

We conducted a systematic review and meta-analysis of the effects of HBR on balance and gait in patients with stroke. Eleven studies were included, and the results showed that HBR was more effective for gait function than for balance, and more effective for patients with acute or subacute stroke than for those with chronic stroke. Although the overall effect size was low, detailed analyses suggest that HBR is effective in improving balance and gait function in patients with stroke. This study is clinically significant for determining the effectiveness of HBR in clinical practice.

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CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article are reported.

AUTHOR CONTRIBUTION

Conceptualization: YH, CY. Data curation: YH. Formal analysis: YH. Investigation: YH. Methodology: YH, CY. Project administration: YH, CY. Resources: YH, CY. Software: YH. Supervision: CY. Validation: YH, CY. Visualization: YH. Writing – original draft: YH. Writing – review & editing: CY.

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