REVIEW

The Effect of Multimodal Therapy on Balance Outcomes of Stroke Survivors: A Systematic Review

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ABSTRACT

Background and objective: Stroke often lead to motor impairments and balance disorders in affected individuals. The improvement of balance control is of utmost importance in stroke treatment, and recent research suggests that combining specialized techniques may offer promising results in enhancing balance outcomes. However, the optimal combination of therapies for achieving the best outcomes remains unclear. Therefore, this study aims to examine the effect of combining two or more therapy approaches on balance control among patients with stroke by conducting a comprehensive systematic review. **Methods:** A systematic search was conducted across six electronic databases (PubMed, Scopus, EBSCOHost, Web of Sciences, OVID Medline, and Wiley) until October 2020 to find pertinent studies. The inclusion criteria involved clinical trials that compared combined specialized approaches with conventional rehabilitation exercise to conventional exercise alone, with reported balance outcomes, conducted in humans, and published in English. The methodological quality of the chosen articles was evaluated using the PEDro scale. **Results:** This study reviewed eleven high-quality studies, published between 2015 and 2019, with PEDro scores ranging from six to eight out of 11. These scores indicated that the included studies can be categorized as high-quality evidences. The findings from the majority of these studies indicated that combining conventional exercise with task-oriented exercise, water-based therapy, mirror therapy, electrical stimulation, or proprioceptive neuromuscular facilitation resulted in significant improvements in postural balance when compared to the control group after the intervention. **Conclusions:** Multimodal therapy techniques have demonstrated favorable outcomes in improving balance performance among patients with stroke, emphasizing the importance of personalized combinations and dosages for effective rehabilitation.

Keywords: Balance; Cerebrovascular accident; Combined therapy; Multimodal; Postural control; Stroke

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INTRODUCTION

The global prevalence of stroke has been on the rise, making it the most morbid condition worldwide and the second leading cause of mortality (Feigin & Brainin, 2022), surpassed only by heart disease (Eyvaz et al., 2018). This debilitating condition manifests in various motor impairments among patients with stroke (Feigin & Brainin, 2022), including muscle weakness, increased muscle tone, as well as decreased sensory function, balance, coordination, and walking ability (Cha & Oh, 2016; D. Lee et al., 2016; Vahlberg et al., 2017). Elderly individuals, in particular, experience severe and long-lasting consequences that result in a loss of mobility independence and the need for long-term care in home or nursing house settings (Feigin & Brainin, 2022). Studies have shown that balance disorders affect up to 83% of patients with acute stroke (Feigin & Brainin, 2022), resulting in impaired mobility and an increased risk of falls, further worsening the disability associated with stroke (Hung et al., 2016; Li et al., 2019). Given these challenges, it is crucial to implement appropriate interventions aimed at enhancing balance control among patients with stroke.

In stroke treatment, improving balance performance is essential for enhancing functional mobility among patients (J. Park & Kim, 2019). Therapeutic exercise, a conventional component of physiotherapy interventions, has been proven effective in achieving this goal (Mazzini et al., 2019; J. Park & Kim, 2019). These exercises encompass postural changes, weight shifting, unassisted standing, and dynamic movements aimed at improving functional balance abilities and reducing the risk of mortality (Cha & Oh, 2016). However, relying solely on conventional rehabilitation exercises may not suffice. To address this limitation, researchers have explored the combination of specialised techniques with conventional exercises to improve balance outcomes in patients with stroke. These techniques include water-based exercise (H. K. Park et al., 2019), the Bobath technique (Raine, 2009), proprioceptive neuromuscular facilitation (PNF) (Seo & Kim, 2015), mirror therapy (D. Lee & Lee, 2019), and others (J. B. Lee et al., 2019; Mazzini et al., 2019).

For example, Shin et al. (2011) demonstrated that the combination of aerobic and functional strengthening exercises significantly improved static and dynamic balance performance compared to single therapy, as evidences by higher scores on the Berg Balance Scale (BBS) (Shin et al., 2011). Nevertheless, determining the most effective combination to achieve optimal outcomes remains uncertain (Li et al., 2019). Two systematic reviews conducted by Paci et al. (2003) and Luke et al. (2004) aimed to examine the effectiveness of the Bobath technique compared to other approaches (Luke et al., 2004; Paci, 2003). These reviews revealed a predominance of studies with poor methodology assessing the effectiveness of the Bobath technique. Moreover, the authors suggested that a singular approach cannot universally address all phases of stroke patient recovery (Luke et al., 2004; Paci, 2003). Thus, further research is required to determine the most effective combination of techniques and exercises for optimizing balance outcomes in patients with stroke.

Previous reviews in the field have not adequately addressed the impact of multimodal therapy, often overlooking conventional balance rehabilitation exercises (Lubetzky-Vilnai & Kartin, 2010), or have solely focused on physical exercise while disregarding technology-based approaches, such as virtual reality and robot-assisted exercises (Li et al., 2019; Luke et al., 2004; Paci, 2003). Consequently, there exists a research gap that necessitates further investigation. In light of this, the present study aims to examine the effect of combining two or more therapies on balance control among patients with stroke by conducting a comprehensive systematic review. By doing so, this study aims to shed light on the available literature evidence and contribute to the understanding of this important topic.

METHODS

Review protocol

This study followed the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The research question was formulated using the Population, Intervention, Comparison, and Outcome (PICO) model: "Is multimodal therapy more effective than conventional rehabilitation exercise in enhancing balance outcomes among patients with stroke, as evaluated by valid assessment tools or clinical measures?"

Data sources and search strategy

The systematic article searching was performed across six electronic databases: PubMed, EBSCOHost, Web of Sciences, Medline (Ovid), and Wiley. The search applied the main keywords such as 'stroke,' 'cerebrovascular accident,' 'balance,' 'combination physical therapy,' and 'postural control.' Boolean operators 'AND' and 'OR' were utilized to combine the keywords and expand the search. The search strategy 'stroke AND balance' was preferred due to its high relevance and number of hits. Additionally, cross-referencing was conducted based on the retrieved articles. However, no attempts were made to contact the authors for further information in this study. Two authors (E.M. and E.Y.) performed the database searches using standardized search strategies.

Study selection criteria

This review employed the following inclusion criteria: (1) randomized controlled trials (RCTs); (2) adult population diagnosed with haemorraghic or infarction stroke aged 18 years and above; (3) interventions involving a combination of two or more therapeutic approaches aimed at improving balance performances, such as exercise therapy, electrotherapy, virtual reality, and robot-assisted therapy; (4) the control group received conventional rehabilitation exercise; and (5) assessment of outcomes with at least one measure related to balance or postural control. Additionally, the search was limited to articles published in English or Bahasa Indonesia from 2010 up to and including 24 October 2020. Review articles, single case studies, letters to editor, and animal trials were excluded from the analysis to maintain focus and relevance.

After removing duplicates, three authors (E.M., E.Y., and D.A.P.) screened the list of identified articles based on their titles and abstracts. Subsequently, the authors then examined the full-text articles according to the inclusion and exclusion criteria, to obtain a final list of eligible articles.

Quality assessment

The methodological quality of each article was assessed independently by three authors using the Physiotherapy Evidence Database scale (PEDro scale), and any discrepancies were resolved through consensus. The PEDro scale is a widely used assessment tool for comparing and evaluating RCTs. It comprises 11 scoring components that assess various aspects of study design and methodology (de Morton, 2009; Maher et al., 2003). The scores obtained from the PEDro scale can be classified into three categories, which are: (1) high quality for a total score of more than 6; (2) lower quality for a total score of 5; and (3) acceptable quality for a total score of 4 (de Morton, 2009; Maher et al., 2003).

Data Extraction

A structured data extraction sheet was generated to systematically capture all pertinent data and information from included studies. The extracted data encompassed the following components: (1) study details; (2) patients characteristics, including, sample size, age, gender, and stroke type; (3) a detailed description of the intervention and its dosage; (4) control group activities; (5) outcome measures employed and the specific instruments used for their assessment; and (6) the primary findings and results reported in the studies. To ensure accuracy and reliability, three authors (E.M., E.Y., and D.A.P.) independently performed the data extraction process and any discrepancies were resolved through consultation with the fourth author (M.A.A.).

RESULTS

Study outcomes

In total, 832 studies were initially retrieved from the six databases through systematic searches. After eliminating duplicate records, 532 studies underwent screening process based on their titles and abstracts, in accordance to the predetermined selection criteria. Subsequently, 477 studies were excluded due to lack of relevance (review articles, single case studies, or letters to editor), absence of investigation on the impact of multimodal therapy in patients with stroke, and failure to examine balance outcomes. Following a thorough assessment of the full-text articles, 11 studies were deemed eligible for inclusion in this review. The comprehensive process of study selection is visually represented in Figure 1 of the PRISMA flow chart, providing a clear depiction of the articles screening and selection process.

Characteristics of included studies

This review included a total of 11 RCTs that were published between the years of 2015 and 2019. Out of these, eight studies were conducted in South Korea, while one study was conducted in the USA (Hung et al., 2016), Turkey (Eyvaz et al., 2018), Sweden (Vahlberg et al., 2017), respectively. A total of 434 patients with stroke were included across the studies, with the sample size ranged from 20 to 72 patients per study. The average age of the samples in the included studies ranged from 47 to 72 years old. Among the patients, approximately 40-60% patients were female with 10 out of the 11 studies including patients with both

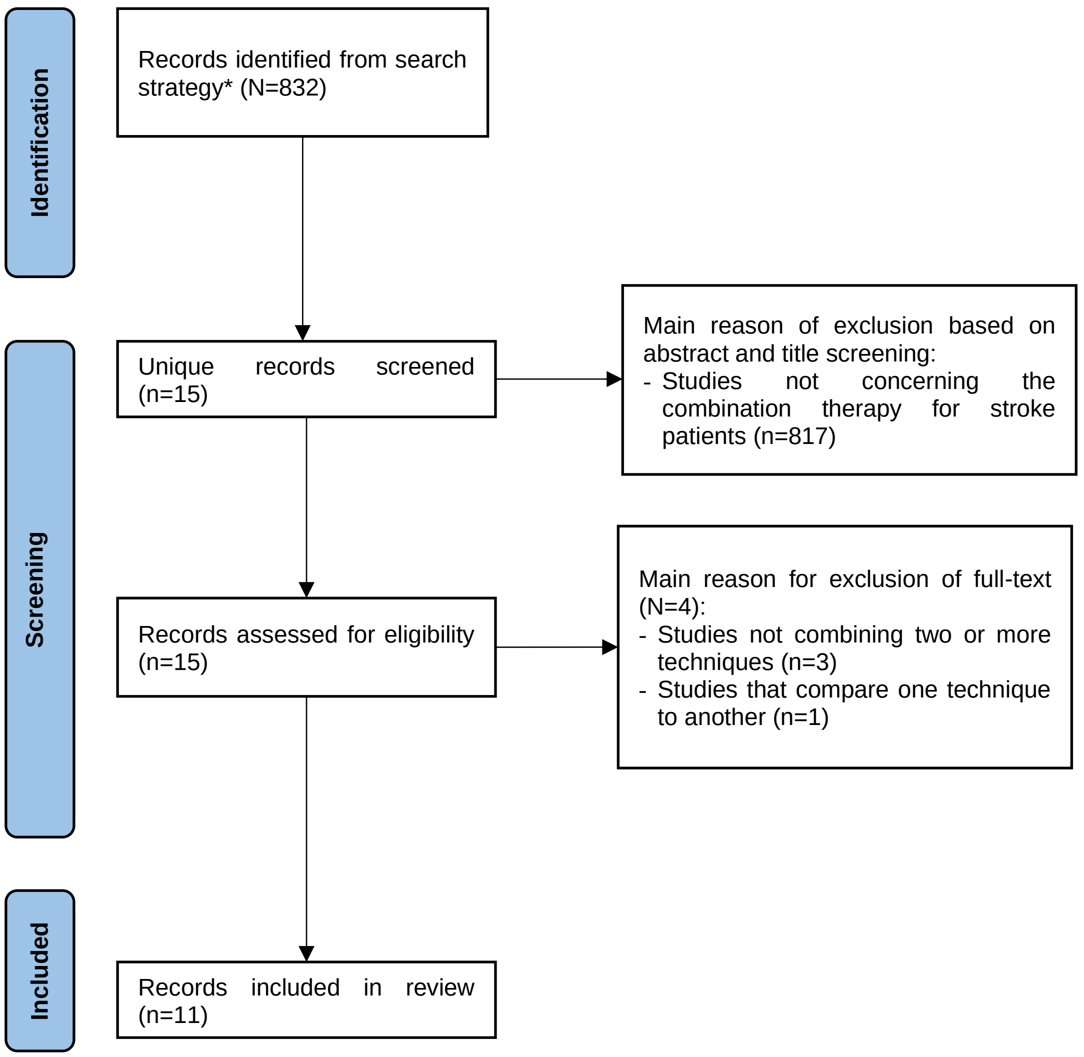

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Figure 1: PRISMA flowchart on study selection process

Table 1: Extracted data on studies' characteristics and results

Author(s)	Patients' Characteristics: n (Exp[a]/ Con[b]) initial → final	Age (Mean ± SD[c])	Gender (%female)	Stroke type (ischemic /hemorrhage)	Treatments and Dosage (Exp)	Control Activity (Con)	Outcome Measures → Instruments	Balance results
Cha & Oh (2016)	13/12 → 10/10	Exp: 60 ± 3.19; Con: 58.60 ± 4.08	Exp: 60%; Con: 50%	Exp: 3/7; Con: 2/8	Task-oriented exercise and mirror therapy with the mirror (5 x 3) placed in the room to provide visual feedback during training → 30 min, 2x/day, 5x/week for 4 weeks	Task-oriented exercise → 30 min, 2x/day, 5x/week for 4 weeks	**Primary Outcome Measures (OM):** Balance → BBS[1], TUG[2], balance measurement system (balance index/BI, dynamic limits of stability/DLOS) **Secondary OM:** -	Change values → **BBS:** Exp = 13.00 ± 3.20; Con = 6.60 ± 4.55 (t = 3.64, p<0.01); **TUG:** Exp = 6.45 ± 3.00; Con = 3.61 ± 1.84 (t = -2.55, p<0.05); **BI:** Exp = 2.29 ± 0.51; Con = 0.96 ± 0.65 (t = -5.11, p<0.01); **DOLS:** Exp = 7.70 ± 3.83; Con = 3,70 ± 4,60 (t = 2.11, p = 0.05) Exp showed higher increase in change values of each OM than in Con.
Eyvaz et al (2018)	33/32 → 30/30	Exp: 58.5 ± 6.27; Con: 58.3 ± 5.43	Exp: 30%; Con: 56.67%	Exp: 27/3; Con: 23/7	LBE (Land-based exercise): ROM[3] exercise, strengthening exercise, trunk mobility exercise, balance exercise, walking training → 60 min/day, 2x/week for 6 weeks; WBE (Water-based exercise): in a swimming pool at 33°C and comprises of strengthening exercise dan balance coordination exercise → 60 min/day, 3x/week for 6 weeks	LBE: ROM exercise, strengthening exercise, trunk mobility exercise, balance exercise, walking training → 60 min/day, 5x/week for 6 weeks	**Primary OM:** Balance and fall risk → BBS, BI (static & dynamic), TUG **Secondary OM:** Self-care, sphincter control, mobility, locomotion, communication, social cognition; QoL[4]; maximal peak torque measurement of isokinetic quadriceps and hamstring → FIM[5], SF-36[6], isokinetic dynamometer (at two different speeds 90°/s and 120°/s)	Baseline → **BBS:** Exp = 39.6 ± 7.1; Con = 30.3 ± 10.9 (p = 0.001); **SBI:** Exp = 1331.7 ± 276.1; Con = 1446.9 ± 644.0 (p = 0.192); **DBI:** Exp = 2310.3 ± 716.1; Con = 2492.2 ± 437.6 (p = 0.305); **TUG:** Exp = 18.5 ± 6.3; Con = 26.5 ± 10.5 (p < 0,001) Post-treatment → **BBS:** Exp = 45.1 ± 6.7; Con = 36.7 ± 10.2 (p < 0.001); **SBI:** Exp = 1011.0 ± 272.4; Con = 1083.0 ± 296.8 (p = 0.001); **DBI:** Exp **=** 1760.5 ± 499.6; Con = 2009.0 ± 593.8 (p < 0.001); **TUG:** Exp = 14.7 ± 3.8; Con = 20.0 ± 8.6 (p < 0.001) Con presented higher increase in BBS score compared to Exp (change values: Exp = 5.5 vs Con = 6.4). However, DBI in Exp has higher improvement than in Con (change values: Exp = -549.8 vs Con =-483.2).
Vahlberg et al (2018)	34/33 → 24/29 (after 15 months)	Exp: 72.6 ± 5.5; Con: 73.7 ± 5.3	Exp: 20.6%; Con: 27.3%	Exp: 28/6; Con: 27/6	PRB (Progressive Resistance and Balance Training): 10 min warm-up using stationary cycling or walking; 45 min circuit class PRB; 20 min motivational session that discuss issues and personal goals related to their physical activities → 2x/week for 3 months	Encouraged to continue their regular activities and not restricted from participating in ordinary physical activities and rehabilitation programs	**Primary OM:** Balance and mobility → BBS, SPPB[7] **Secondary OM:** Walking capacity, weekly physical activities, motor function, QoL, depression symptoms, and fall-related self-efficacy → SMWT[8], TMWT[9], PASE[10], MMAS[11], EQ-5D[12], GDS-20[13], FES(S)[14]	Baseline in median (IQR) → **BBS:** Exp = 49 (6); Con = 51 (7); **SPPB**: Exp = 9 (4); Con = 9 (3) Median difference in change (MD[15]): *3 mo* → **BBS** = -2.5 (p = 0.001); **SPPB** = -1 (p = 0.09) *6 mo* → **BBS** = -1 (p = 0.24); **SPBB** = 0 (p = 0.68) *15 mo* → **BBS** = -2 (p = 0.06); **SPBB** = 0 (p = 0.3) Exp in 3rd month showed significantly higher increases in balance than Con.
Lee & Lee (2019)	15/15 → 15/15	Exp: 50.80 ± 9.00;	Exp: 26.66%;	Exp: 5/10; Con: 5/10	AES[18] combined with mirror therapy/MT (mirror with size	Sham AES and sham MT (with no reflection on the	**Primary OM:** Motor function →	Change values → **BBS:** Exp = 2.13 ± 3.48; Con = 1.67 ± 4.01 (p = 0.01)

		Con: 50.13 ± 6.53	Con: 33.33%		of 50 x 70 cm and designed to reflect the healthy side) for 30 min, followed by AES and gait training for 30 min → 60 min/session, 5x/week for 4 weeks	mirror) for 30 min, followed by sham AES combined with gait training for 30 min → 60 min/session, 5x/week for 4 weeks	Dynamometer, MAS[19] **Secondary OM:** Balance and spatiotemporal gait variables → BBS, GAITRite walkway	Change values of BBS scores in Exp was found significantly higher than in Con.
Jung et al (2017)	20/21 → 20/20	Exp: 56.2 ± 10.4; Con: 56.3 ± 10.2	Exp: 45%; Con: 40%	Exp: 12/8; Con: 11/9	Sit-to-stand training using: TENS (pulse width = 200µs; frequency = 100 Hz) → 15 min/day, 5x/week for 6 weeks Conventional therapy → 60 min/day, 5x/week for 6 weeks	Sit-to-stand training using: Non electrically stimulated TENS → 15 min/day, 5x/week for 6 weeks Conventional therapy → 60 min/day, 5x/week for 6 weeks	***Primary OM:*** Balance; isometric strength in the extensor of hip, knee, and ankle; spacticy of ankle plantar flexor → Postural sway WBB[20], Handheld Dynamometer, CSS[21] ***Secondary OM:*** -	Changes value → **Postural sway distance (cm) eyes open:** Exp = -21.0; Con = -8.8 (p = 0.013); **Postural sway distance (cm) eyes closed:** Exp = -26.4; Con = -13.1 (p = 0.017) Exp has significantly more decreases in postural sway when patients stood with their eyes open and closed than Con.
Park et al (2018)	15/15 → 14/15	Exp: 56.23 ± 13.74; Con: 57.13 ± 11.73	Exp: 40%; Con: 25%	Exp: 7/7; Con: 8/7	NDT[30]/bobath and Land-based and Aquatic Exercise (LATE) → 30 min/day, 5x/week for 4 weeks	NDT/bobath→ Dosis latihan: 30 min/day, 5x/week for 4 weeks	**Primary OM:** Trunk control, balance, ADL abilities → K-TIS[22], PASS-3L[23], BBS-3L[24], FRT[25], MBI[26] **Secondary OM:** -	Baseline → **BBS:** Exp = 16.71 ± 3.97; Con = 19.87 ± 4.41 (p = 0.054); **FRT (cm):** Exp = 23.42 ± 8.28; Con = 28.58 ± 5.23 (p = 0.053) Post-treatment → **BBS:** Exp **=** 21.5 ± 3.94; Con = 22.73 ± 3.6 (p = 0.035); **FRT (cm):** Exp = 29.11 ± 7.8; Con = 31.29 ± 5.62 (p = 0.045) Exp showed significantly higher increases in BBS score compared to Con (change values: Exp = 4.79 (p = 0.001) vs Con = 2.86 (p = 0.001)).
Lee et al (2016)	15/15 → 14/13	Exp: 56.2 ± 10.4; Con: 56.3 ± 10.2	Exp: 50%; Con: 46%	Exp: 12/8; Con: 11/9	MT (mirror size: 50 x 70 cm) combined with NMES[31] (frequency: 35 Hz, pulse duration: 250 µs, intensity: set such that the ankle joint could be completely dorsiflexed) → 1x/day, 5x/week for 4 weeks	Conventional therapy comprises of NDT, balance and gait training, and task-specific functional training → 60 menit	***Primary OM:*** Muscle strength, muscle tone → *Hand-held dynamometer,* MAS ***Secondary OM:*** Balance and gait velocity → BBS, TUG, dan SMWT	Percentage of change → **BBS:** Exp **=** 14.89%; Con = -4.30% (p = 0.048); **TUG:** Exp = -11.59%; Con = 1.34% (p = 0.669) There were significant increases of BBS scores in Exp.
Lee et al (2019)	35/39 → 30/30	Exp: 67.2; Con: 68.5	Exp: 43.3%; Con: 46.7%	Exp: 17/13; Con: 18/12	FES[32] and standing frame was performed simultaneously → 20 min/session, 2x/day, 5 days/week for 3 weeks Conventional therapy for standing balance training → 30 min/session, 2x/day, 5 days/week for 3 weeks	FES and standing frame training were given separately → 20 min/session, 2x/day, 5 days/week for 3 weeks Conventional therapy for standing balance training → 30 min/session, 2x/day, 5 days/week for 3 weeks	***Primary OM:*** Standing stability, physical and cognitive abilities →Posturography using Balance master system, BBS, K-MBI[27], K-MMSE[28], MMT[29] ***Secondary OM:*** -	Changes value → **BBS:** Exp = 12.17 ± 4.35; Con = 7.10 ± 3.26 (p = 0.043); **Overall stability index:** Exp = -4.55 ± 3.20; Con = -2.35 ± 2.25 (p = 0.045) Exp had significantly better improvement in BBS score and overall stability index when compared to Con.
Jung et al (2015)	15/10	Exp: 47.9 ± 10.6; Con: 53.2 ± 12.3	Exp: 33.3%; Con: 50%	Exp: 8/7; Con: 5/5	Multifactorial exercise program: education regarding fall prevention, NDT, muscle strengthening exercise, balance training, and flexibility exercise → 30 min/day, 5x/week for 5 weeks	Treadmill exercise program included NDT and treadmill exercise with a 0.4 km/h increase in speed per week → 2x/day, 5x/week for 5 weeks	***Primary OM:*** Gait speed, endurance, and balance → FES-K[34], POMA-K[36], SMWT, TMWT, ABC-K[35] ***Secondary OM:*** -	Baseline → **FES-K:** Exp = 59.00 ± 21.03 (p > 0.05); Con = 57.30 ± 19.32 (p > 0.05); **ABC-K:** Exp = 47.35 ± 18.14 (p > 0.05); Con = 39.45 ± 19.78 (p > 0.05) Posttest → **FES-K:** Exp = 72.93 ± 15.61 (p < 0.01); Con = 55.50 ± 25.67 (p < 0.01); **ABC-K:** Exp = 62.40 ± 17.28 (p < 0.01); Con =

								40.70 ± 25.50 (p < 0.01) FES-K and ABC-K scores were significantly improved in Exp (change values: **FES-K:** Exp = 13.93 vs Con = -1.8 (p < 0.05); **ABC-K:** Exp = 15.05 vs Con = 1.25 (p < 0.05)).
Hung et al (2016)	14/13 → 12/11	Exp: 52.75; Con: 55.20	Exp: 33.3%; Con: 27.3%	Exp: 9/3; Con: 8/3	Conventional rehabilitation therapy → 50 min of physiotherapy and 50 min occupational therapy per day, 3x/week for 6 weeks Tetrax biofeedback balance training → 20 min/day, 3x/week for 6 weeks	Conventional rehabilitation therapy → 50 min of physiotherapy and 50 min occupational therapy per day, 3x/week for 6 weeks	***Primary OM:*** Feasibility including adherence, safety, and satisfaction → session attendance, adverse events record, satisfaction questionnaire ***Secondary OM:*** Body function and balance → physiologic profile assessments, posturography, TUG, FRT	Percentage of Change → **TUG:** Exp = -0.12; Con = 0.00 (p < 0.001); **FRT:** Exp = 0.08; Con = 0.00 (p = 0.01) Compared to Con, Exp presented a significantly greater improvement in TUG and FRT.
Seo & Kim (2015)	10/10	Exp: 62.1 ± 6.2; Con: 60.5 ± 2.1	Exp: 40%; Con: 50%	Exp: 0/10; Con: 0/10	Basic exercises including muscle strengthening exercise, ROM exercise, and stretching exercise, followed by: PNF gait pattern training on a specifically devised ramp (inclination: 10°; length: 10 m; width: 0.8 m) → 30 min/day, 3x/week for 4 weeks	Basic exercises including muscle strengthening exercise, ROM exercise, and stretching exercise, followed by: PNF gait pattern training → 30 min 3x/week for 4 weeks	***Primary OM:*** Dynamic balance and gait ability → BBS, TUG, FRT ***Secondary OM:*** -	Pretest → **BBS:** Exp = 23.1 ± 3.1; Con = 22.8 ± 2.1; **TUG:** Exp = 51.2 ± 7.3; Con = 53.4 ± 6.2; **FRT:** Exp = 5.3 ± 2.1; Con = 6.1 ± 1.3 Posttest → **BBS:** Exp = 23.3 ± 2.3 (p < 0.05); Con = 28.1 ± 2.9; **TUG:** Exp = 50.9 ± 7.1 (p < 0.05); Con = 48.6 ± 4.6; **FRT:** Exp = 5.4 ± 1.1 (p < 0.05); Con = 7.1 ± 2.7 Exp has significantly greater improvements in BBS, TUG, and FRT scores.

[a]Exp = treatment groups; [b]Con = control groups; [c]SD = standard deviation; [1]BBS = Berg's balance scale; [2]TUG = timed-up and go test; [3]ROM = range of motion; [4]QoL = quality of life; [5]FIM = functional independence measures; [6]SF-36 = short-form health survey; [7]SPBB = short physical performance battery; [8]SMWT = six minutes walking test;[9]TMWT= ten minutes walking test; [10]PASE = physical activity scale for elderly;[11]MMAS = modified motor assessment scale; [12]EQ-5D = EuroQol 5-dimension; [13]GDS-20 = geriatric depression scale; [14]FES(S) = falls self-efficacy scale; [15]MD = median difference in change; [16]ES = effect size; [17]SE = standard error; [18]AES = Afferent Electrical Stimulation; [19]MAS = modified ashworth scale; [20]WBB = Wii balance board; [21]CSS = composite spasticity board;[22]K-TIS = Korean version of trunk impairment scale; [23]PASS-3L =3-level postural assessment scale for stroke; [24]BBS-3L = 3-level Berg's balance scale; [25]FRT = functional reach test; [26]MBI = modified barthel index; [27]K-MBI = Korean version of modified barthel index; [28]K-MMSE = Korean version of mini mental state examination; [29]MMT = manual muscle testing; [30]NDT = neurodevelopmental technique; [31]NMES = neuromuscular electrical stimulation; [32]FES = functional electrical stimulation; [33]PNF = proprioceptive neuromuscular facilitation; [34]FES-K = Korean version of falls self-efficacy scale; [35]ABC-K = Korean version of activities-specific balance confidence scale; [36]POMA-K = Korean version of performance-oriented motor assessment.

ischemic and haemorrhagic stroke. Further details on the characteristics of each article's extracted data are summarised in Table 1.

Methodological quality

The assessment of methodological quality using the PEDro scale revealed variations among the reviewed articles, with the PEDro total scores ranged from six to eight points, indicating a high level of quality. Four studies (Cha & Oh, 2016; K. S. Jung et al., 2017; D. Lee et al., 2016; H. K. Park et al., 2019) achieved scores of 8 out of 11, indicating robust methodological rigor. The majority of the studies applied a single-blinded design, while only one study (K. S. Jung et al., 2017) utilized a double-blinded design. The evaluation highlighted that the most commonly unmet criteria were PEDro scale item no. 5 (subjects blinding) and No. 6 (blinding of therapist), indicating a lack blinding in these specific components. The PEDro scores for each study can be found in Table 2.

Intervention

The included 11 studies used combination various of therapy techniques for their patients. Two studies combined land-based and water-based therapy (Eyvaz et al., 2018). Five other studies combined mirror therapy or physical activities with electrotherapy, such as, Afferent Electrical Stimulation (AES) (D. Lee & Lee, 2019), Neuromuscular Electrical Stimulation (NMES) (D. Lee et al., 2016), Transcutaneous Electrical Nerve Stimulation (TENS) (K. S. Jung et al., 2017), Functional Electrical Stimulation (FES) (J. B. Lee et al., 2019), and tetrax feedback (Hung et al., 2016).

Vahlberg et al. (2016) combined Progressive Resistance and Balance Training (PRB) with a motivational discussion session regarding the patients' physical activities. The stroke patients in Cha and Oh (2016) received a combination of task-oriented exercise and mirror therapy. Jung et al. (2015) compared two programs with different combination. One program consists of bobath that followed by strengthening exercise, balance exercise, flexibility exercises, and patient education. Whilst the other one comprises treadmill and bobath exercises. Meanwhile, Seo & Kim (2015) used the combination of basic exercises with ramp gait and Proprioceptive Neuromuscular Facilitation (PNF) (Seo & Kim, 2015).

Dosage

Four of eleven studies applied 60 minutes/session (total 3-5 sessions/week) which consists of 10 minutes warming up, 10 minutes main exercises, and 10 minutes cooling down to their treatment groups (Eyvaz et al., 2018; K. S. Jung et al., 2017; D. Lee & Lee, 2019; Seo & Kim, 2015). Patients in the other three studies underwent exercises for 30 minutes/session with a total of five sessions per week (Cha & Oh, 2016; Y. Jung et al., 2015; H. K. Park et al., 2019).

Vahlberg et al. (2017) applied 45 minutes circuit class PRB and 20 minutes motivational discussion session to their patients twice a week (Vahlberg et al., 2017). Patients in the study by Lee et al. (2016) received NMES and mirror therapy once a day with total five session per week. The parameters they used for NMES were: (1) frequency: 35 Hz; (2) pulse duration = 250 μs; (3) intensity = increased until the patients had a visible full-ROM ankle dorsiflexion (D. Lee et al., 2016). J.B. Lee et al. (2019) who combined FES, standing frame, and conventional therapy gave their program twice a day (5 sessions/week) with the following details: (1) FES + standing frame: intensity = 20-30 mA, frequency = 30-40 Hz, 20 minutes/session; (2) conventional therapy: 30

Table 2: Methodological quality assessment using PEDro Scale

Article	Level of Evidence[c]	PEDro[a] Scale Item[b]											Total Scores
		1	2	3	4	5	6	7	8	9	10	11	
Cha & Oh/2016/South Korea	IIb	Y	1	1	1	0	0	1	1	1	1	1	8/10
Eyvaz et al/2018/Turkey	IIb	Y	1	0	1	0	0	0	1	1	1	1	6/10
Vahlberg et al/2016/Sweden	IIb	Y	1	1	0	0	0	1	1	1	1	1	7/10
Lee & Lee/2019/South Korea	IIb	Y	1	0	0	0	0	1	1	1	1	1	6/10
Jung et al/2017/South Korea	IIb	Y	1	0	0	1	1	1	1	1	1	1	8/10
Park et al/2018/South Korea	IIb	Y	1	1	1	1	0	0	1	1	1	1	8/10
Lee et al/2016/South Korea	IIb	Y	1	1	1	0	0	1	1	1	1	1	8/10
Lee et al/2019/South Korea	IIb	Y	1	1	1	0	0	0	1	1	1	1	7/10
Jung et al/2015/South Korea	IIb	Y	1	1	0	0	0	0	1	1	1	1	6/10
Hung et al/2016/USA	IIb	Y	1	1	0	0	0	0	1	1	1	1	6/10
Seo & Kim/2015/South Korea	IIb	Y	1	1	0	0	0	0	1	1	1	1	6/10

[a]PEDro = Physiotherapy Evidence Database; [b]1 = eligibility criteria specified (does not included in the total score calculation; 2 = random allocation; 3 = concealed allocation; 4 = groups similar at baseline; 5 = subject blinding; 6 = therapist blinding; 7 = assessor blinding; 8 = less than 15% dropouts; 9 = intention-to-treat analysis; 10 = between-group statistical comparisons; 11 = point measures and variability data; Y = yes; 1 = yes; 0 = no; [c]according to Oxford Centre for Evidence-Based Medicine

minutes/session (J. B. Lee et al., 2019). Jen-Wen et al. (2016) give tetrax biofeedback balance training for 20 minutes/session (3 sessions/week) as supplementary therapy following 50 minutes physiotherapy session and 50 minutes occupational therapy session.

Follow-up period

One study by Vahlberg et al (2017) has the longest follow-up period, which was 15 months (Vahlberg et al., 2017). Meanwhile, the other ten studies followed up their patients' condition after 3-6 weeks.

Balance performance results

Majority of the studies measured the patients' balance using BBS and showed quite similar results. The patients who received a combination of two or more therapies showed higher increases in BBS scores, postural sway distance, Timed Up and Go test (TUG), and Functional Reach Test (FRT). These scores indicated that there were greater improvements in balance outcomes of patients after given the multimodal therapy. The treatment groups demonstrated better improvements in their BBS and other instruments results, when compared to the control groups.

DISCUSSION

This comprehensive systematic review aimed to examine the effects of combining multiple therapies on balance control in stroke patients. Eleven high-quality studies, published between 2015 and 2019, were included in the review. The studies investigated various therapy approaches, including, land-based and water-based therapy, mirror therapy, electrotherapy, and others, as adjunctive treatments to conventional rehabilitation exercise. The majority of the studies indicated that combining conventional exercise with task-oriented exercise, mirror therapy, electrical stimulation, and PNF led to significant improvements in postural balance scores compared to the control group before and after the intervention. These findings highlight the importance of personalized combinations and dosage in achieving effective rehabilitation outcomes for patients with stroke, emphasizing the clinical significance of multimodal therapy approaches in improving balance performance.

The PEDro scores of the eligible articles reviewed in this study were ranging from six to eight points. These scores indicated that all eleven articles were categorized as high-quality evidence. Eight of eleven articles that evaluated balance using BBS, showed higher score changes in treatment group, which indicated that multimodal therapy was more effective in improving balance performances of stroke patients when compared to conventional or single therapy. Beside improving balance, the correct combination of therapy approaches could give various positive results for stroke patients, such as increased aerobic capacity and increased muscle strength that subsequently lead to improved abilities to walk and perform other daily activities. Numerous therapy techniques can be combined, they were: (1) exercise therapy, including bobath, PNF, muscle strengthening, gait exercise, and flexibility exercise; (2) electrotherapy, including NMES, TENS, FES, and AES; (3) other techniques, including pool therapy, mirror therapy, and biofeedback.

A study by Cha and Oh (2016) evaluated balance in stroke patients that divided into treatment and control groups. Treatment groups received the combination of task-oriented exercise and mirror therapy for four weeks. The results showed significantly higher changes in BBS scores when compared to the control groups that only received task-oriented exercise (Cha & Oh, 2016). This result was in line with another study by D. Lee and Lee (2019) that combined AFE and mirror therapy for four weeks. They found that groups with this combination had significantly higher balance score changes compared to the control group that only received AFE (D. Lee & Lee, 2019). Similar results were found in the study by Seo & Kim (2015) whose treatment group received the combination of conventional therapy, ramp gait exercise, and PNF. Their treatment group also showed higher balance score changes than the control group that received conventional therapy only. These studies proved that multimodal therapy was more effective in improving balance of stroke patients.

The studies in this review also suggested that in order to get an optimal effectiveness of the multimodal therapy, clinicians must do a comprehensive evaluation to choose the most suitable techniques to combine and its dosage for each patient.

Despite the significant findings of our study, it is important to acknowledge several limitations that could impact the interpretation of the results. Firstly, our search was restricted to articles published within the last 20 years (from 2010 onwards), potentially excluding relevant publications published before that time. Secondly, there was considerable heterogeneity among the included studies, especially regarding the variations or interventions examined, which precluded conducted meta-analysis. Additionally, the overrepresentation of studies from South Korea and limited representation from other countries may introduce geographic and cultural biases. Consequently, caution should be exercised when interpreting the findings of this study.

CONCLUSION

In conclusion, this systematic review reveals that multimodal therapy techniques have demonstrated effectiveness in enhancing balance performance among patients with stroke. The integration of conventional therapy with diverse approaches, such as, exercise therapy, electrotherapy, and other modalities, has shown superior outcomes compared to singular or conventional therapy alone. Particularly, the individual studies included in this review indicated that the combination of task-oriented exercise with mirror therapy, AES with mirror therapy, and conventional therapy with ramp gait exercise and PNF led to significant improvements in balance outcomes. These findings underscore the significance of identifying the most appropriate combination and dosage of therapy techniques tailored to individual stroke survivor.

CONFLICT OF INTEREST

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REFERENCES

1. Cha, H. G., & Oh, D. W. (2016). Effects of mirror therapy integrated with task-Oriented exercise on the balance function of patients with poststroke hemiparesis: A randomized-Controlled pilot trial. *International Journal of Rehabilitation Research*, *39*(1), 70–76. https://doi.org/10.1097/MRR.0000000000000148
2. de Morton, N. A. (2009). The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. *Aust J Physiother*, *55*(2), 129–133. https://doi.org/10.1016/s0004-9514(09)70043-1
3. Eyvaz, N., Dundar, U., & Yesil, H. (2018). Effects of water-based and land-based exercises on walking and balance functions of patients with hemiplegia. *NeuroRehabilitation*, *43*(2), 237–245. https://doi.org/10.3233/NRE-182422
4. Feigin, V. L., & Brainin, M. (2022). *World Stroke Organization (WSO): Global Stroke Fact Sheet 2022*. *17*(1), 18–29. https://doi.org/10.1177/17474930211065917
5. Hung, J. W., Yu, M. Y., Chang, K. C., Lee, H. C., Hsieh, Y. W., & Chen, P. C. (2016). Feasibility of Using Tetrax Biofeedback Video Games for Balance Training in Patients With Chronic Hemiplegic Stroke. *PM and R*, *8*(10), 962–970. https://doi.org/10.1016/j.pmrj.2016.02.009
6. Jung, K. S., In, T. S., & Cho, H. young. (2017). Effects of sit-to-stand training combined with transcutaneous electrical stimulation on spasticity, muscle strength and balance ability in patients with stroke: A randomized controlled study. *Gait and Posture*, *54*, 183–187. https://doi.org/10.1016/j.gaitpost.2017.03.007
7. Jung, Y., Lee, kYeongbong, Shin, S., & Lee, W. (2015). *Effects of a multifactorial fall prevention program on balance, gait, and fear of falling in post-stroke inpatients*.
8. Lee, D., & Lee, G. (2019). Effect of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors: A randomized controlled trial. *European Journal of Physical and Rehabilitation Medicine*, *55*(4), 442–449. https://doi.org/10.23736/S1973-9087.19.05334-6
9. Lee, D., Lee, G., & Jeong, J. (2016). Mirror therapy with neuromuscular electrical stimulation for improving motor function of stroke survivors: A pilot randomized clinical study. *Technology and Health Care*, *24*(4), 503–511. https://doi.org/10.3233/THC-161144
10. Lee, J. B., Kim, S. B., Lee, K. W., Lee, J. H., Park, J. G., & Lee, S. J. (2019). Combined therapy with functional electrical stimulation and standing frame in stroke patients. *Annals of Rehabilitation Medicine*, *43*(1), 96–105. https://doi.org/10.5535/arm.2019.43.1.96
11. Li, J., Zhong, D., Ye, J., He, M., Liu, X., Zheng, H., Jin, R., & Zhang, S. L. (2019). Rehabilitation for balance impairment in patients after stroke: a protocol of a systematic review and network meta-analysis. *BMJ Open*, *9*(7), e026844. https://doi.org/10.1136/bmjopen-2018-026844
12. Lubetzky-Vilnai, A., & Kartin, D. (2010). The effect of balance training on balance performance in individuals poststroke: a systematic review. *J Neurol Phys Ther*, *34*(3), 127–137. https://doi.org/10.1097/NPT.0b013e3181ef764d
13. Luke, C., Dodd, K. J., & Brock, K. (2004). Outcomes of the Bobath concept on upper limb recovery following stroke. *Clinical Rehabilitation*, *18*(8), 888–898. https://doi.org/10.1191/0269215504cr793oa
14. Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro Scale for Rating Quality of Randomized Controlled Trials. *Physical Therapy*, *83*(8), 713–721. https://doi.org/10.1093/ptj/83.8.713
15. Mazzini, N. A., Almeida, M. G. R., Pompeu, J. E., Polese, J. C., & Torriani-Pasin, C. (2019). A combination of multimodal physical exercises in real and virtual environments for individuals after chronic stroke: study protocol for a randomized controlled trial. *Trials*, *20*(1), 436. https://doi.org/10.1186/s13063-019-3396-2
16. Paci, M. (2003). Physiotherapy based on the Bobath concept for adults with post-stroke hemiplegia: a review of effectiveness studies. *J Rehabil Med*, *35*(1), 2–7. https://doi.org/10.1080/16501970306106
17. Park, H. K., Lee, H. J., Lee, S. J., & Lee, W. H. (2019). Land-based and aquatic trunk exercise program improve trunk control, balance and activities of daily living ability in stroke: A randomized CLINICAL trial. *European Journal of Physical and Rehabilitation Medicine*, *55*(6), 687–694. https://doi.org/10.23736/S1973-9087.18.05369-8
18. Park, J., & Kim, T. H. (2019). The effects of balance and gait function on quality of life of stroke patients. *NeuroRehabilitation*, *44*(1), 37–41. https://doi.org/10.3233/nre-182467
19. Raine, S. (2009). The bobath concept: Developments and current theoritical underpinning. In S. Raine, L. Meadows, & M. Lynch-Ellerington (Eds.), *Bobath concept: Theory and clinical practice in neurological rehabilitation* (pp. 3–10). Blackwell Publishing Ltd.
20. Seo, K. C., & Kim, A. (2015). *The effects of ramp gait exercise with PNF on stroke patients' dynamic balance*.
21. Shin, W. S., Lee, S. W., Lee, Y. W., Choi, S. B., & Song, C. H. (2011). Effects of Combined Exercise Training on Balance of Hemiplegic Stroke Patients. *Journal of Physical Therapy Science*, *23*(4), 639–643. https://doi.org/10.1589/jpts.23.639
22. Vahlberg, B., Cederholm, T., Lindmark, B., Zetterberg, L., & Hellström, K. (2017). Short-term and long-term effects of a progressive resistance and balance exercise program in individuals with chronic stroke: a randomized controlled trial. *Disability and Rehabilitation*, *39*(16), 1615–1622. https://doi.org/10.1080/09638288.2016.1206631