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Comparing the Effectiveness of Physical Rehabilitation Interventions for Post-Stroke Function and Mobility Recovery: A Meta-Analysis

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HIGHLIGHTS

- Stroke rehabilitation aims to restore physical function with various interventions.
- A systematic review found no superiority or inferiority among these interventions.

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Comparing the Effectiveness of Physical Rehabilitation Interventions for Post-Stroke Function and Mobility Recovery: A Meta-Analysis

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ABSTRACT

Various interventions to physical rehabilitation have been used after stroke, including musculoskeletal, neurophysiological, and motor learning interventions, with ongoing debates and controversies about their relative effectiveness. In this systematic review, we searched 3 international electronic databases (MEDLINE, Embase, and Cochrane Library) to identify relevant studies. We included only randomized controlled trials (RCTs) that directly compared motor relearning, neurophysiological, and musculoskeletal interventions for improving motor function in adult stroke patients. Risk of bias (RoB) assessment was performed using Cochrane's RoB tool, and meta-analysis was conducted using Revman 5.4 with a random effects model. Certainty of evidence was assessed using the Grading of Recommendations, Assessment, Development, and Evaluations method. The meta-analysis for immediate outcome for physical rehabilitation included 9 RCTs for balance, 10 RCTs for gait velocity, 7 RCTs for lower extremity motor function and 8 RCTs for performance of activities of daily living. There was no statistically significant different on improvement of balance, gait velocity, lower extremity motor function and performance of activity among physical rehabilitation interventions. Moderate-level evidence supports that no single intervention is superior. Clinicians and therapist should consider individual patient characteristics, preferences, and available resources when selecting the intervention for stroke rehabilitation.

Keywords: Physical Therapy Modalities; Randomized Controlled Trials as Topic; Recovery of Function; Stroke Rehabilitation

INTRODUCTION

Stroke is a major cause of death and disability in the developed countries, including Australia, the UK, the USA, and Korea [1,2]. Motor impairment, characterized by loss or limitation of muscle control, movement, or mobility, is a common sequela of stroke, affecting about two-thirds of patients and resulting in deficits [3]. Therefore, stroke rehabilitation, particularly physical rehabilitation, focuses on restoring physical independence and functional ability, with an emphasis on improving gait, balance, and movement [4].

Various physical rehabilitation interventions have been used for patients after stroke, and ongoing debates and controversies exist regarding which intervention is more appropriate and effective [4]. These interventions can be best understood within a historical context. Prior to the 1940s, physical rehabilitation was primarily a treatment of musculoskeletal interventions based on orthopedic principles that focused on strengthening the affected limbs or corrective exercises to compensate for the unaffected limbs [5]. In the 1950s and 1960s, techniques based on neurophysiological intervention emerged, such as the Bobath, Brunnström, and Rood techniques, as well as the proprioceptive neuromuscular facilitation technique [6-9]. In the 1980s, a motor learning or relearning intervention was proposed that emphasized the importance of actively practicing task-specific motor exercise with appropriate feedback [10]. These different interventions resulted in substantial differences in patient treatment, with neurophysiological intervention involving more passive patient involvement, while motor learning intervention (functional task training) emphasized active patient participation, and musculoskeletal intervention focused on muscle strengthening and compensation with the non-paretic side.

From the 1980s there has been an increasing emphasis on developing neurophysiological intervention based on scientific research and developing evidence-based physical rehabilitation. Much research has been done on the relevant evidence for these interventions for stroke rehabilitation since the 1990s, with the Bobath therapy, based on neurophysiological principles, being recognized as the most widely used method in countries such as Australia, the UK and Korea. However, while some regions favor neurophysiological approaches, others prefer to apply multiple treatment methods simultaneously.

In 2014, the Cochrane group conducted a meta-analysis for which physical rehabilitation intervention is more effective than another intervention, they could not verify any statistically significance for treatment effectiveness. physical rehabilitation intervention is more effective than another [4]. The objective of this study was to use a meta-analysis of randomized controlled trials (RCTs) to investigate significant difference among physical rehabilitation interventions adding the most recent evidence available.

MATERIALS AND METHODS

Registration of the study protocol
Although the protocol of this study was not registered on a formalized registration site, the protocol was predetermined as a result of prior systematic steering meetings as part of the development of Clinical Practice Guideline for Stroke Rehabilitation in Korea. Part 1: Rehabilitation for Motor Function (2022) and proceeded according to the protocol.

Criteria for this review (PICO)
(1) Patient (P): Adult stroke patients (age 18 and older, includes both cerebral hemorrhage and cerebral infarction).
(2) Intervention (I): Mobility-related physical rehabilitation (including motor learning, neurophysiological, and musculoskeletal).
(3) Comparison (C): Comparing the include each intervention of interest vs. does not include the intervention of interest.
(4) Outcomes (O): Performance of activities of daily living tasks and mobility-related motor function (assessing balance, gait velocity, lower extremity motor function, and performance of activities of daily living).

Search and selection

The literature search was conducted utilizing 3 international electronical databases: MEDLINE, Embase, and the Cochrane Library. To ensure a comprehensive literature search, the scope of the search did not specify a start date and the end date was February 28, 2022. The searches were performed using MeSH terms for MEDLINE and the Cochrane Library and Emtree terms for Embase, combined with natural language to increase sensitivity. Detailed search terms are provided in **Supplementary Table 1**. The search results were independently assessed and selected by 2 authors. For the literature selection process, we followed the flowchart in Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and included only RCTs that directly compared motor relearning, neurophysiological, and musculoskeletal interventions for improving motor function, and excluded studies that did not meet PICO and studies in languages other than English or Korean.

Risk of bias (RoB) assessment

The final selected articles were independently assessed and agreed by 2 authors using the literature screening assessment tool with a Cochrane's RoB of 1.0.

Statistical analysis of evidence

To analyze the evidence, we performed a meta-analysis of the literature using Reviewer Manager Software 5.4 (Cochrane Collaboration, Oxford, UK). A statistical analysis for continuous variables was performed. To estimate heterogeneity, we used $I2$, which measures the percentage of total variation across trials. An $I2$ value greater than 50.0% was considered to be substantial heterogeneity. The meta-analysis was divided into groups that included and did not include individual treatment interventions. Because this method of comparison can lead to overlap of participants within each outcome measure, the total results of the meta-analyses were not interpreted, and only the subgroup analysis was used for interpretation. The analytical model used for the meta-analyses were a random effects model with an inverse variance method for continuous outcome variables.

Assessment of certainty of evidence

The certainty of evidence was performed using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) method. The GRADE method was used to determine the certainty of evidence as high, moderate, low, or very low. Depending on the study design, the certainty of evidence is first determined as 'high,' and then whether the evidence level can be lowered is determined according to the guidelines. For RCTs, 5 factors are considered: ① RoB, ② inconsistency, ③ indirectness, ④ imprecision, and ⑤ publication bias, and the certainty of evidence can be lowered by 1 or 2 grades. These processes were conducted independently by 2 authors and then subjected to a consensus process.

RESULTS

Study selection

After a comprehensive literature search, 2 authors screened 44,441 studies for duplicates using the PRISMA method, and 20 RCTs were finally selected. A description of the included studies is detailed in **Table 1**. Of the final selection, Epple et al. [14] and Mikołajewska [23] were excluded from the analysis because data extraction for meta-analysis was not possible. The Kanase [17] study had a significant RoB in the quality assessment of the literature, which significantly increased the heterogeneity when included in the meta-analysis.

Table 1. Characteristics of included studies

1st author	Title	Journal	Year	Design	Follow-up	Outcome tool	Outcomes	Remark	Exclusion
Bale [11]	Does functional strength training of the leg in subacute stroke improve physical performance? A pilot randomized controlled trial	*Clinical Rehabilitation*	2008	RCT	No	Gait velocity	The improvement was found to be larger in the functional strength training group than in the training-as-usual group for both gait speeds, and the difference in improvement between the groups was statistically significant for the habitual gait speed, but not for the maximum gait speed.		
Brock [12]	Does physiotherapy based on the Bobath concept achieve greater improvement in walking ability in people with stroke compared to structured task practice? A pilot randomized controlled trial	*Clinical Rehabilitation*	2012	RCT	No	Balance, gait velocity	Table 2 shows the pre- and post-test measures for both groups. There were no significant differences between groups at baseline for the 6MWT (p = 0.79), gait velocity (p = 0.27) and BBS (p = 0.77).		
Dubey [13]	Effects of pelvic stability training on movement control, hip muscles strength, walking speed and daily activities after stroke: a randomized controlled trial	*Annals of Neurosciences*	2018	RCT	No	ADL, balance, gait velocity, motor function	For between-groups comparison, the experimental group, that is, pelvic stability training showed statistically significant improvement in all outcome measures except MBI compared to standard physiotherapy.	Baseline control (−)	
Epple [14]	Vojta therapy improves postural control in very early stroke rehabilitation: a randomized controlled pilot trial	*Neurological Research and Practice*	2020	RCT	3 mon	ADL, balance	The median improvement in TCT within 9 days was 25.5 points (= 25.5%) (IQR, 12.5–42.5) in the Vojta group and 0 (IQR, 0–13) in the control group (p = 0.001). Patients treated with Vojta therapy achieved a greater improvement in the MESUPES than patients in the control group (20% vs. 10%, p = 0.006).	Baseline control (−)	Data unavailable
Gelber [15]	Comparison of two therapy approaches in the rehabilitation of the pure motor hemiparetic stroke patient	*Journal of Neurologic Rehabilitation*	1995	RCT	6 mon, 1 yr	ADL, gait velocity	Other than an increased gait velocity in NDT treated patients at hospital discharge (p = 0.04), there was no significant difference in gait measures, upper extremity motor skills, or FIM scores at hospital discharge, 6 mon, or 12 mon follow-up.	Data used incorrectly in a Cochrane review meta-analysis (2014) (FIM)	
Haruyama [16]	Effect of core stability training on trunk function, standing balance, and mobility in stroke patients: a randomized controlled trial	*Neurorehabilitation and Neural Repair*	2017	RCT	No	Balance, gait velocity	A treatment effect was found for the experimental group on the dynamic balance subscale and total score of the TIS (p = 0.002 and p < 0.001, respectively), pelvic tilt active range of motion (p < 0.001), Brief-BESTest (p < 0.001), TUG (p = 0.008), and FAC (p = 0.022).		
Kanase [17]	Effect of motor relearning programme and conventional training on functional mobility in post stroke patients	*Indian Journal of Public Health Research & Development*	2020	RCT	No	ADL	When compared within the groups, motor relearning program and conventional training was effective in improving functional mobility. But when compared between the groups, motor relearning program was found to be extremely significant for improving functional mobility (p value < 0.001).	Baseline control (−) RoB high	Significantly increased the heterogeneity
Khallaf [18]	Effect of task-specific training on trunk control and balance in patients with subacute stroke	*Neurology Research International*	2020	RCT	No	Balance	Significant differences between the baseline and the follow-up measures including TIS, PAS, FRT, and trunk (ROM) were found in both groups (p ≤ 0.05). In-between group comparison also showed significant differences between the results of both groups indicating more improvements among patients representing the study group.		

Table 1. (Continued) Characteristics of included studies

1st author	Title	Journal	Year	Design	Follow-up	Outcome tool	Outcomes	Remark	Exclusion
Kılınç [19]	The effects of Bobath-based trunk exercises on trunk control, functional capacity, balance, and gait: a pilot randomized controlled trial	Topics in Stroke Rehabilitation	2016	RCT	No	Balance, gait velocity, motor function	In group analyses, both groups showed improvement in STREAM, TIS, and TUG tests. Only the study group produced significant gains in the BBT, FR, and 10 mWT (p < 0.05). According to the pre- and post-treatment results, no significant difference was observed in any of the evaluated parameters between the 2 groups (p > 0.05).		
Langhammer [20]	Bobath or motor relearning programme? A comparison of two different approaches of physiotherapy in stroke rehabilitation: a randomized controlled study	Clinical Rehabilitation	2000	RCT	No	ADL, motor function	Both groups improved in MAS and SMES, but the improvement in motor function was significantly better in the MRP group. The 2 groups improved in Barthel ADL Index without significant differences between the groups. However, women treated by MRP improved more in ADL than women treated by Bobath.		
Langhammer [21]	Bobath or motor relearning programme? A follow-up one- and four-years post stroke	Clinical Rehabilitation	2003	RCT	3 mon, 1 yr, 4 yr	ADL, motor function	We found no significant differences in the measured variables in the group treated with MRP vs. the group treated with Bobath.		
van Vliet [22]	Comparison of Bobath-based and movement science based treatment for stroke: a randomised controlled trial	Journal of Neurology, Neurosurgery and Psychiatry	2005	RCT	1, 3, 6 mon	ADL, gait velocity, motor function	Comparison between groups showed no significant difference for any outcome measures.		
Mikolajewska [23]	Bobath and traditional approaches in post-stroke gait rehabilitation in adults	Biomedical Human Kinetics	2017	RCT	No	Gait velocity	Statistically significant and favorable changes in the gait velocity, cadence and stride length and their normalized values were observed in both groups (within groups and between groups).	Baseline control (−)	Data unavailable
Mudie [24]	Training symmetry of weight distribution after stroke: a randomized controlled pilot study comparing task-related reach, Bobath and feedback training approaches	Clinical Rehabilitation	2002	RCT	No	ADL	As there was no significant difference between the admission total and mobility (BI) scores of the task-specific reach, Bobath or control groups (F = 1.051, df =2, p = 0.363 [total], F = 2.488, df = 2, p = 0.102 [mobility]), it appeared that the functional status of the BPM training group was initially superior. However, over time the 3 groups with lower scores gained ground with no significant differences remaining between the groups in both (F = 0.910, df = 3, p = 0.446) total BI and (F = 0.920, df = 3, p = 0.441) mobility scores at discharge.		
Richards [25]	Task-specific physical therapy for optimization of gait recovery in acute stroke patients	Archives of Physical Medicine	1993	RCT	No	ADL, balance, gait velocity, motor function	Group results at 6 weeks demonstrated that gait velocity was similar in the 2 conventional groups thereby eliminating the timing of the interventions as an important factor. At that point, gait velocity was faster in the experimental group. The difference translated into a moderate effect size of 0.58. The time dedicated to gait training but not to total therapy time was correlated (r = 0.63) to gait velocity. This effect disappeared at 3 and 6 months after stroke.		
Shin [26]	Effects of combined exercise training on balance of hemiplegic stroke patients	Journal of Physical Therapy Science	2011	RCT	No	Balance	The result of this study suggests that combined exercise training with functional strengthening exercise and aerobic exercise was effective at improve static and dynamic balance ability and was more effective than conventional exercise at improving dynamic balance.		

(continued to the next page)

Table 1. (Continued) Characteristics of included studies

1st author	Title	Journal	Year	Design	Follow-up	Outcome tool	Outcomes	Remark	Exclusion
Thaut [27]	Rhythmic auditory stimulation improves gait more than NDT/Bobath training in near-ambulatory patients early poststroke: a single-blind, randomized trial	*Neurorehabilitation and Neural Repair*	2007	RCT	No	Gait velocity	Pre- to post-test measures showed a significant improvement in the RAS group for velocity ($p = 0.006$), stride length ($p = 0.0001$), cadence ($p = 0.0001$) and symmetry ($p = 0.0049$) over the NDT/Bobath group. Effect sizes for RAS over NDT/Bobath training were 13.1 m/min for velocity, 0.18 m for stride length, and 19 steps/min for cadence.		
Verma [28]	Task-oriented circuit class training program with motor imagery for gait rehabilitation in poststroke patients: a randomized controlled trial	*Topics in Stroke Rehabilitation*	2011	RCT	No	ADL, gait velocity	The TOCCT with MI group showed a positive improvement in the mean/median scores on most of the outcome measures at post and follow-up assessments in comparison to the control group. However, statistically significant differences were observed in changes between the groups at post and follow-up assessment for FAC, RVGA, walking speed, and 6MWT (ANOVA, $p = 0.001$ to 0.049; Mann-Whitney U test, $p = 0.001$).		
Wang [29]	Efficacy of Bobath versus orthopedic approach on impairment and function at different motor recovery stages after stroke: a randomized controlled study	*Clinical Rehabilitation*	2005	RCT	No	Balance, motor function	Participants with relative recovery receiving Bobath treatment showed greater improvement in MAS (change score: $6.14 + 5.55$ vs. $2.77 + 9.89$, $p = 0.007$), BBS (change score: $19.18 + 15.94$ vs. $6.85 + 5.23$, $p = 0.015$), and SIS scores (change score: $8.50 + 3.41$ vs. $3.62 + 4.07$, $p = 0.006$) than those with orthopedic treatment.	Baseline control (–)	
Yazıcı [30]	Investigation of early term neurodevelopmental treatment-Bobath approach results in patients with stroke	*Turkish Journal of Cerebrovascular Diseases*	2021	RCT	No	ADL, balance, motor function	When the treatment methods were compared, it was observed that lower extremity and basic mobility skills improved more in the NDT-B group. Significant improvements were achieved only in the NDT-B group in BBS. Improvements were observed in TIS and BI in both groups following treatment ($p < 0.05$). No complications were encountered during the study.	Baseline control (–)	

The gray shading in the table indicates the papers excluded from the meta-analysis.
RCT, randomized controlled trial; 6MWT, 6 minute walk test; BBS, berg balance scale; MBI, modified Barthel index; ADL, activities of daily living; TCT, trunk control test; IQR, interquartile range; MESUPES, Motor Evaluation Scale for Upper Extremity in Stroke Patients; NDT, neurodevelopmental techniques; FIM, functional independence measure; TIS, trunk impairment scale; TUG, timed up and go test; FAC, functional ambulation classification; PAS, postural assessment scale; FRT, functional reach test; ROM, ranges of motions; STREAM, stroke rehabilitation assessment of movement; BBT, berg balance test; FR, functional reach; 10mWT, 10 meter walk test; MAS, motor assessment scale; SMES, sodring motor evaluation scale; MRP, motor relearning programme; BI, Barthel index; BPM, balance performance monitor; RAS, rhythmic auditory stimulation; TOCCT, task-oriented circuit class training; MI, motor imagery; RVGA, Rivermead visual gait assessment; ANOVA, analysis of variance; SIS, stroke impact scale; NDT-B, neurodevelopmental techniques-Bobath.

Study characteristics

The meta-analysis included 9 RCTs for balance (immediate outcome), 10 RCTs for gait velocity (immediate outcome), 7 RCTs for lower extremity motor function (immediate outcome), and 8 RCTs for performance of activities of daily living (immediate outcome). For persistence outcome beyond 6 months after the end of the intervention, 2 RCTs were included for gait velocity, 2 RCTs for lower extremity motor function, and 3 RCTs for performance of activities of daily living, but no studies identified persistence outcome for balance. The RoB for the studies included in the analysis is shown in **Fig. 1**.

Meta-analysis for effects of physical rehabilitation

The evidence summaries and GRADEs of the analyses are presented in **Table 2**, and the forest plots of the meta-analyses are presented in **Figs. 2-8**. In all analyses, the 95% confidence intervals (CIs) of the standardized mean difference (SMD) and mean difference (MD) for the effectiveness of the 3 physical rehabilitation interventions were distributed including zeroes, indicating no significant difference between the interventions.

Balance (immediate)
The studies included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy on balance (immediate) were a total of 8, and the evaluation tools for the outcome measures were berg balance scale (BBS), trunk impairment scale (TIS), and functional reach test (FRT). The effect size was calculated using SMD and the result was −0.09 (−0.52, 0.34).

For the effects of functional task training vs. does not include functional task training on balance (immediate), a total of 4 studies were included in the meta-analysis. The evaluation tools for the outcome measures were BBS and FRT, and the effect size was calculated using SMD. The result was 0.20 (−0.70, 1.09).

To determine the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on balance (immediate), a total of 5 studies were included in the meta-analysis. The evaluation tools for the outcome measures were BBS, TIS, and FRT, and the effect size was calculated using SMD. The result was 0.14 (−0.35, 0.64) (**Fig. 2**).

Fig. 1. RoB for included studies. The included studies were independently assessed and agreed by 2 authors using the Cochrane's RoB of 1.0. RoB, risk of bias.

Table 2. The evidence summaries and GRADEs

Outcomes	No. of participants (No. of studies)	GRADE certainty of evidence (deduction factors)	Statistical methods	Effect estimates
1. Balance (immediate effect)	(9)	Moderate (Imprecision −1)	SMD (IV, Random, 95% CI)	Subtotals only
1.1. Includes neurophysiologic vs. does not include neurophysiological	204 (8)		SMD (IV, Random, 95% CI)	−0.09 (−0.52, 0.34)
1.2. Includes functional task training vs. does not include functional task training	107 (4)		SMD (IV, Random, 95% CI)	0.20 (−0.70, 1.09)
1.3. Includes musculoskeletal vs. does not include musculoskeletal	113 (5)		SMD (IV, Random, 95% CI)	0.14 (−0.35, 0.64)
2. Gait velocity (immediate effect)	(10)	Moderate (Imprecision −1)	SMD (IV, Random, 95% CI)	Subtotals only
2.1. Includes neurophysiologic vs. does not include neurophysiological	325 (9)		SMD (IV, Random, 95% CI)	−0.04 (−0.71, 0.63)
2.2. Includes functional task training vs. does not include functional task training	174 (5)		SMD (IV, Random, 95% CI)	0.03 (−0.66, 0.72)
2.3. Includes musculoskeletal vs. does not include musculoskeletal	109 (5)		SMD (IV, Random, 95% CI)	−0.13 (−0.51, 0.25)
3. Motor function (immediate effect)	(7)	Moderate (Imprecision −1)	SMD (IV, Random, 95% CI)	Subtotals only
3.1. Includes neurophysiologic vs. does not include neurophysiological	272 (7)		SMD (IV, Random, 95% CI)	0.20 (−0.04, 0.44)
3.2. Includes functional task training vs. does not include functional task training	225 (5)		SMD (IV, Random, 95% CI)	−0.17 (−0.47, 0.13)
3.3. Includes musculoskeletal vs. does not include musculoskeletal	81 (4)		SMD (IV, Random, 95% CI)	−0.23 (−0.67, 0.22)
4. Activities of daily living (immediate effect)	(8)	Moderate (Imprecision −1)	SMD (IV, Random, 95% CI)	Subtotals only
4.1. Includes neurophysiologic vs. does not include neurophysiological	304 (8)		SMD (IV, Random, 95% CI)	−0.25 (−0.58, 0.07)
4.2. Includes functional task training vs. does not include functional task training	278 (7)		SMD (IV, Random, 95% CI)	0.28 (−0.09, 0.65)
4.3. Includes musculoskeletal vs. does not include musculoskeletal	41 (2)		SMD (IV, Random, 95% CI)	0.15 (−0.46, 0.77)
5. Gait velocity (persistence effect)	(2)	Low (Imprecision −2)	MD (IV, Random, 95% CI)	Subtotals only
5.1. Includes neurophysiologic vs. does not include neurophysiological	101 (2)		MD (IV, Random, 95% CI)	0.06 (−0.15, 0.26)
5.2. Includes functional task training vs. does not include functional task training	101 (2)		MD (IV, Random, 95% CI)	−0.06 (−0.26, 0.15)
5.3. Includes musculoskeletal vs. does not include musculoskeletal	0			Not estimable
6. Motor function (persistence effect)	(2)	Low (Imprecision −2)	SMD (IV, Random, 95% CI)	Subtotals only
6.1. Includes neurophysiologic vs. does not include neurophysiological	135 (2)		SMD (IV, Random, 95% CI)	−0.05 (−0.39, 0.28)
6.2. Includes functional task training vs. does not include functional task training	135 (2)		SMD (IV, Random, 95% CI)	0.05 (−0.28, 0.39)
6.3. Includes musculoskeletal vs. does not include musculoskeletal	0			Not estimable
7. Activities of daily living (persistence effect)	(3)	Low (Imprecision −2)	SMD (IV, Random, 95% CI)	Subtotals only
7.1. Includes neurophysiologic vs. does not include neurophysiological	162 (3)		SMD (IV, Random, 95% CI)	−0.00 (−0.44, 0.44)
7.2. Includes functional task training vs. does not include functional task training	162 (3)		SMD (IV, Random, 95% CI)	0.00 (−0.44, 0.44)
7.3. Includes musculoskeletal vs. does not include musculoskeletal	0			Not estimable

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

Gait velocity (immediate)

For gait velocity (immediate), a total of 9 studies were included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tools for the outcome measures were 6 minute walk test (6MWT), 10 meter walk test (10mWT), and timed up and go test (TUG) and the effect size was calculated using SMD. The result was −0.04 (−0.71, 0.63).

For the effects of functional task training vs. does not include functional task training on gait velocity (immediate), a total of 5 studies were included in the meta-analysis. The evaluation tools for the outcome measures were 6MWT, 10mWT, and TUG, and the effect size was calculated using SMD. The result was 0.03 (−0.66, 0.72).

To determine the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on gait velocity (immediate), a total of 5 studies were included in the meta-analysis. The evaluation tools for the outcome measures were 6MWT, 10mWT, and TUG, and the effect size was calculated using SMD. The result was −0.13 (−0.51, 0.25) (**Fig. 3**).
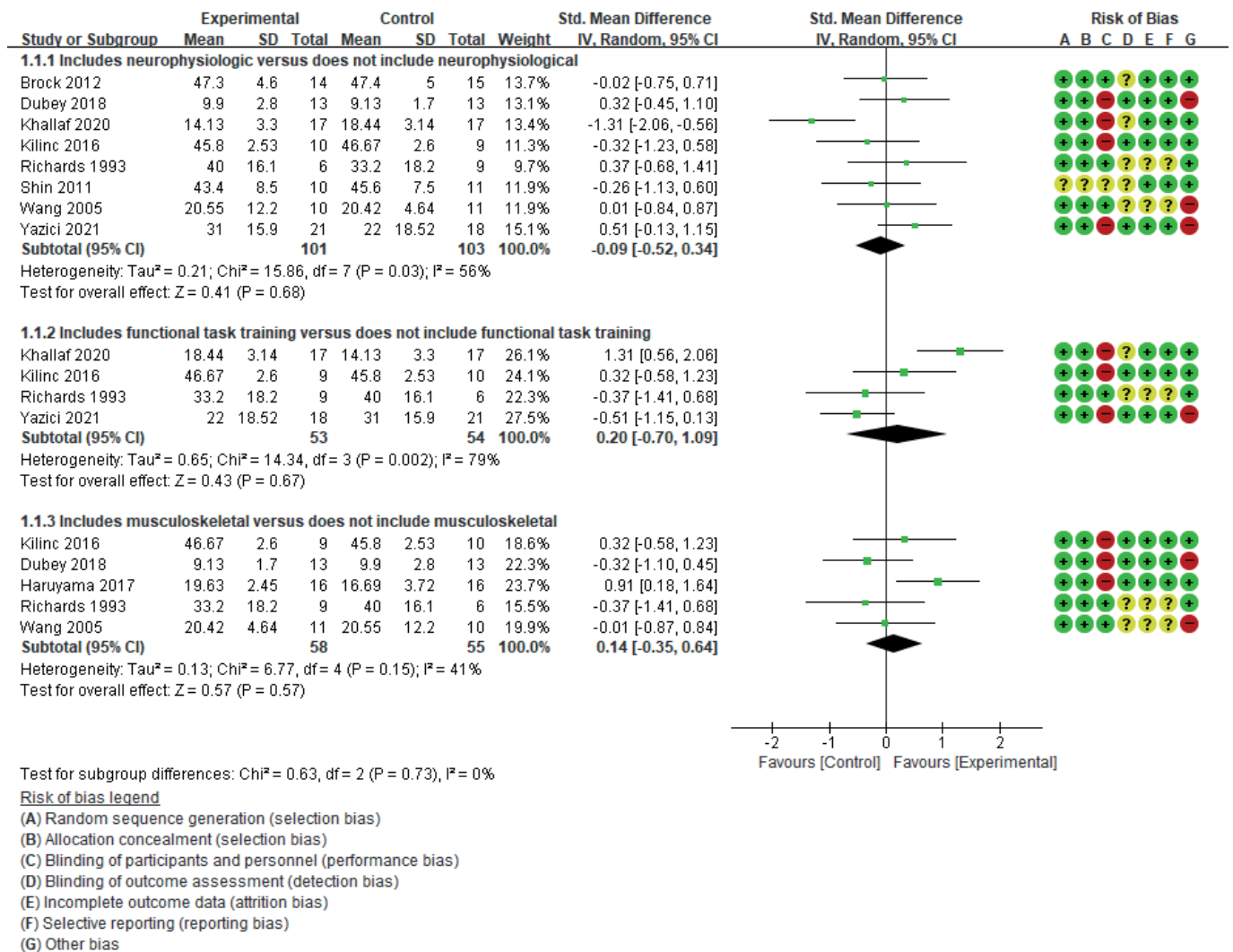
Fig. 2. Forest plot of meta-analyses: balance (immediate effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval.

Motor function (immediate)

For motor function (immediate), a total of 7 studies were included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tools for the outcome measures were Fugl-Meyer assessment (FMA), stroke rehabilitation assessment of movement (STREAM), motor assessment scale (MAS), and Rivermead motor assessment (RMA), and the effect size was calculated using SMD. The result was 0.20 (−0.04, 0.44).

For the effects of functional task training vs. does not include functional task training on motor function (immediate), a total of 5 studies were included in the meta-analysis. The evaluation tools for the outcome measures were FMA, STREAM, MAS, and RMA, and the effect size was calculated using SMD. The result was −0.17 (−0.47, 0.13).

To determine the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on motor function (immediate), a total of 4 studies were included in the meta-
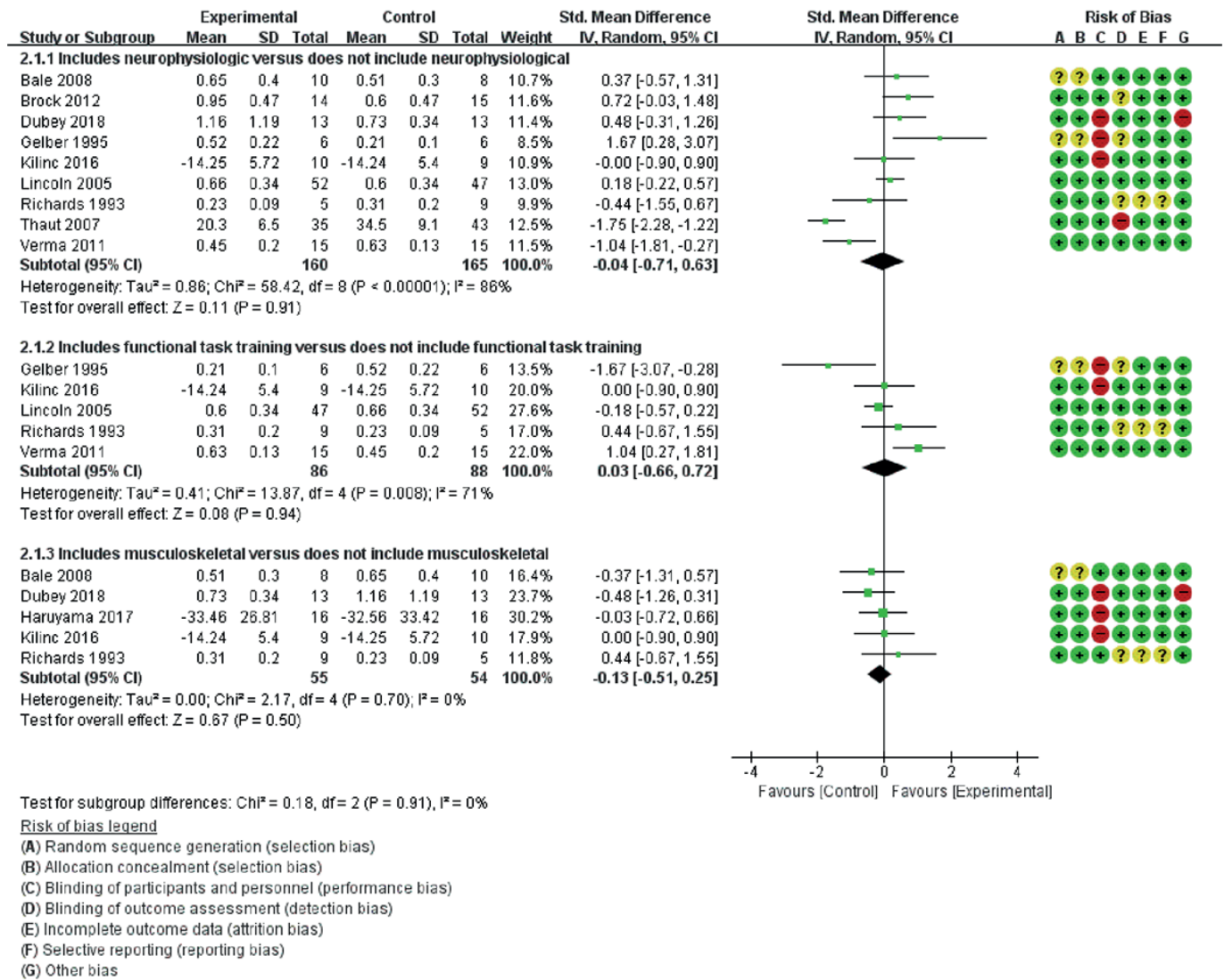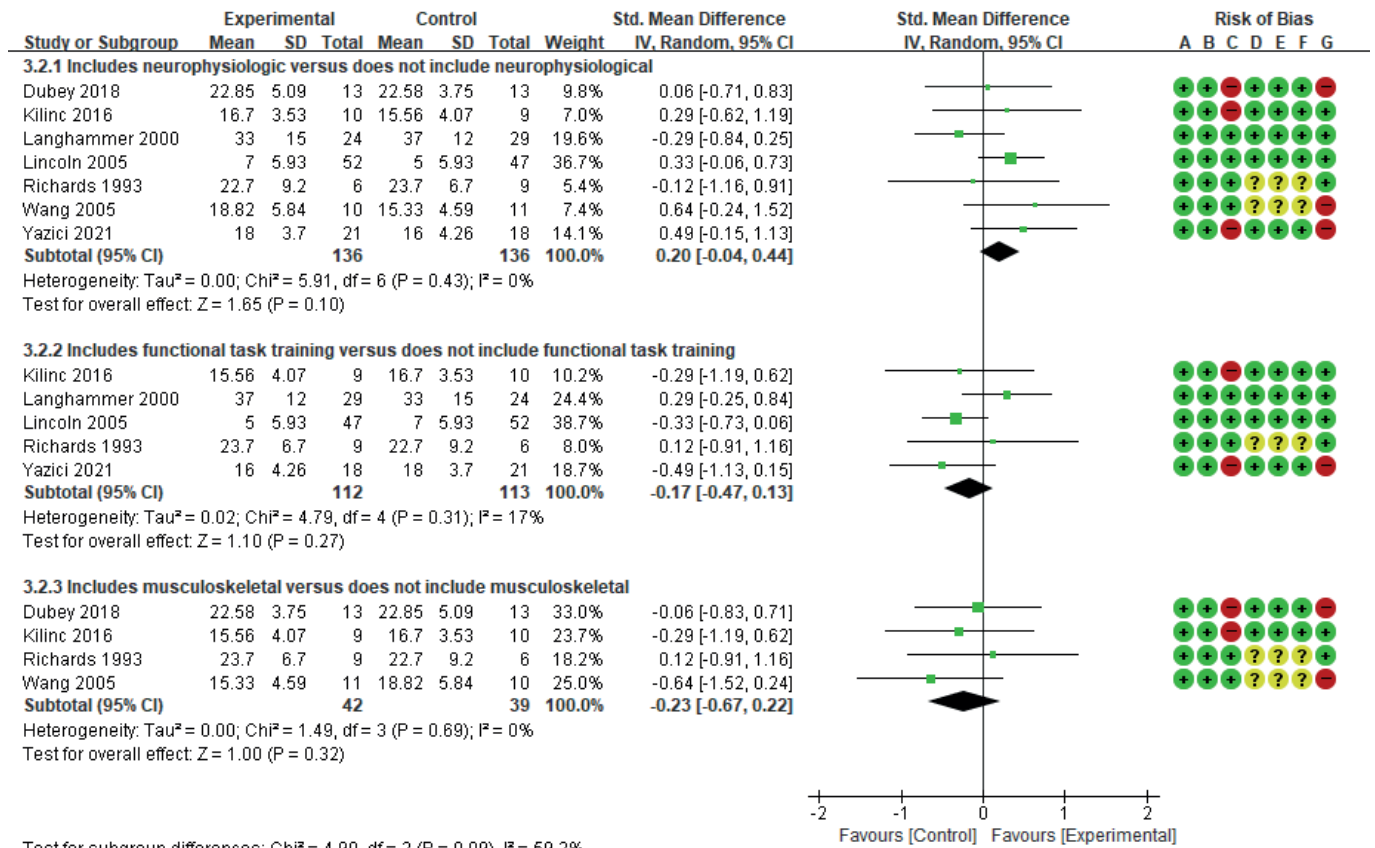
Fig. 3. Forest plot of meta-analyses: gait velocity (immediate effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval.

analysis. The evaluation tools for the outcome measures were FMA, STREAM, and MAS, and the effect size was calculated using SMD. The result was −0.23 (−0.67, 0.22) (**Fig. 4**).

Activities of daily living (immediate)
For activities of daily living, a total of 8 studies were included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tools for the outcome measures were Barthel index (BI), modified Barthel index (MBI), and functional independence measure (FIM), and the effect size was calculated using SMD. The result was −0.25 (−0.58, 0.07).

For the effects of functional task training vs. does not include functional task training on activities of daily living (immediate), a total of 7 studies were included in the meta-analysis. The evaluation tools for the outcome measures were BI, MBI, and FIM, and the effect size was calculated using SMD. The result was 0.28 (−0.09, 0.65).

Fig. 4. Forest plot of meta-analyses: motor function (immediate effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval.

To determine the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on activities of daily living (immediate), a total of 2 studies were included in the meta-analysis. The evaluation tools for the outcome measures were BI and MBI, and the effect size was calculated using SMD. The result was 0.15 (−0.46, 0.77) (**Fig. 5**).

Balance (persistence, > 3 months)
There were no studies that examined the persistence effects on balance.

Gait velocity (persistence, > 3 months)
For gait velocity (persistence), there were a total of 2 studies included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tool used for the outcome was only the 6 meter walk test, and the effect size was analyzed using MD in the meta-analysis. The effect size was 0.06 (−0.15, 0.26).

For the effects of functional task training vs. does not include functional task training on gait velocity (persistence), a total of 2 studies were included in the meta-analysis. The evaluation

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
4.1.1 Includes neurophysiologic versus does not include neurophysiological								
Dubey 2018	78.62	14	13	80.42	7.8	13	11.2%	-0.15 [-0.92, 0.62]
Gelber 1995	101.2	14.72	15	105.3	16.63	12	11.4%	-0.26 [-1.02, 0.51]
Langhammer 2000	72	34	24	83	25	29	16.4%	-0.37 [-0.91, 0.18]
Lincoln 2005	15	4.44	52	14	5.93	47	21.1%	0.19 [-0.20, 0.59]
Mudie 2002	68.9	21.5	7	79.5	22.11	8	7.5%	-0.46 [-1.49, 0.58]
Richards 1993	23.3	16.6	6	25.8	14.8	9	7.4%	-0.15 [-1.19, 0.88]
Verma 2011	74.67	15.52	15	90.67	5.93	15	10.7%	-1.33 [-2.13, -0.52]
Yazici 2021	75	14.81	21	75	26.85	18	14.2%	0.00 [-0.63, 0.63]
Subtotal (95% CI)			153			151	100.0%	-0.25 [-0.58, 0.07]

Heterogeneity: Tau² = 0.09; Chi² = 12.32, df = 7 (P = 0.09); I² = 43%
Test for overall effect: Z = 1.53 (P = 0.13)

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
4.1.2 Includes functional task training versus does not include functional task training								
Gelber 1995	105.3	16.63	12	101.2	14.72	15	13.2%	0.26 [-0.51, 1.02]
Langhammer 2000	83	25	29	72	34	24	18.1%	0.37 [-0.18, 0.91]
Lincoln 2005	14	5.93	47	15	4.44	52	22.2%	-0.19 [-0.59, 0.20]
Mudie 2002	79.5	22.11	8	68.9	21.5	7	9.0%	0.46 [-0.58, 1.49]
Richards 1993	25.8	14.8	9	23.3	16.6	6	9.0%	0.15 [-0.88, 1.19]
Verma 2011	90.67	5.93	15	74.67	15.52	15	12.5%	1.33 [0.52, 2.13]
Yazici 2021	75	26.85	18	75	14.81	21	16.0%	0.00 [-0.63, 0.63]
Subtotal (95% CI)			138			140	100.0%	0.28 [-0.09, 0.65]

Heterogeneity: Tau² = 0.12; Chi² = 12.32, df = 6 (P = 0.06); I² = 51%
Test for overall effect: Z = 1.47 (P = 0.14)

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
4.1.3 Includes musculoskeletal versus does not include musculoskeletal								
Dubey 2018	80.42	7.8	13	78.62	14	13	64.4%	0.15 [-0.62, 0.92]
Richards 1993	25.8	14.8	9	23.3	16.6	6	35.6%	0.15 [-0.88, 1.19]
Subtotal (95% CI)			22			19	100.0%	0.15 [-0.46, 0.77]

Heterogeneity: Tau² = 0.00; Chi² = 0.00, df = 1 (P = 1.00); I² = 0%
Test for overall effect: Z = 0.49 (P = 0.63)

Test for subgroup differences: Chi² = 4.74, df = 2 (P = 0.09), I² = 57.8%

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. 5. Forest plot of meta-analyses: ADL (immediate effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval; ADL, activities of daily living.

tool for the outcome was again the 6 meter walk test, and the effect size was analyzed using MD. The effect size was −0.06 (−0.26, 0.15).

There were no studies that examined the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on gait velocity (persistence) (**Fig. 6**).

Motor function (persistence, > 3 months)
For motor function (persistence), there were a total of 2 studies included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tools for the outcome were MAS and RMA, and the effect size was analyzed using SMD. The effect size was −0.05 (−0.39, 0.28).
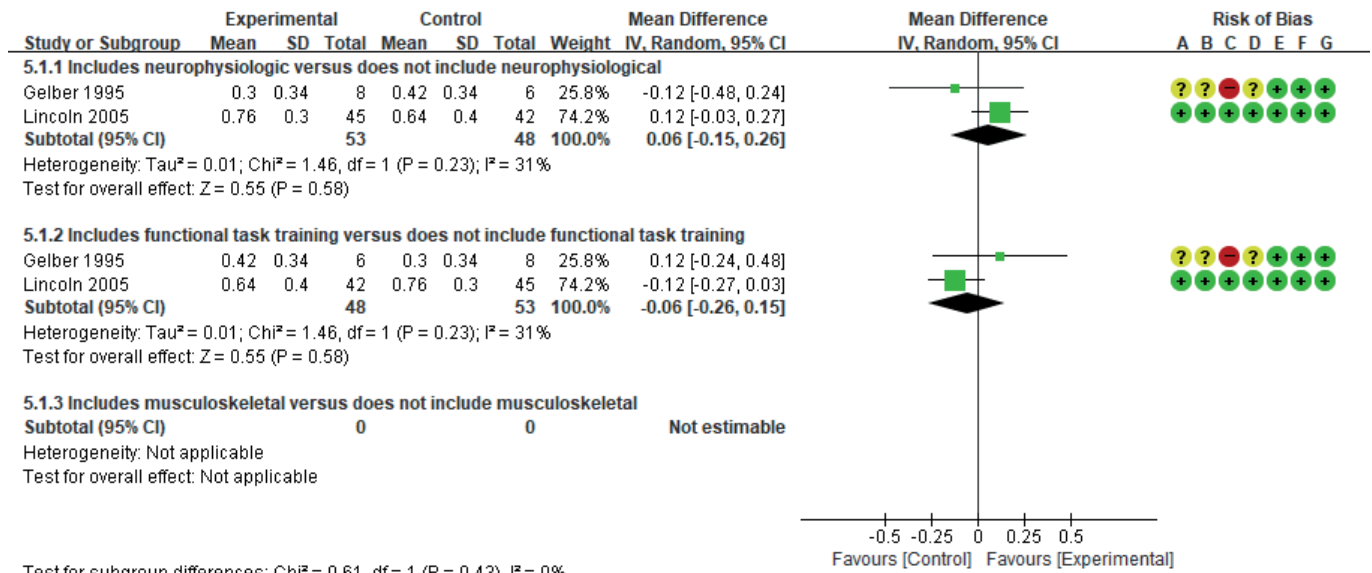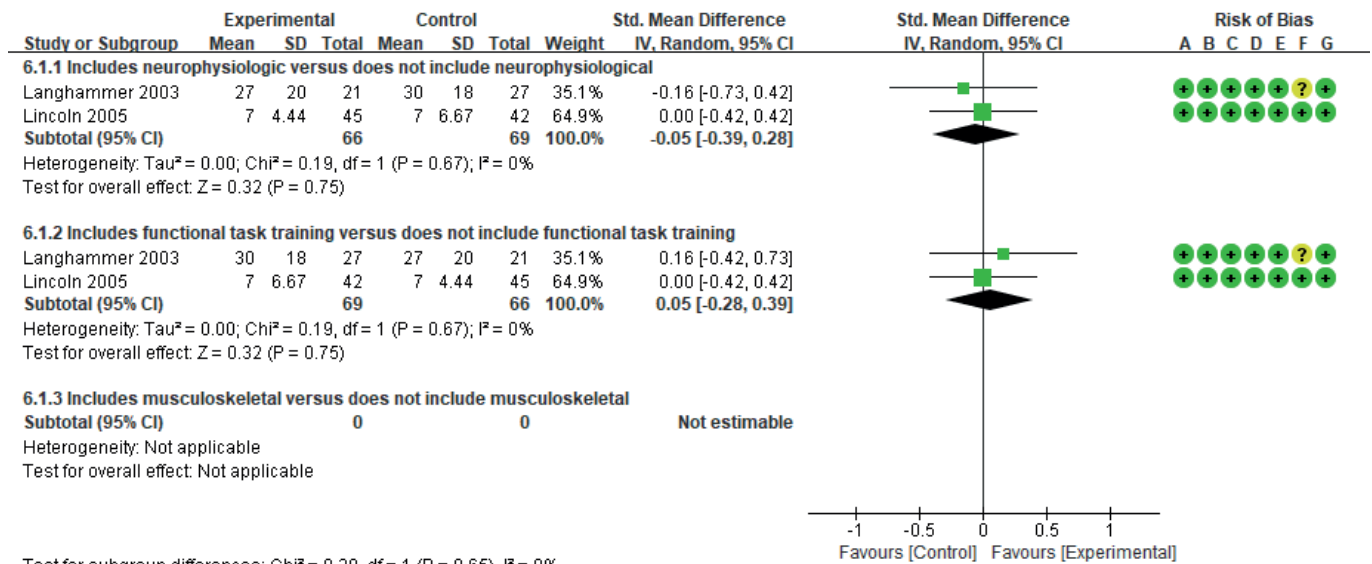
For the effects of functional task training vs. does not include functional task training on motor function (persistence), a total of 2 studies were included in the meta-analysis. The

Fig. 6. Forest plot of meta-analyses: gait velocity (persistence effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval.

Fig. 7. Forest plot of meta-analyses: motor function (persistence effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval.

evaluation tools for the outcome were MAS and RMA, and the effect size was analyzed using SMD. The effect size was 0.05 (−0.28, 0.39).

There were no studies that examined the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on motor function (persistence) (**Fig. 7**).

Activities of daily living (persistence, > 3 months)
For activities of daily living (persistence), there were a total of 3 studies included in the meta-analysis to determine the effects of neurophysiological therapy vs. does not include neurophysiological therapy. The evaluation tools for the outcome were BI and FIM, and the effect size was analyzed using SMD. The effect size was −0.00 (−0.44, 0.44).

For the effects of functional task training vs. does not include functional task training on activities of daily living (persistence), a total of 3 studies were included in the meta-analysis. The evaluation tools for the outcome were BI and FIM, and the effect size was analyzed using SMD. The effect size was 0.00 (−0.44, 0.44).

There were no studies that examined the effects of musculoskeletal therapy vs. does not include musculoskeletal therapy on activities of daily living (persistence) (**Fig. 8**).
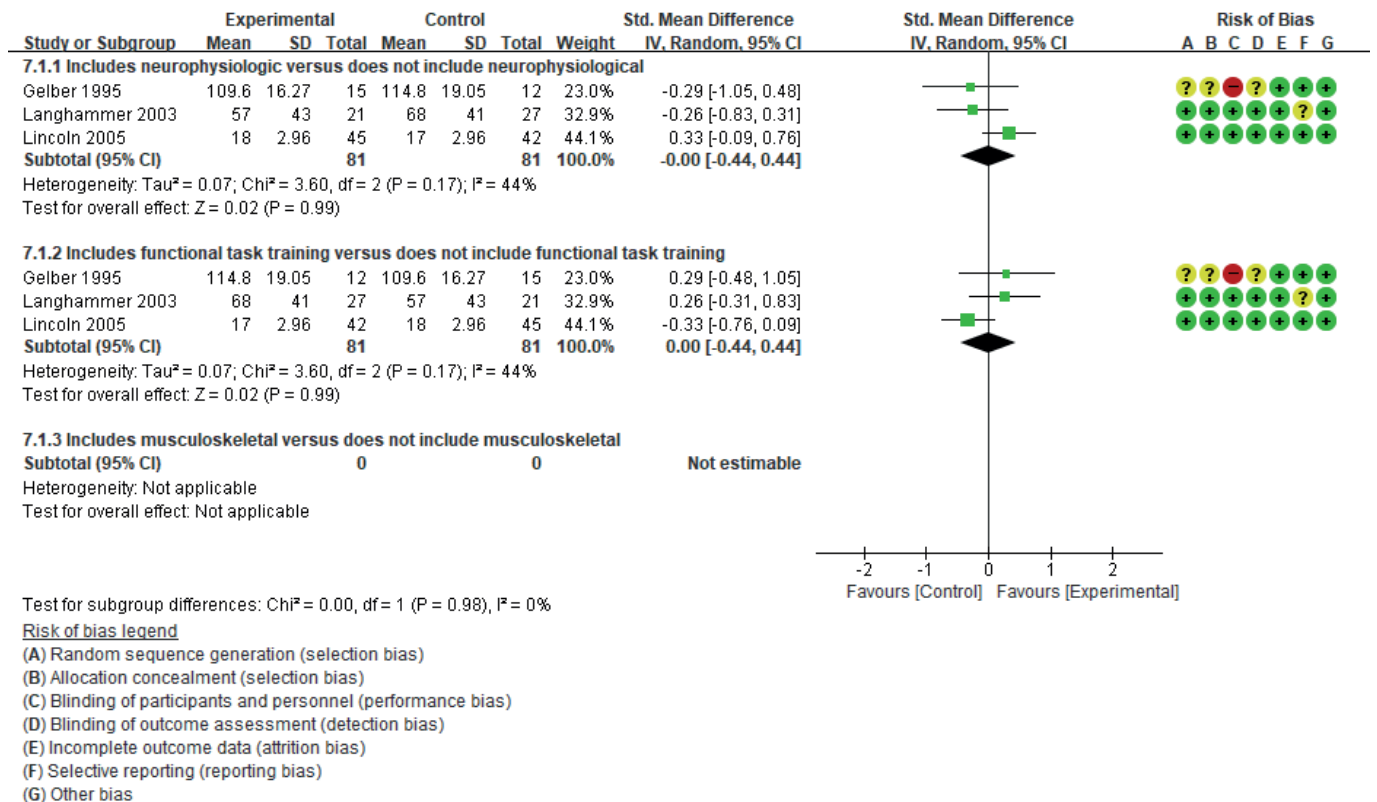

Fig. 8. Forest plot of meta-analyses: ADL (persistence effect).
SD, standard deviation; IV, inverse-variance; CI, confidence interval; ADL, activities of daily living.

DISCUSSION

The results of the meta-analyses, which included this recent evidence, were consistent with previous Cochrane reviews. Physical rehabilitation that incorporates components of different interventions is effective in restoring function and mobility after stroke, but there is no superiority or inferiority between interventions of therapy. In the 2020s, these therapies are now standard of care and already widely used clinically, so there are fewer studies that have attempted to prove their effectiveness, which may explain the lack of studies that objectively prove their effectiveness. Nevertheless, the field of rehabilitation medicine will be further developed if we continue to think about these topics in clinical practice and research.

First, for clinical practice, we should keep the following points in mind. Based on the evidence, it is evident that no single intervention to physical rehabilitation is superior or inferior in promoting recovery of function and mobility after stroke. Therefore, clinicians should select the most appropriate physical interventions for individual stroke survivors based on evidence-based interventions and critical clinical reasoning. The key implications for practice, include: (1) Selecting treatment components based on the assessment of the individual stroke survivor, considering the full range of treatment techniques that the therapists have the skills and expertise to administer. (2) Implementing evidence-based rehabilitation after stroke, with critical evaluation and awareness that no single intervention is superior to any other. (3) Physical rehabilitation should not be limited to specific, named rehabilitation interventions, but should comprise clearly defined, well-described, evidence-based physical treatments.

Next, to secure objective evidence and research, the following should be considered when researching related fields. Moderate-level evidence now supports that no single intervention is superior or inferior to another. To expand the evidence base, researchers need to understand the contribution of individual treatment components to the beneficial effects of physical rehabilitation. RCTs should be designed to assess the effectiveness of clearly defined individual interventions regardless of their historical or philosophical origins. Larger studies are needed to demonstrate the effectiveness of specific single treatments, rather than mixtures of treatments. In addition to studies evaluating specific interventions of therapy, there may also be a need for pragmatic research designs for patient-centered interventions that select treatment components based on individual patient assessment. Valid and reliable methods for systematic documentation and description of patient-centered physical rehabilitation may need to be explored to build the evidence base in new ways.

SUPPLEMENTARY MATERIAL

Supplementary Table 1
Search terms and strategies

Click here to view

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