J Int Acad Phys Ther Res 2020; 11(3): 2164~2172
ISSN 2092-8475
www.iaptr.org
https://doi.org/10.20540/JIAPTR.2020.11.3.2164

Effects of Sling Exercise on Balance and Gait in Patients with Stroke: Meta-Analysis of Studies in Korea

Background: Stroke patients have multiple disorders, but most have problems with balance and gait. Post-stroke rehabilitation exercise has been shown to be very important for functional recovery.
Objectives: To systematically review and meta-analyze the effects of sling exercise (SE) on patients with stroke in studies published in Korea.
Design: Meta-analysis.
Methods: Five databases, namely, RISS, KISS, NDSL, DBpia and Earticle, were used to collect articles on vibration. Keywords such as "Stroke," "Hemiplegia," "Sling," and "Sling Exercise" were used in the search for published articles. Interventions and comparisons were SE and other exercise (OE). Outcome measures were berg balance scale (BBS) and timed up and go (TUG). Consequently, eight studies were selected in the second screening using meta-analyses.
Results: Based on the results of the meta-analysis, SE was effective for BBS in the comparison of SE and OE [2.71, 95% CI (1.42, 4.01)]. It was effective for TUG in the comparison of SE and OE [-1.89, 95% CI (-3.01, -0.77)].
Conclusion: Based on eight limited studies, SE improved BBS and TUG over OE, suggesting improved stroke balance and gait. Therefore, more studies and large-scale sample randomized controlled trials are needed to confirm clinical application.

Keywords: *Stroke; Sling exercise; Balance; Gait; Meta-analysis*

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Received : 20 June 2020
Revised : 29 July 2020
Accepted : 10 August 2020

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INTRODUCTION

Stroke can cause acute nerve injury, blockage of blood flow in the brain, or loss of brain function due to bleeding.[1] Stroke is one of the most common causes of acquired disability and death.[2,3] Surviving stroke patients have sequelae of dysfunction.[4] Stroke patients have multiple disorders, but most have problems with balance and gait.[5,6]

Post-stroke rehabilitation exercise has been shown to be very important for functional recovery.[7] Among the various exercise methods, it has been reported that trunk exercise is effective for trunk control and balance.[8] It has been reported that to improve the gait of stroke patients, trunk exercises are performed on stable and unstable support surfaces.[9] Unstable support surface exercise has been reported to be effective in improving balance and gait.[10,11]

One of the methods of unstable support surface exercise is sling exercise (SE). A sling is used for trunk exercise by providing an unstable support surface from the ceiling.[12,13] Previous studies have reported that sling exercise is effective in improving the balance and gait of stroke patients.[14,15] However, in other previous studies, there was no difference from other exercises.[16,17] Therefore, the effectiveness of SE compared with other treatments remains unclear.

In order to analyze these unclear effects, there is a meta-analysis preceding study that analyzed the effects of SE in stroke patients.[18] This previous study reported that SE has a large effect size on improving

the balance of stroke patients. However, the effect size was not analyzed for gait. And Korea studies were not included.

Korean research is provided by the Korean Citation Index (KCI), which is the Korean version of the Science Citation Index (SCI). So, study published in Korea is not included in overseas meta-analysis study. Therefore, the purpose of this study is to meta-analyze the effect size on balance and gait by comparing SE and other exercise interventions in stroke patients published in Korea.

METHODS

Literature Search

The following databases were searched from the earliest available date to June 2020: Research Information Sharing Service (RISS), Korean Studies Information Service System (KISS), National Digital Science Library (NDSL), DBpia and Earticle. We searched the search terms "Stroke," "Hemiplegia," "Sling," and "Sling Exercise" in two languages (Korean and English) published at Korea. Re-search was conducted at the end of the study. However, additional studies were not search.

Inclusion Criteria

Types of studies

Randomized controlled trials (RCT) and non-randomized controlled trials (NRCT) investigating the use of SE as a treatment for patients with stroke were included.

Types of participants

The study samples included patients with stroke and hemiplegia. The diagnosis should have been confirmed with head computerized tomography (CT) or magnetic resonance imaging (MRI) diagnosis. Patients should be able to understand instructions.

Types of interventions and comparisons

We included articles on intervention SE and other exercise (OE) in patients with stroke.

Types of outcome measures

The findings were analyzed in two primary outcome categories: balance and gait. Among the various measures, berg balance scale (BBS) and timed up and go (TUG), which were used in many studies, were selected.

Selection of Studies

Two reviewers (Cho and Kim) independently screened for potentially relevant titles and abstracts based on the pre-specified criteria, and full-text articles were retrieved whenever necessary. If a journal article and thesis paper were duplicated, the journal article was adopted.

Data Extraction

Two independent reviewers (Cho and Kim) abstracted and cross-checked the data obtained from the included trials. Any disagreements were resolved by co-author (Lee) to obtain a consensus.

Quality Assessment

As a tool for evaluating the quality of research methods, the RCT study used the Risk of Bias (RoB) tool developed by the Cochrane group, and the NRCT study used the Risk of Bias Assessment tool for Non-randomized Study (RoBANS). For each item of the RoB and RoBANS tools, there are three risks of skew: "high," "low," and "uncertain." Assessed by two independent reviewers (Cho and Kim). Any disagreements were resolved by co-author (Lee) to obtain a consensus.

Statistical Analysis

The meta-analysis procedure was performed with Revman 5.4. The random effects model and weighted mean difference (WMD) were used to calculate the mean effect size. A chi-square test was performed to detect statistically significant heterogeneity. We then estimated the amount of heterogeneity among studies by using the I^2 statistic. Heterogeneity was further investigated by checking data extracted from outlier studies and exploring the effects of study exclusion in sensitivity analyses. No funnel plots or assessments for publication bias were performed because of the small number of studies that were pooled in the comparisons included in this literature. We then performed separate subgroup analyses for week time points.

RESULTS

Literature Search

We initially retrieved 405 articles (Journal: 228,

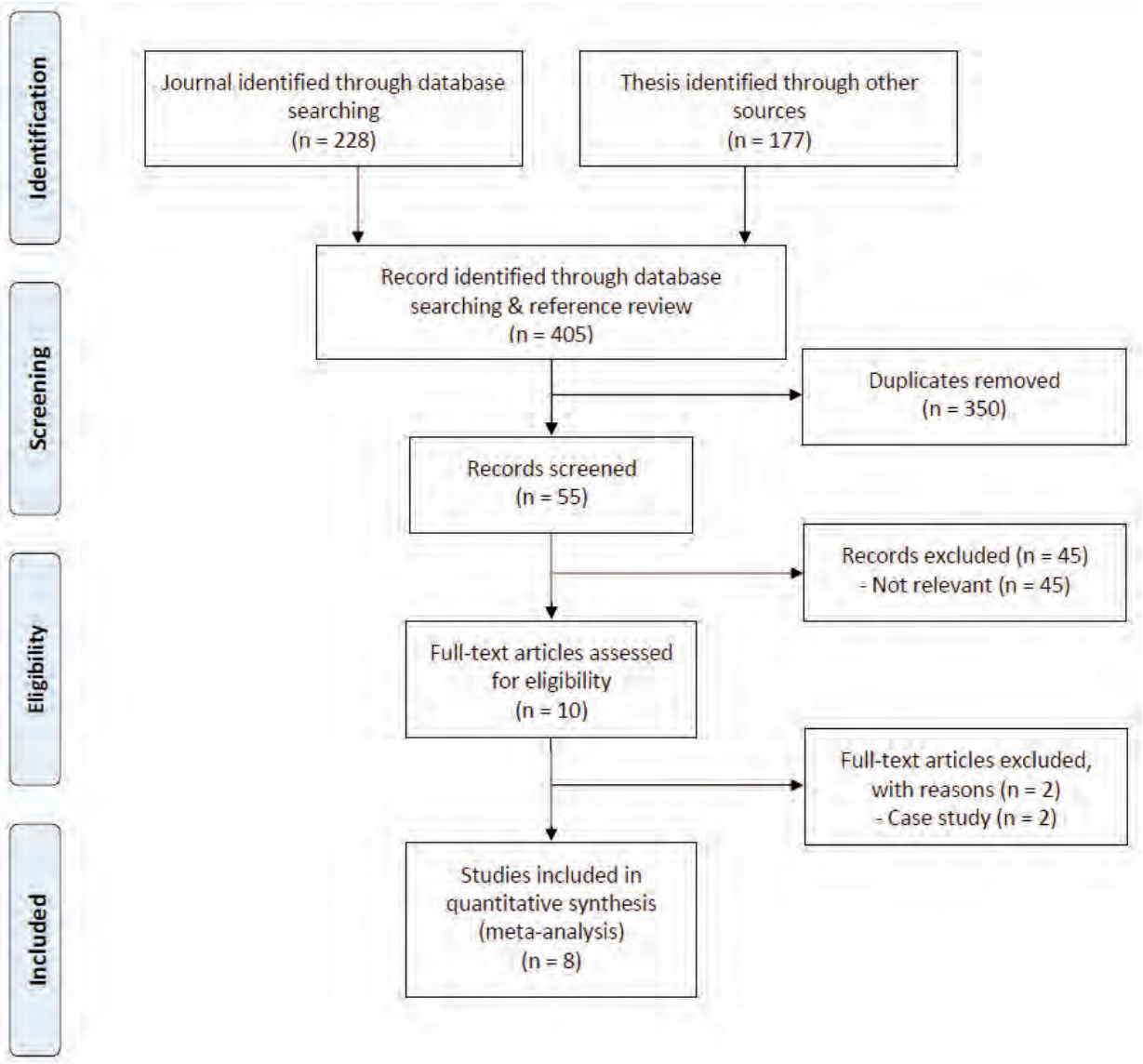

Figure 1. Flowchart of the study selection process

Thesis: 177) from the databases that were relevant to the search terms. Eight studies were finally included for analysis (Figure 1).[14,19-25]

Study characteristics

Four RCT studies and four NRCT studies were included to investigate the SE effect on patients with stroke. These were three journal articles and five theses. They were published between 2011 and 2020. All studies were published in Korean. The summarized characteristics of the studies included in our systematic review are presented in Table 1.

Methodological Quality of Included Studies

In this study, eight studies were conducted with methodological quality assessment using ROB (RCT: 5 studies) and RoBANS (NRCT: 3 studies) of the Cochrane library. The results are shown in Tables 2 and 3.

Table 1. Characteristics of studies included in the analysis

Authors (years)	Publication type	Study design	Patient characteristics, Sample size (G1: SE, G2: Control)	Intervention	Duration of trial period	Outcomes
Park (2011)	NRCT	NRCT	40 patients diagnosed with stroke (G1: 20, male: 11, female: 9; G2: 20, male 13, female: 7), Mean age (SD): G1=51.15(3.31); G2=48.65(2.86)	G1: SE G2: ME	Once 30 minutes, 3 times a week, 8 weeks in total	Biorescue, BBS, TUG, 10MWT, MMSE-K
Jang and Kim (2011)	Journal	RCT	20 patients diagnosed with stroke (G1: 10, male: unclear, female: unclear; G2: 10, male unclear, female: unclear), Mean age (SD): G1=56.60(4.74); G2=55.40(8.64)	G1: SE G2: GE	Once 40 minutes, 5 times a week, 4 weeks in total	TIS, EMG, FMA, MTD-BS
Park et al. (2012)	Journal	NRCT	16 patients diagnosed with stroke (G1: 8, male: 3, female: 5; G2: 8, male 4, female: 4), Mean age (SD): G1=67.25(4.65); G2=68.13(7.49)	G1: SE G2: GE	Once 50 minutes, 5 times a week, 12 weeks in total	BBS, PASS, MMAS, 10MWT, TUG, FIM
Lee (2012)	Thesis	NRCT	20 patients diagnosed with stroke (G1: 10, male: 6, female: 4; G2: 10, male 6, female: 4), Mean age (SD): G1=62.50(8.48); G2=63.40(4.94)	G1: SE G2: ME	Once 30 minutes, 3 times a week, 4 weeks in total	EMG, BBS, FICSIT-4, TUG, Biorescue
Kwon (2016)	Thesis	RCT	30 patients diagnosed with stroke (G1: 10, male: 6, female: 4; G2: 10, male: 5, female: 5; G3: 10, male: 6, female: 4), Mean age (SD): G1=53.00(6.89); G2=54.47(6.5); G3=56.57(7.13)	G1: VSBE G2: SBE G3: BE	Once 40 minutes, 3 times a week, 6 weeks in total	EMG, BT
Park (2016)	Thesis	RCT	30 patients diagnosed with stroke (G1: 15, male: 8, female: 7; G2: 15, male: 10, female: 5), Mean age (SD): G1=64.13(4.06); G2=63.53(3.37)	G1: SE G2: SSWE	Once 30 minutes, 5 times a week, 8 weeks in total	MS, Will, BBS, TUG
Choi (2018)	Thesis	RCT	20 patients diagnosed with stroke (G1: 10, male: 10, female: 0; G2: 10, male: 7, female: 3), Mean age (SD): G1=50.20(17.1); G2=58.70(14.5)	G1: SE G2: ME	Once 30 minutes, 3 times a week, 6 weeks in total	BBS, FRT, Gym plate, EMG
Jang et al. (2020)	Journal	RCT	16 patients diagnosed with stroke (G1: 8, male: 6, female: 2; G2: 8, male: 6, female: 2), Mean age (SD): G1=59.13(3.35); G2=54.88(4.05)	G1: VSE G2: GE	Once 35 minutes, 3 times a week, 6 weeks in total	Biorescue, LEGsys

G: group, NRCT: non-randomized controlled trials, SD: standard deviation, SE: sling exercise, ME: mat exercise, BBS: berg balance scale, TUG: timed up and go, 10MWT: 10 meter walk test, MMSE-K: mini mental state examination korea, RCT: randomized controlled trials, GE: general exercise, TIS: trunk impairment scale, EMG: Electromyography, FMA: fugl-meyer assessement, MTD-BS: measurement training and documentation-balance system, PASS: postural assessment scale for stroke patients, MMAS: modified motor assessment scale, FIM: functional independence measure, FICSIT-4: frailty and injuries cooperative studies of intervention technique-4, VSBE: vibration sling bridge exercise, SBE: sling bridge exercise, BE: bridge exercise, BT: balance trainer, SSWE: standing side wall exercise, MS: muscle strength, FRT: functional reaching test, VSE: vibration sling exercise

Table 2. Methodological evaluation of RCT study using RoB tool

Study	Random sequence generation	Allocation concealment	Blinding of participants	Blinding of outcome assesment	Incomplete outcome	Selective reporting	Other bias
Jang and Kim (2011)	Unclear	Unclear	High	High	Low	Unclear	Unclear
Kwon (2016)	Unclear	Unclear	High	High	High	Unclear	Unclear
Park (2016)	Unclear	Unclear	High	High	Low	Unclear	Unclear
Choi (2018)	Unclear	Unclear	High	High	Low	Unclear	Unclear
Jang et al. (2020)	Low	Unclear	High	High	Low	Unclear	Unclear

Table 3. Methodological evaluation of NRCT study using RoBANS tool

Study	Selection of participants	Confounding variables	Measurement of intervention	Blinding of outcome assessment	Incomplete outcome data	Selective reporting
Park (2011)	Low	Low	High	High	Low	Unclear
Park et al. (2012)	Low	Low	High	High	High	Unclear
Lee (2012)	Low	Low	High	High	Low	Unclear

Comparison of SE and OE for BBS

Five studies using BBS were performed to evaluate the effect of the treatment. The BBS score for the meta-analysis of SE was significantly improved (WMD=2.71, 95% CI [1.42, 4.45], P<0.00001) compared with other exercise alone, as shown in Figure 2 (P≤0.1 and I^2=75%); thus, the heterogeneity existed in every study. We further conducted sensitivity analysis, and the results were high, as shown in Figure 3.

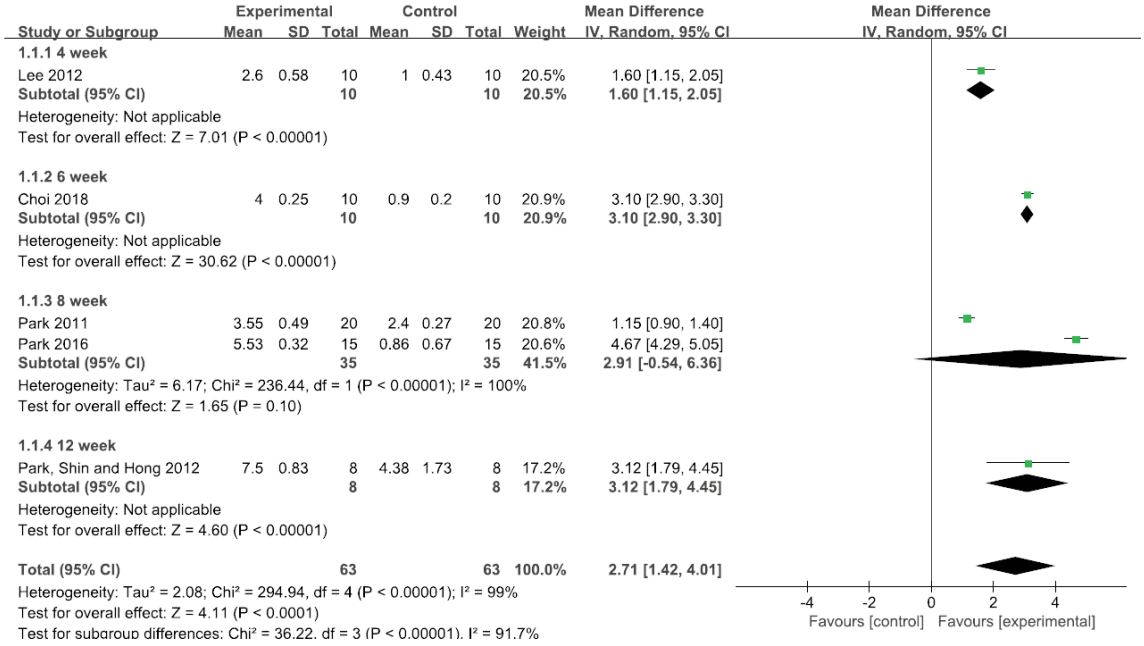

Figure 2. Forest plots for effect size comparison of SE and OE for BBS

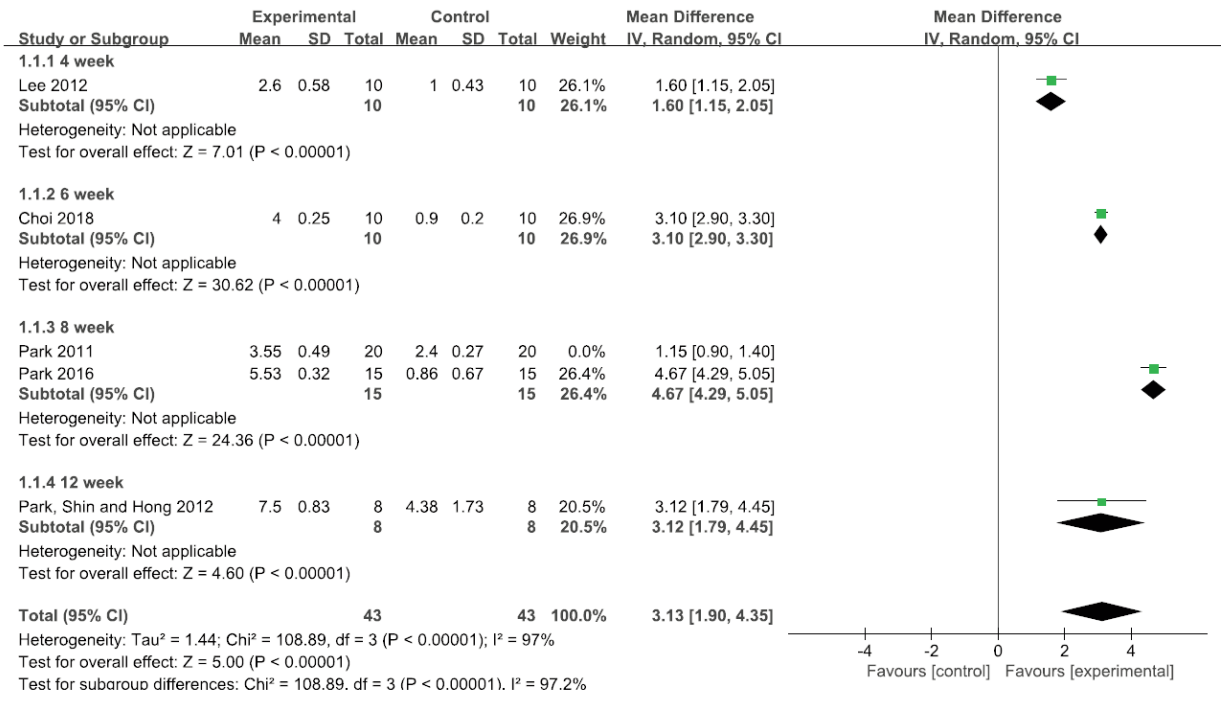

Figure 3. Forest plots for sensitivity analysis after effect size comparison of SE and OE for BBS

Comparison of SE and OE for TUG

Four studies using TUG were performed to evaluate the effect of the treatment. The TUG for the meta-analysis of SE was significantly improved (WMD=−1.89, 95% CI [−3.01, −0.77], P=0.0009) compared with other exercise alone, as shown in Figure 4($P \leq 0.1$ and I^2=75%); thus, the heterogeneity existed in every study. We further conducted sensitivity analysis, and the results were decrease, as shown in Figure 5.

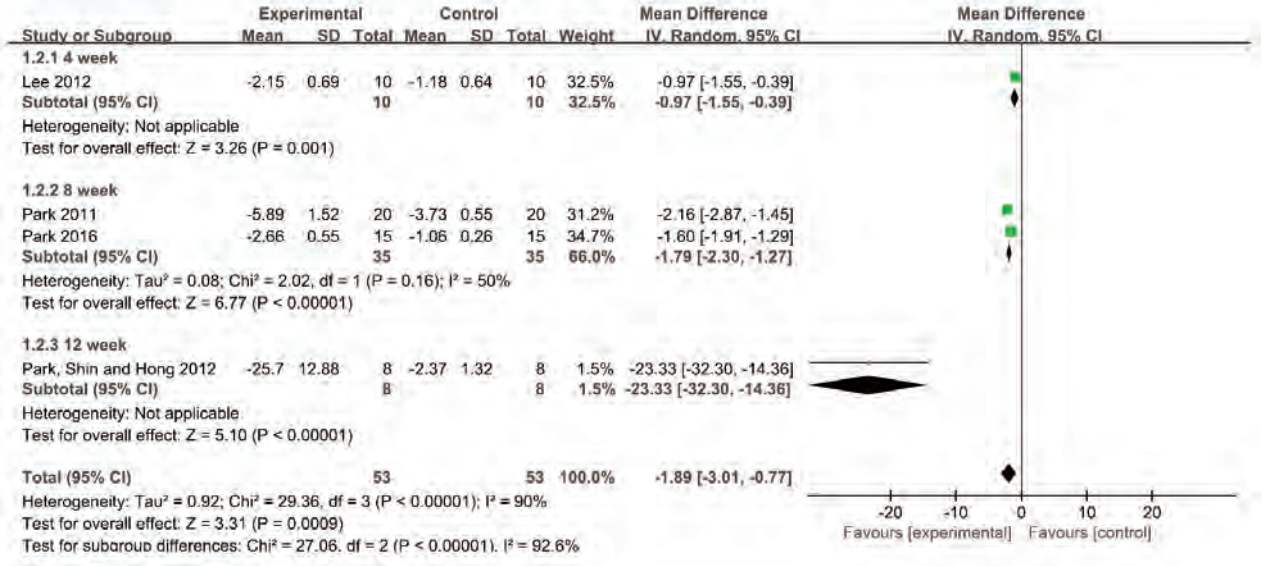

Figure 4. Forest plots for effect size comparison of SE and OE for TUG

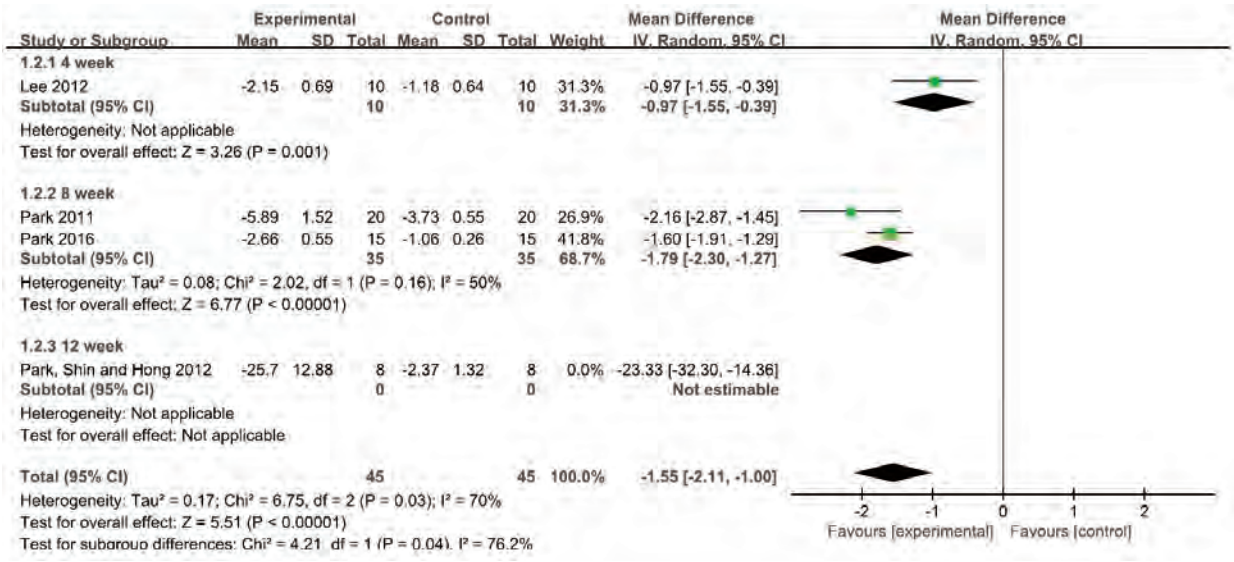

Figure 5. Forest plots for sensitivity analysis after effect size comparison of SE and OE for TUG

Other Types of Outcome Measures

A combined meta-analysis could not be performed because of the limited number of studies included and different evaluation methods employed. Park showed that Biorescue and 10MWT were significantly improved after SE.[20] Jang and Kim showed that FMA and MTD-BS were significantly improved after SE.[19] Park et al. showed that PASS, MMAS and 10MWT were significantly improved after SE.[21] Lee showed that FICSIT-4 and Biorescue were significantly improved after SE.[22] Kwon showed that BT was significantly improved after SE.[23] Park showed that Will was significantly improved after SE.[24] Choi showed that FRT and Gym-Plate were significantly improved after SE.[25] Jang et al. showed that Biorescue and LEGSys were significantly improved after SE.[14]

DISCUSSION

This study was conducted to investigate the effectiveness of SE through a meta-analysis of studies on SE therapy for patients with stroke that were published in South Korea. In this study, we analyzed balance and gait. In previous meta-analysis studies published abroad, only balance was studied. This suggests the necessity of analyzing the effect of SE on gait in stroke patients.

The effect size analyzed through meta-analysis in this study showed a high effect size of 2.71 for BBS and -1.89 for TUG. Balance had a larger effect size than gait. This result suggests that a sling provides an unstable support surface, which seems to have an effect on stabilizing the trunk of stroke patients by activating the trunk muscles more on the unstable support surface than on the stable support surface.[17] Therefore, it is thought that trunk control primarily improves balance ability, and its influence secondarily improves gait ability.[16,26]

A prior meta-analysis study of balance after applying SE to stroke patients also showed a high effect size. This was consistent with this study. For stroke patients, the effect of SE on gait came with a high effect size. However, there has been no study that determined the effect size by meta-analyzing gait after applying SE to stroke patients, so more studies need to be conducted.

Overall, heterogeneity in this study was high. The reason for the high heterogeneity is considered to be due to the difference of effect size according to the intervention period, as in the design of this study. Further analysis is needed to find the reasons for high heterogeneity in each period and on the whole. However, due to the lack of research, further analysis was not possible.

As a result of meta-analyzing a study published in Korea, SE was effective in improving balance and

gait. The results of this study could be used as evidence for the use of SE in the treatment of stroke patients in hospitals in Korea.

There are some limitations to this study. First, not only RCT, but also NRCT studies are included. Second, only studies with a small number of subjects are included. Third, unpublished article and hand search were not conducted in this study. Complementing these limitations will require future high-quality RCT and studies with larger sample sizes.

CONCLUSION

Based on eight limited studies, SE improved BBS and TUG over OE, suggesting improved stroke balance and gait. It should be used with caution due to the limitations of the studies included, such as small sample size and risk of bias. Therefore, more studies and large-scale sample RCTs are needed to confirm clinical application.

CONFLICT OF INTERESTS

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGEMENT

This study was supported (in part) by research funds from Nambu University, 2020.

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APPENDIX

Search strategy : RISS, KISS, NDSL, DBpia and Earticle

Koeran

#1 뇌졸중 AND 슬링

#2 뇌졸중 AND 슬링운동

#3 편마비 AND 슬링

#4 편마비 AND 슬링운동

English

#5 Stroke AND sling

#6 Stroke AND sling exercise

#7 Hemiplegia AND sling

#8 Hemiplegia AND sling exercise