The Effect Of Mirror Therapy On Improving Limb Function In Post-Stroke Patients With Hemiparesis: A Narrative Review

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Abstract

Stroke is a global health problem and deaths. Stroke with hemiparesis can cause long-term disability if not treated properly. Intervention with the right therapy can prevent various obstacles, one of which is mirror therapy which is an intervention method that is cheap, easy, safe, and can be done independently. However, the review of comprehensive studies is limited. This study aimed to determine the benefits of mirror therapy on the extremity function of post-stroke patients who had hemiparesis. This study used a narrative review approach basaed on PRISMA 2020 guidelines. Searching article were conducted in four databases, namely PubMed, CINAHL, Sage Journal, and Google Scholar, with the keywords were mirror therapy, Stroke rehabilitation, post-stroke, hemiparesis, and stroke. Inclusion criteria in this study were stroke patients with hemiparesis, randomized controlled trial (RCT) research design, quasi-experimental and clinical trials, using English and Indonesian, full-text articles available in 2012-2022, with the outcome of the study were quality of life, increased extremity motor function, cognitive, emotional and reduce the patient's pain. Results: twelve articles show the effect of mirror therapy in post-stroke patients who experience hemiparesis and the review notes that mirror therapy has a positive effect on motor improvement which has an impact on increasing the ability to carry out daily activities, preventing depressive disorders, and improving the quality of life of patients. The combination of the application of conventional rehabilitation therapy, neuromuscular electrical stimulation, and the use of virtual reality-based mirror therapy can enhance the therapeutic effect. Conclusion: Mirror therapy can be used as a therapeutic recommendation that can improve limb function in post-stroke patients. More research is needed by meta-analysis to find more comprehensive evidence.

Keywords: Hemiparesis, Mirror Therapy, Post Stroke

Introduction

Stroke was the second leading cause of death in the world in 2019 (Feigin et al., 2021). Ischemic stroke is the most common type of stroke. Stroke is the biggest health and economic burden. Globally 77.19 million people experience stroke, 63.48 million of whom live with disability, and 3.29 million experience death (Abbafati, Abbas, et al., 2020). It is thought that among adults over 25 years of age, the risk of stroke is 24.9% and ischemic stroke is 18.3% (Liyuan et al., 2023). This is due to the shift in lifestyle as the main risk factor that occurs today (WHO, 2019).

Stroke occurs due to rupture of blood vessels in the brain (Smith et al., 2017). After someone has a stroke, 80% of sufferers experience motor impairment in both upper and lower extremities (Gandhi et al., 2020). This impairment is usually caused by a stroke of the anterior cerebral artery, resulting in infarction of the part of the brain that should control movement, becoming uncontrollable again, in this context, the motor nerves of the frontal cortex (Toh & Fong, 2012). Impaired limb function has 80% mild paresis (weakness) and 20% severe paresis (Gandhi et al., 2020). Two-thirds of people with paresis disorders are unable to walk independently immediately after a stroke, and after the rehabilitation that is carried out, only half of them have independent walking function (Thieme et al., 2018). The initial severity of upper and lower extremity paresis is one of the most important predictors of long-term functional recovery after stroke (Rodrigues et al., 2016).

Recovery of the extremities after a stroke is a major problem that needs to be addressed immediately. The paresis experienced can result in muscle weakness, decreased soft tissue flexibility, and impaired motor control in stroke patients resulting in loss of coordination in maintaining posture and stroke can cause serious permanent physical disability (Olviani & Rahmawati, 2017). This condition prevents the patient from performing Activity Daily Living (ADL) such as dressing, walking, eating and washing, which basically requires muscle strength in carrying out these activities, making the patient feel very dependent on assistance and will continue until the patient returns home (Hwang et al., 2021).

Therapeutic interventions that can improve limb function are crucial to the recovery of stoke patients (Park et al., 2015). Various rehabilitation interventions have revealed therapeutic benefits towards the recovery of motor function, such as paresis arm exercise, distraction-oriented arm training, robot-assisted rehabilitation, weight training, and balance training (M & Kusgiarti, 2017). However, most of the available treatment protocols require manual interaction with a therapist for several weeks, which impacts the care provider to be more intensive and the cost of therapy is expensive. So a therapy that is simple, inexpensive, can be done independently and has the function of increasing the extremities of post-stroke patients is needed, namely mirror therapy (Thieme et al., 2018).

Mirror therapy is a relatively new therapeutic intervention that focuses on moving the unimpaired limb. It is a form of imaging where a mirror is used to transmit visual stimuli to the brain by observing the unaffected body part while performing a series of movements (Thieme et al., 2018). This procedure is performed by placing a mirror in the patient's midsagittal plane, so that the patient can see an image of the healthy hand and provide visual feedback so as to correct the hand on the paresis side (Dohle et al., 2009). Mirror therapy is performed by looking at and moving the healthy limb in front of the mirror and the affected limb behind the mirror (bilateral exercise). The bilateral exercise method is different from the unilateral exercise method because the bilateral exercise method combines the movements of both limbs simultaneously (Cunningham et al., 2015). The effect of Mirror therapy in addition to helping upper extremity recovery, can also help lower extremity recovery and reduce walking difficulties in post-stroke patients who experience hemiparesis with exercise 5 days a week for 4 weeks and at least 30 minutes per day (Maisyaroh et al., 2021).

Literature studies related to mirror therapy for stroke patients were conducted by Tong and Fong in 2012 and there is still limited

evidence reviewing the effects of mirror therapy on stroke patients. A new analysis is needed that reveals evidence of the effect of mirror therapy in post-stroke patients on limb function. This literatiure study is expected to provide an updated review of the effects of mirror therapy, as an evidence-based intervention in post-stroke patients. Therefore, this study aims to determine the effect of mirror therapy on the limb function of post-stroke patients who experience hemiparesis.

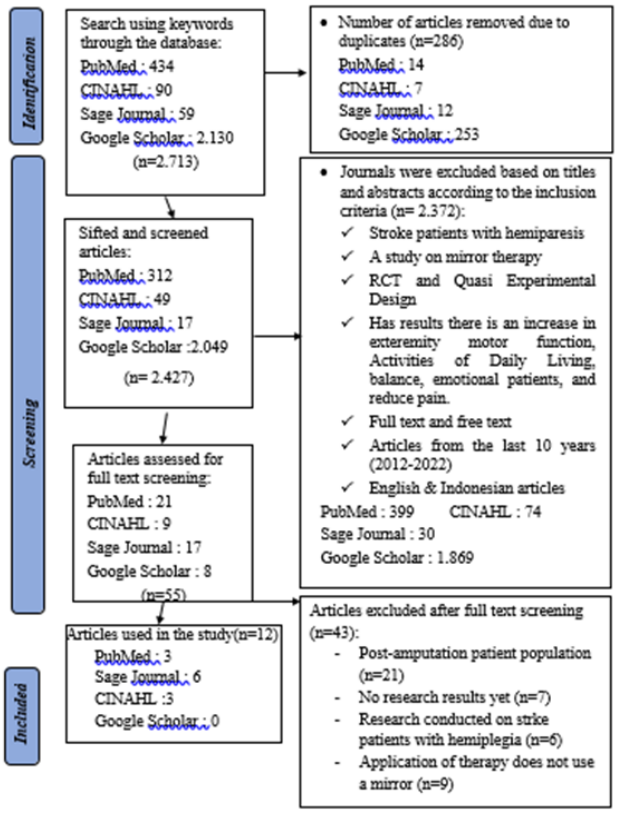
Research Methods

Design

This research uses a narrative review approach, which is a narrative literature study or narrative review that aims to identify and summarize articles that have been published, avoid duplication of research, and look for new areas of study that have not been researched. (Ferrari, 2015). The focus of the narrative review was to determine the effect of mirror therapy on limb function in post-stroke patients. The narrative review approach does not have a specific protocol, so the use of a systematic review methodology can be useful to improve the quality of the narrative review and reduce bias in the selection of articles for review (Ferrari, 2015). In addition, the use of a systematic review methodology is useful to assist in the selection of articles. The protocol used in the literature review to document and select study findings from several predetermined databases is the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) 27-item checklist.

Eligibility Criteria

The selection process of articles in this review was conducted by three reviewers through the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) 27-item checklist and described in chart form (Figure 1). The research questions and eligibility criteria for this research article used the PICO approach.



Picture 1. PRISMA flow diagram

PRISMA image adapted from Page MJ, et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. doi: 10.1136/bmj.n71

P (Population) : Pasien stroke hemiparesis
I (Intervention) : Mirror Therapy
C (Comparison) : No Comparison
O (Outcomes) : motor, ADL, emotional, pain, and balance

Secondary studies such as literature reviews and editorials were not included in this review. Inclusion criteria were full text in English, focus on adults older than 18 years, sample was hemiparesis stroke patients and articles reviewed mirror therapy published from 2012 to 2022.

Data Collection and Analysis

Search Strategy

The article search process was conducted with four main databases namely: PubMed, CINAHL, Sage Journal and Google Scholar, with the keywords "Stroke OR post stroke AND Hemiparesis AND Mirror movement therapy OR Mirror therapy AND Motoric function OR Activities of Daily Living OR Pain relief OR Balance". For each term verified by MeSH (Medical Subject Headings), synonyms were used to retrieve all relevant articles. The researcher used the Boolean operators "AND" and "OR" to truncate or expand the search results for different word forms.

Study Selection

Three authors selected articles that met the eligibility criteria. Articles were removed based on duplication at an early stage using a reference manager application. The authors conducted an evaluation by assessing the relevance of titles and abstracts after duplicates were removed. Then, the authors reviewed all eligible full-text articles according to the inclusion and exclusion criteria. Selected articles were analyzed for a more detailed review.

Data Extraction and Analysis

Data extraction in this study was carried out using tabular form to describe all results related to the topic discussed. The table contains data related to author, year, country, study design, sample size and characteristics, research instruments, key interventions and findings. Key points of discussion can be identified and grouped together for further discussion. This data extraction table was created to facilitate the authors in describing the review results.
Data analysis began with the identification and presentation of data obtained in the form of a table. All authors analyzed and explained each finding based on the findings of the effect of mirror therapy on limb function. After the results were obtained, categorization was carried out based on the type of mirror therapy provided, namely mirror therapy independently, a combination of mirror therapy with other therapies (conventional occupational therapy & physiotherapy and neuromuscular electrical stimulation therapy) and modified mirror therapy with a Virtual Reality (VR) approach.

Results

Study Characteristics

A total of 12 articles were analyzed from various years of publication found from 2012 to 2022. The 12 articles found were all in English. The research was conducted in various countries including 6 articles in South Korea, 3 articles in China, 3 other articles each conducted in Germany, Turkey, and Taiwan. The types of articles analyzed consisted of 1 quasi-experimental design article and 11 other articles with a Randomized Controlled Trial design.
This study involved 508 research samples. The sample size ranged from 25 to 69 participants. The average age of participants was between 45 and 65 years, dominated by 279 male and 197 female participants. However, one study did not specifically describe the sample distribution by gender (Lee et al., 2017). All samples in each article had an intervention group and a control group. From the results of all articles, there was a significant difference in limb function in patients who received mirror therapy intervention and

patients who did not receive the intervention or control group. The average mirror therapy intervention provided in all articles was 4-6 weeks with a therapy duration of 30 minutes. Differences in extremity function levels were measured and recognized after the end of the therapy session. The extraction results are shown in the following table (Table 1).

Table 1. Data Extraction

Author / Country	Study Design	Sample Size	Intervention	Duration	Outcome
(Thieme et al., 2012) Germany	RCT	60 patients	Mirror Therapy	30 minutes each session in 20 sessions over five weeks	•There was an improvement in motor function as evidenced by an increase in Fugl-Meyer Test scores over time ($P < 0.001$). •In ADL there was an increase in the ability to perform daily activities ($P < 0.001$). Results further improved on the last day of intervention •Passive range of motion and pain scores decreased over time
(K. Kim et al., 2016) South Korea	RCT	25 patients	Combination of mirror therapy and conventional stroke physiotherapy	30 minutes per session for five times a week	•There was an increase in the results of upper extremity motor measurements after administering mirror therapy for four weeks ($p<0.05$). •Mirror therapy can also increase patient independence in performing daily activities ($p<0.05$). •The findings state that the group with mirror therapy has improved results in all measurements with better results compared to the conventional physiotherapy group.
(M. K. Kim et al., 2016) South Korea	Quasi Experiment	34 patients	Mirror Therapy	30 minutes for 5 days/ week for 4 weeks.	•There was an improvement in balance in both the control and experimental groups ($p<0.05$). •Balance improvement is better aimed at the medial and lateral stability index sections
(Lim et al., 2016) South Korea	RCT	60 patients	Mirror Therapy	20 minutes per session	•Measurement of mobility function using the Brunnstrom stage found no change before and after the intervention. •In the upper extremity functional assessment with Fugl-Meyer Assessment, it was found that there was an increase after the intervention in the mirror therapy group ($p<0.001$). •There was an increase in independence in the patient's ADL function after the intervention ($p<0.001$)

(Gurbuz et al., 2016) **Turkey**	**RCT**	**31 patients**	**Mirror Therapy combined with conventional rehabilitation programs**	**20 minutes, 5 times a week**	**•There was an increase in Brunnstrom stage score in the mirror therapy group (P=0.001) and conventional therapy (P=0.008).** **•The Fugl-Meyer upper extremity functional score was found to improve in both groups but the mirror therapy group had a higher improvement (P=0.001) In the self-care score, there was an increase in ability in both groups, with the conventional therapy group having a better improvement in ability than the mirror therapy group (P<0.001, P=0.001).**
(Y. Park et al., 2015) **South Korea**	**RCT**	**30 patients**	**Mirror Therapy**	**5 days/ week for 6 weeks.**	**•There was an increase in motor function and self-care skills in the mirror therapy group (p<0.05).**
(Salem & Huang, 2015) **China**	**RCT**	**30 patients**	**Mirror Therapy**	**5 days a week for 4 weeks with a duration of 30 minutes per session**	**•There was an improvement in the motor recovery test results of both control and experimental groups.** **•The Brunnstrom measurement and dorsiflexion ankle ROM improved positively in both groups after treatment (p < 0.05).** **•The experimental group showed a significantly greater number and percentage increase in walking speed (p < 0.001).**
(Zhang et al., 2021) **China**	**RCT**	**60 patients**	**Mirror Therapy**	**30 minutes per session for five days per week, for a total of four weeks**	**•The mirror therapy group showed an increase in scores on motor function ability and ADL ability (P < 0.01).** **•In the assessment of depression, there was a decrease in depression scores after mirror therapy intervention in stroke patients (p<0.05).** **•The mirror therapy group showed better results in all assessments compared to the control group (p<0.001)**

(Xu et al., 2017) **China**	**RCT**	**69 patients**	**Mirror Therapy combined with neuromuscular electrical stimulation**	**30 minutes per session**	**•There was an improvement in walking ability in the mirror therapy group (P<0.05) and mirror therapy + neuromuscular electrical stimulation therapy (p<0.05).** **•The combination therapy group had a better improvement** **•In the measurement of lower extremity motor recovery, both groups showed improvement but had differences. In the mirror therapy group (P = 0.04) and the combination group had a better improvement (P < 0.001).** **•In the measurement of passive range of motion, better results were found in both groups. In the increase in flexibility found in the mirror therapy group compared to the combination group.**
(Lee et al., 2017) **South Korea**	**RCT**	**35 patients**	**Mirror Therapy**	**30 minutes per session twice a week**	**•There was a decrease in the balance index in the action observation therapy group with the activity group (P <0.05), increased in the mirror therapy group and mirror therapy observation group.** **•There was a decrease in the anteroposterior balance index in the action observation therapy group with the activity group (P <0.05) but increased in the mirror therapy group and the mirror therapy observation group In the fall risk assessment, there was a decrease in the action observation therapy group with the activity group and mirror therapy, and an increase in the observation group..**

(Hsu et al., 2022) **Taiwan**	**RCT**	**52 patients**	**Mirror Therapy combined with conventional occupational therapy, and virtual reality-based mirror therapy**	**30 minutes per session**	**•Overall, VR-based mirror therapy can improve motor function (P=0.075).** **•Improved wrist function was found in the VR-based mirror therapy group (P=0.004).** **•Better coordination improvement was shown in the VR-based mirror therapy group (P = 0.030) compared to the regular mirror therapy group (P = 0.016).** **•In the measurement of dexterity, there was an increase in both groups, but the VR-based mirror therapy group had a better effect on post-intervention (P=0.16) and follow-up (P=0.13). There was an increase in sensitivity to motor sensations in both groups, but there was no significant difference between the two groups (P<0.05).**
(In et al., 2016) **South Korea**	**RCT**	**25 patients**	**Virtual Reality-based Mirror Therapy**	**30 minutes, five days a week, for four weeks**	**•There was an improvement in balance results in both groups, both groups with regular mirror therapy and VR-based mirror therapy groups (P <0.05).** **•In the Berg Balance Scale balance score, there was a better balance improvement in the VR-based mirror therapy group (P<0.05).** **•Measurement of balance with the Timed Up and Go Test and walking ability with 10-meter walking velocity found that the group using VR-based mirror therapy had an increase (P < 0.05), while in the regular mirror therapy group there was no increase In changes in postural sway distance, all conditions with eyes open and medial-lateral sway with eyes closed showed a positive increase in VR-based mirror therapy (p < 0.05).**

Discussion

Mirror therapy is carried out by directing the patient to move the hemiplegic limb in accordance with the mirror reflection movement of a healthy hand movement, mirror therapy can be collaborated using virtual reality (VR), and can be collaborated with neuromuscular electrical stimulation (Hsu et al., 2022; In et al., 2016; Knutson et al., 2015). Mirror therapy had a positive impact on the group of patients who received a 45-minute treatment session with conventional therapy along with mirror therapy for three weeks, with the result that there was an effect on motor improvement and recovery of limbs that were impaired due to stroke, periodically (Chinnavan et al., 2020; Gurbuz et al., 2016; M.-K. Kim et al., 2016; Thieme et al., 2012).

Mirror therapy is considered as training to improve motor function, which is based on repetitive imagination (Thieme et al., 2012). Mirror therapy trains the patient's motor imagery or imagination, where the mirror provides visual stimulation to the brain for the movement of limbs that experience muscle weakness (Lesmana et al., 2018). The use of mirror therapy will have an effect on stroke patients with paresis, this will increase the ability of the patient's motor function to recover quickly. Therapeutic intervention of mirror therapy is effective to restore the motor function of patients (Van Peppen et al., 2004). Mirror therapy requires a large role from the patient, the patient is required to follow commands and perform movements voluntarily (French et al., 2016). For this reason, mirror intervention is not applicable to people with severe paresis after stroke, so mirror therapy is more appropriate for patients with mild paresis or hemiparesis (Thieme et al., 2018). Selain itu, mirror therapy merupakan terapi modalitas baru yang banyak digunakan and has a high potential to be recommended as a therapy that can be done by post-stroke patients because of its ease and simplicity of use and low cost, so that it can be a suitable alternative therapy for use (M.-K. Kim et al., 2016; Michielsen et al., 2011; Xu et al., 2017).

Hemiparesis patients diagnosed with stroke for more than 12 months can use mirror therapy as an exercise to improve limb function. There was an improvement in the motor recovery test results of both control and experimental groups, Brunnstrom measurement results and dorsiflexion ankle ROM increased positively in both groups after treatment ($p < 0.05$) and the experimental group showed a significantly greater number and percentage of walking speed improvements ($p < 0.001$). Mirror therapy has a positive impact on lower extremity functional improvement in stroke patients. In addition, walking ability also improved after therapy. Combination of conventional therapies can be considered to increase the benefits of therapy (Salem & Huang, 2015). Thus, for patients who have paresis for more than 12 months can use mirror therapy as the chosen intervention. The improvement of motor ability in stroke patients has been shown by various studies that reveal the effect of mirror therapy on stroke patients who experience hemiparesis. All articles show that mirror therapy can improve motor function in stroke patients. In addition, mirror therapy can also increase the range of motion (M.-K. Kim et al., 2016; Lee et al., 2017), balance (Hsu et al., 2022; Lee et al., 2017), walking ability (In et al., 2016; Lee et al., 2017; Salem & Huang, 2015; Xu et al., 2017), as well as movement speed and accuracy (M. K. Kim et al., 2016; Salem & Huang, 2015).

The effect of mirror therapy can be felt through combination therapy. In this study, two combination therapies were found, namely conventional stroke rehabilitation therapy and electrical stimulation therapy. The combination of conventional stroke rehabilitation therapy with mirror therapy can improve better results in the recovery of limbs that are impaired due to stroke. (Chinnavan et al., 2020; Gurbuz et al., 2016; K. Kim et al., 2016; M. K. Kim et al., 2016; Lee et al., 2017; Lim et al., 2016; Y. Park et al., 2015; Salem & Huang, 2015; Thieme et al., 2012). The use of mirror therapy combined with neuromuscular electrical stimulation therapy produces better results when compared to mirror therapy alone (Xu et al., 2017). Neuromuscular electrical stimulation is performed by placing one electrode over the common peroneal nerve of the affected

limb and another electrode at the midpoint of the anterior tibialis muscle of the affected leg. The effects of neuromuscular electrical stimulation are due to a combination of peripheral and central effects (Knutson et al., 2015). Peripheral effects consist of the conversion of type II muscle fibers to type I muscle fibers (Gondin et al., 2011), increased contractile strength and endurance, and increased muscle mass (Jones et al., 2016). Neuromuscular electrical stimulation can promote cortical reorganization through a central mechanism by activating motor and sensory nerve fibers (Shin et al., 2008).

The effect of using mirror therapy is also enhanced by the application of virtual reality (VR) (Hsu et al., 2022; In et al., 2016). Mirror therapy in VR is an effective strategy to promote functional motor recovery of stroke patients because VR provides therapy involving intensive visual, auditory, and haptic feedback from computerized technology (Laver et al., 2017; Massetti et al., 2018). The mirror visual illusion that emerges through VR systems reinforces multisensory integration, or the effect of visual signals interacting with bilateral proprioceptive signals (Giroux et al., 2018). VR technology is used as an observation medium for bilateral hand actions that can be an additional treatment for regular nerve rehabilitation for stroke patients (Choi et al., 2020). VR images of non-paretic extremities can improve the balance of cortical activation between hemispheres (Chang et al., 2019). Sensory function can also be enhanced by the use of VR through brain activation patterns (Diers et al., 2015). Stronger activation occurred in the primary sensorimotor cortex for VR-based mirror therapy compared to the traditional mirror box condition. Synchronous multisensory perception, viewing a mirrored hand presented in a VR scenario, increased activation in somatosensory areas more than viewing a hand in a mirror (Matamala-Gomez et al., 2019).

The inability of stroke patients to perform activities indirectly affects the psychological reactions of patients, namely the incidence of post-stroke depression (Husseini et al., 2017). Depression will worsen the motor-functional recovery process and reduce one's quality of life (Wijeratne, 2021). So, from the research that has been researched, the effects provided by mirror therapy can reduce a person's risk of experiencing post-stroke depression (Zhang et al., 2021). The use of mirrors suggests that the intervention can help reduce depression in post-stroke patients. This may be due to mirror therapy-induced activation of the cortex and other brain regions that are relevant to patients' depressive emotions. After activation of the cortex, mirror therapy can have a positive influence on the patient's emotions (Zhang et al., 2021). Effect of mirror therapy on balance, muscle strength, walking ability, and depression score reduction (Aimée et al., 2017). Similar research was conducted by Bekker et al (2022) revealing basic physical function is closely related to a decrease in depressive symptoms over time. A person who is less independent in performing daily activities after stroke, more often experiences feelings of depression (Kutlubaev & Hackett, 2014).

Conclusion

The study results show that mirror therapy has an effect on improving body functional abilities such as the ability to move, walk, reduce depression levels and improve the ability to perform daily activities in stroke patients with hemiparesis. In addition, this increase in ability can improve the quality of life of stroke patients so that they can restore patient activities in daily life. Of the 12 articles analyzed, there are four therapy options that can be carried out, namely mirror therapy alone, mirror therapy combined with conventional rehabilitation therapy, mirror therapy combined with neuromuscular electrical stimulation therapy and virtual reality-based mirror therapy. In the implementation of these therapies, there are various limitations, namely therapy can only be carried out on stroke patients with good mental and visual conditions, hearing ability and not experiencing total paralysis. Next study about cluster intervention in nursing to increase the quality of nursing care plan is needed.

References

Abbafati, C., Abbas, K. M., Abbasi-Kangevari, M., Abd-Allah, F., Abdelalim, A., Abdollahi, M., Abdollahpour, I., Abegaz, K. H., Abolhassani, H., Aboyans, V., Abreu, L. G., Abrigo, M. R. M., Abualhasan, A., Abu-Raddad, L. J., Abushouk, A. I., Adabi, M., Adekanmbi, V., Adeoye, A. M., Adetokunboh, O. O., … Murray, C. J. L. (2020). Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, 396(10258), 1223–1249. https://doi.org/10.1016/S0140-6736(20)30752-2

Abbafati, C., Machado, D. B., Cislaghi, B., Salman, O. M., Karanikolos, M., McKee, M., Abbas, K. M., Brady, O. J., Larson, H. J., Trias-Llimós, S., Cummins, S., Langan, S. M., Sartorius, B., Hafiz, A., Jenabi, E., Mohammad Gholi Mezerji, N., Borzouei, S., Azarian, G., Khazaei, S., … Zhu, C. (2020). Five insights from the Global Burden of Disease Study 2019. *The Lancet*, 396(10258), 1135–1159. https://doi.org/10.1016/S0140-6736(20)31404-5

Aimée, L., Kvæl, H., Bergland, A., & Telenius, E. W. (2017). A*ssociations between physical function and depression in nursing home residents with mild and moderate dementia : a cross-sectional study*. 1–11. https://doi.org/10.1136/bmjopen-2017-016875

Bekker, A. De, Geerlings, M. I., Uitewaal-poslawsky, I. E., & Ginkel, J. M. D. M. (2022). Depression in Stroke Survivors : Ten-Year Follow-Up . Determinants of the Natural Course of Depressive Symptoms in Stroke Survivors in the Netherlands : *The SMART-Medea Study.* 31(3), 1–9. https://doi.org/10.1016/j.jstrokecerebrovasdis.2021.106272

Cabanas-Valdés, R., Bagur-Calafat, C., Girabent-Farrés, M., Caballero-Gómez, F. M., Hernández-Valiño, M., & Urrútia Cuchí, G. (2016). The effect of additional core stability exercises on improving dynamic sitting balance and trunk control for subacute stroke patients: a randomized controlled trial. *Clinical Rehabilitation*, 30(10), 1024–1033. https://doi.org/10.1177/0269215515609414

Chinnavan, E., Priya, Y., Ragupathy, R., & Wah, Y. C. (2020). Effectiveness of mirror therapy on upper limb motor functions among hemiplegic patients. *Bangladesh Journal of Medical Science*, 19(2), 208–213. https://doi.org/10.3329/bjms.v19i2.44997

Cunningham, D. A., Potter-Baker, K. A., Knutson, J. S., Sankarasubramanian, V., Machado, A. G., & Plow, E. B. (2015). Tailoring Brain Stimulation to the Nature of Rehabilitative Therapies in Stroke: A Conceptual Framework Based on their Unique Mechanisms of Recovery. *Physical Medicine and Rehabilitation Clinics of North America*, 26(4), 759–774. https://doi.org/10.1016/j.pmr.2015.07.001

de Jong, L. D., van Wijck, F., Stewart, R. E., Geurts, A. C. H., & Dijkstra, P. U. (2018). Content of conventional therapy for the severely affected arm during subacute rehabilitation after stroke: An analysis of physiotherapy and occupational therapy practice. Physiotherapy Research International : *The Journal for Researchers and Clinicians in Physical Therapy*, 23(1). https://doi.org/10.1002/pri.1683

Feigin, V. L., Stark, B. A., Johnson, C. O., Roth, G. A., Bisignano, C., Abady, G. G., Abbasifard, M., Abbasi-Kangevari, M., Abd-Allah, F., Abedi, V., Abualhasan, A., Abu-Rmeileh, N. M. E., Abushouk, A. I., Adebayo, O. M., Agarwal, G., Agasthi, P., Ahinkorah, B. O., Ahmad, S., Ahmadi, S., … Murray, C. J. L. (2021). Global, regional, and national burden of stroke and its risk factors, 1990-2019: A systematic analysis for the Global Burden of Disease Study 2019. *The Lancet Neurology,* 20(10), 1–26. https://doi.org/10.1016/S1474-4422(21)00252-0

Ferrari, R. (2015). Writing narrative style literature reviews. *Medical Writing*, 24(4), 230–235. https://doi.org/https://doi.org/10.1179/2047480615z.000000000329

French, B., Thomas, L. H., Coupe, J., McMahon, N. E., Connell, L., Harrison, J., Sutton, C. J., Tishkovskaya, S., & Watkins,

C. L. (2016). R*epetitive task training for improving functional ability after stroke. The Cochrane Database of Systematic Reviews*, 11(11), CD006073. https://doi.org/10.1002/14651858.CD006073.pub3

Gandhi, D. B., Sterba, A., Khatter, H., & Pandian, J. D. (2020). Mirror Therapy in Stroke Rehabilitation: Current Perspectives. *Therapeutics and Clinical Risk Management*, 16, 75–85. https://doi.org/10.2147/TCRM.S206883

Gondin, J., Brocca, L., Bellinzona, E., D'Antona, G., Maffiuletti, N. A., Miotti, D., Pellegrino, M. A., & Bottinelli, R. (2011). Neuromuscular electrical stimulation training induces atypical adaptations of the human skeletal muscle phenotype: a functional and proteomic analysis. *Journal of Applied Physiology* (Bethesda, Md. : 1985), 110(2), 433–450. https://doi.org/10.1152/japplphysiol.00914.2010

Gurbuz, N., Afsar, S. I., Ayaş, S., & Cosar, S. N. S. (2016). Effect of mirror therapy on upper extremity motor function in stroke patients: A randomized controlled trial. *Journal of Physical Therapy Science,* 28(9), 2501–2506. https://doi.org/10.1589/jpts.28.2501

Haruyama, K., Kawakami, M., & Otsuka, T. (2017). Effect of Core Stability Training on Trunk Function, Standing Balance, and Mobility in Stroke Patients. *Neurorehabilitation and Neural Repair*, 31(3), 240–249. https://doi.org/10.1177/1545968316675431

Hsu, H. Y., Kuo, L. C., Lin, Y. C., Su, F. C., Yang, T. H., & Lin, C. W. (2022). Effects of a Virtual Reality–Based Mirror Therapy Program on Improving Sensorimotor Function of Hands in Chronic Stroke Patients: A Randomized Controlled Trial. *Neurorehabilitation and Neural Repair,* 36(6), 335–345. https://doi.org/10.1177/15459683221081430

Husseini, N. El, Hackett, M. L., Jorge, R. E., Kissela, B. M., Mitchell, P. H., Skolarus, L. E., Whooley, M. A., & Williams, L. S. (2017). *AHA / ASA Scientific Statement Poststroke Depression.* 30–43. https://doi.org/10.1161/STR.0000000000000113

Hwang, N. K., Park, J. S., & Chang, M. Y. (2021). Telehealth interventions to support self-management in stroke survivors: A systematic review. In Healthcare (Switzerland) (Vol. 9, Issue 4). *MDPI AG.* https://doi.org/10.3390/healthcare9040472

In, T., Lee, K., & Song, C. (2016). Virtual Reality Reflection Therapy Improves Balance and Gait in Patients with Chronic Stroke: Randomized Controlled Trials. Medical Science Monitor : International Medical *Journal of Experimental and Clinical Research*, 22, 4046–4053. https://doi.org/10.12659/msm.898157

Kim, K., Lee, S., Kim, D., Lee, K., & Kim, Y. (2016). Effects of mirror therapy combined with motor tasks on upper extremity function and activities daily living of stroke patients. *Journal of Physical Therapy Science*, 28(2), 483–487. https://doi.org/10.1589/jpts.28.483

Kim, M.-K., Ji, S.-G., & Cha, H.-G. (2016). The effect of mirror therapy on balance ability of subacute stroke patients. *Hong Kong Physiotherapy Journal : Official Publication of the Hong Kong Physiotherapy Association* Limited = Wu Li Chih Liao, 34, 27–32. https://doi.org/10.1016/j.hkpj.2015.12.001

Kim, M. K., Ji, S. G., & Cha, H. G. (2016). The effect of mirror therapy on balance ability of subacute stroke patients. *Hong Kong Physiotherapy Journal,* 34, 27–32. https://doi.org/10.1016/j.hkpj.2015.12.001

Knutson, J. S., Fu, M. J., Sheffler, L. R., & Chae, J. (2015). Neuromuscular Electrical Stimulation for Motor Restoration in Hemiplegia. *Physical Medicine and Rehabilitation Clinics of North America,* 26(4), 729–745. https://doi.org/10.1016/j.pmr.2015.06.002

Kutlubaev, M. A., & Hackett, M. L. (2014). Part II : *predictors of depression after stroke and impact of depression on stroke outcome : an updated systematic review of observational studies*. 9(August), 1026–1036. https://doi.org/10.1111/ijs.12356

Lee, H. J., Kim, Y. M., & Lee, D. K. (2017). The effects of action observation training and mirror therapy on gait and balance in stroke patients. *Journal of Physical Therapy Science*, 29(3), 523–526. https://doi.org/10.1589/jpts.29.523

Lim, K. B., Lee, H. J., Yoo, J., Yun, H. J., & Hwang, H. J. (2016). Efficacy of mirror therapy containing functional tasks in poststroke patients. *Annals of Rehabilitation Medicine*, 40(4), 629–636. https://doi.org/10.5535/arm.2016.40.4.629

Liyuan Pu., Li Wang., Ruijie Zhang., Tian Zhao., Yannan Jiang., L. H. (2023). Projected Global Trends in Ischemic Stroke Incidence, Deaths and Disability-Adjusted Life Years From 2020 to 2030. *AHA Juournal,* 53, 1330–1339. https://doi.org/10.1161/STROKEAHA.122.040073

Mahmood, W., Syed, H., Ahmed, I., Ehsan, S., Sagheer, B., & Mahmood, T. (2022). Effect of core stabilization exercises in addition to conventional therapy in improving trunk mobility , function , ambulation and quality of life in stroke patients : a randomized controlled trial. *BMC Sports Science, Medicine and Rehabilitation,* 1–9. https://doi.org/10.1186/s13102-022-00452-y

Maisyaroh, A., Azizah, K. N., Abdillah, A., & Fibriansari, R. D. (2021). Efektivitas Mirror Therapy Terhadap Peningkatan Kekuatan Otot Pada Pasien Post Stroke: Literatur Review. *Jurnal Ilmu Keperawatan Medikal Bedah*, 4(1), 13–24. https://doi.org/10.32584/jikmb.v4i1.713

Michielsen, M. E., Selles, R. W., van der Geest, J. N., Eckhardt, M., Yavuzer, G., Stam, H. J., Smits, M., Ribbers, G. M., & Bussmann, J. B. J. (2011). Motor recovery and cortical reorganization after mirror therapy in chronic stroke patients: a phase II randomized controlled trial. *Neurorehabilitation and Neural Repair,* 25(3), 223–233. https://doi.org/10.1177/1545968310385127

Olviani, Y., & Rahmawati, I. (2017). Pengaruh Latihan Range of Motion (Rom) Aktif-Asistif (Spherical Grip) Terhadap Peningkatan Kekuatan Otot Ekstremitas Ataspada Pasien Stroke Di Ruang Rawat Inap Penyakit Syaraf (Seruni) Rsud Ulin Banjarmasin. *Dinamika Kesehatan*, 8(1), 250–257. https://ojs.dinamikakesehatan.unism.ac.id/index.php/dksm/article/view/249/192

Park, J. Y., Chang, M., Kim, K. M., & Kim, H. J. (2015). The effect of mirror therapy on upper-extremity function and activities of daily living in stroke patients. *Journal of Physical Therapy Science*, 27(6), 1681–1683. https://doi.org/10.1589/jpts.27.1681

Park, Y., Chang, M., Kim, K.-M., & An, D.-H. (2015). The effects of mirror therapy with tasks on upper extremity function and self-care in stroke patients. *Journal of Physical Therapy Science*, 27(5), 1499–1501. https://doi.org/10.1589/jpts.27.1499

Rodrigues, L. C., Farias, N. C., Gomes, R. P., & Michaelsen, S. M. (2016). Feasibility and effectiveness of adding object-related bilateral symmetrical training to mirror therapy in chronic stroke: A randomized controlled pilot study. *Physiotherapy Theory & Practice*, 32(2), 83–91. https://doi.org/10.3109/09593985.2015.1091872

Salem, H. M. A., & Huang, X. (2015). The Effects of Mirror Therapy on Clinical Improvement in Hemiplegic Lower Extremity Rehabilitation in Subjects with Chronic Stroke. *International Journal of Medical, Health, Biomedical, Bioengineering and Pharmaceutical Engineering*, 9(2), 163–166.

Shin, H. K., Cho, S. H., Jeon, H., Lee, Y.-H., Song, J. C., Jang, S. H., Lee, C.-H., & Kwon, Y. H. (2008). Cortical effect and functional recovery by the electromyography-triggered neuromuscular stimulation in chronic stroke patients. *Neuroscience Letters,* 442(3), 174–179. https://doi.org/10.1016/j.neulet.2008.07.026

Smith, E. E., Saposnik, G., Biessels, G. J., Doubal, F. N., Fornage, M., Gorelick, P. B., Greenberg, S. M., Higashida, R. T., Kasner, S. E., & Seshadri, S. (2017). Prevention of Stroke in Patients With Silent Cerebrovascular Disease: A Scientific Statement for

Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke*, 48(2), e44–e71. https://doi.org/10.1161/STR.0000000000000116

Stevens, J. A., & Stoykov, M. E. P. (2003). Using motor imagery in the rehabilitation of hemiparesis. *Archives of Physical Medicine and Rehabilitation*, 84(7), 1090–1092. https://doi.org/10.1016/s0003-9993(03)00042-x

Thieme, H., Bayn, M., Wurg, M., Zange, C., Pohl, M., & Behrens, J. (2012). Mirror therapy for patients with severe arm paresis after stroke – *a randomized controlled trial. Clinical Rehabilitation*, 27(4), 314–324. https://doi.org/10.1177/0269215512455651

Thieme, H., Morkisch, N., Mehrholz, J., Pohl, M., Behrens, J., Borgetto, B., & Dohle, C. (2018). Mirror therapy for improving motor function after stroke. In Cochrane Database of Systematic Reviews (Vol. 2018, Issue 7). John Wiley and Sons Ltd. https://doi.org/10.1002/14651858.CD008449.pub3
Toh SF, F. K. (2012). Systematic review on the effectiveness of mirror therapy in training upper limb hemiparesis after stroke. *Hong Kong Journal of Occupational Therapy*, 22(2), 84–95.

Van Peppen, R. P. S., Kwakkel, G., Wood-Dauphinee, S., Hendriks, H. J. M., Van der Wees, P. J., & Dekker, J. (2004). The impact of physical therapy on functional outcomes after stroke: what's the evidence? *Clinical Rehabilitation*, 18(8), 833–862. https://doi.org/10.1191/0269215504cr843oa

WHO. (2019). W*HO package of essential noncommunicable (PEN) disease interventions for primary health care*.

Wijeratne, T. (2021). *Understanding Why Post-Stroke Depression May Be the Norm Rather Than the Exception : The Anatomical and Neuroinflammatory Correlates of Post-Stroke Depression.*

Xu, Q., Guo, F., Salem, H. M. A., Chen, H., & Huang, X. (2017). Effects of mirror therapy combined with neuromuscular electrical stimulation on motor recovery of lower limbs and walking ability of patients with stroke: a randomized controlled study. *Clinical Rehabilitation*, 31(12), 1583–1591. https://doi.org/10.1177/0269215517705689

Zhang, X., Zhang, Y., Liu, Y., & Yao, Q. (2021). Effectiveness of mirror therapy on upper limb function, activities of daily living, and depression in post-stroke depression patients. Turkish *Journal of Physical Medicine and Rehabilitation*, 67(3), 365–369. https://doi.org/10.5606/tftrd.2021.6635