

Effectiveness of Motor Relearning Program in Improving Walking Ability of Post-Stroke Patients: Meta-Analysis

Syazana Zahra Umardi¹, Hilmi Ega Muktabar², Salsabila Saufia Aura Sadin³, Amre Alfarif Khan⁴, Taqiyyah Nurul ‘Azzah⁵, Annisa Nur Kholifah⁶, Arif Pristianto^{7*}

^{1,2,3,4,5,6,7}Program Studi Fisioterapi, Fakultas Ilmu Kesehatan, Universitas Muhammadiyah Surakarta, Indonesia

Email: arif.pristianto@ums.ac.id

Submission : 2024-06-27; Accepted : 2024-10-14; Published : 2025-01-01

ABSTRACT

Introduction: Stroke is a disorder of brain function due to rupture or blockage of blood vessels in the brain. To collect and analyze previous studies related to the improvement of walking ability of post-stroke patients with MRP intervention compared with functional training. **Methods:** The meta-analysis method by sourcing seven research articles that were searched using PICO criteria consisting of population, namely post-stroke patients, intervention provided, namely Motor Relearning Program, and comparisons in the form of functional training with outcomes of improved walking ability. Keywords used in searching articles are “Motor Relearning Program”, “stroke”, and “randomised controlled trial” through a database in the form of Google Scholar. Data was processed using the Review Manager application (RevMan 5.3). **Results:** There was an increase in walking ability in stroke patients who were given a motor relearning program by 1.83 units compared to patients who were given functional training (SMD = 1.83; 95% CI = 0.01 to 3.65) and the results were statistically significant ($p < 0.00001$). The heterogeneity of the study data showed $I^2 = 97\%$ (random effect model). **Conclusion:** A Motor Relearning Program (MRP) is more effective than functional training in improving walking ability in post-stroke patients.

Keywords: Motor Relearning Program (MRP), stroke patients, functional training, walking ability, meta-analysis.

INTRODUCTION

A stroke is a sudden disruption of brain function due to damaged blood vessels and lasts for one day or more (Liu et al., 2018). Based on data from WHO (World Health Organization), there are 15 million stroke sufferers worldwide every year.

Among them, 5,000,000 people died and 5,000,000 others experienced post-stroke disability (Johnson et al., 2016). From 1990 to 2019, the total data on Disability Adjusted Life Years (DALY), stroke risk factors increased from 91.5 million to 125.0 million (Feigin et al., 2022). Although stroke is a deadly disease, the reality is that stroke sufferers can recover completely, but the majority of sufferers have some residual symptoms. Some that appear are disorders of motor, sensory, balance, postural control and

reflexes caused by damage to blood circulation in the brain (Maratis et al., 2020).

Difficulty in motor control, coordination, postural control, maintaining balance and poor gait are common in post-stroke patients (Adi et al., 2023). In the context of balance, changes in posture are a control of upright position and as feedback due to external disturbances (Naz et al., 2022). Impaired balance is one of the motor disorders that can cause disability and increase the risk of falls, especially when walking in stroke patients (Sahin et al., 2019).

Functional ability is an Activity of Daily Living (ADL) consisting of self-care behavior and body, mobilization, and eating and drinking activities so that it is usually called physical ADL or essential ADL to meet basic human physical needs (Pristianto et al., 2022). On the other hand, walking activity is one of the important daily

activities. Therefore, so that daily activities are not disturbed, treatment is needed to improve the walking ability of post-stroke patients.

In stroke treatment, there are several neurophysiological exercises. The principle of this exercise approach is to regain voluntary control and mobility after stroke (Kanase, 2020). The two exercises that are the focus of this study are MRP and functional training. Motor Relearning Program (MRP) is a rehabilitation treatment for stroke patients aimed at improving specific motor control and specific motor exercises and controlled muscle contractions. This program is carried out with repetitive and intensive exercises that gradually increase the level of difficulty so that lost functions can return. The four factors used in MRP to improve motor skills are not doing unnecessary muscle activities, responding, practicing, and combining posture adjustments. This exercise can stimulate brain recovery by involving cognitive and learning functions (Ghrouz et al., 2023).

Functional training includes Conventional Physical Therapy (CPT) and the bobath concept. CPT includes several aspects of training, including gait, balance, stretching and strengthening. The training uses MAT exercises, assisted exercises, weight bearing exercises, gymnasium exercises, electrical stimulation, and others (Kanase, 2020). Meanwhile, Bobath said that the Bobath approach is a neurodevelopment technique based on motor control using problem-solving as an assessment and rehabilitation of individuals who experience impaired function, movement, and postural control due to central nervous system lesions (Bhalerao et al., 2013). Functional mobility is greatly affected and requires the attention of a physiotherapist because it is an important part to be repaired (Kanase, 2020).

A previous study showed that stroke rehabilitation based on Bobath and movement science conducted by Van Vliet et al. (2005),

resulted in no significant difference in movement ability or functional independence between patients in the Bobath Based (BB) intervention group and patients in the Movement Science Based (MSB) group. This shows that no one intervention approach is more effective than another in a rehabilitation program (Kanase, 2020). Meanwhile, in a study conducted by Hasbiah & Ahmad (2021), regarding the provision of MRP and PNF to improve the functional abilities of post-stroke patients, there was no significant difference so in increasing functional activities, the MRP or PNF approach can be used.

The ability to walk supported by the trunk, lower extremity function, and balance are important elements in mobility that support human functional activities (Pristianto et al., 2024). The importance of improving walking ability is a challenge for post-stroke rehabilitation programs. Exercise is needed as a modality to rehabilitate post-stroke patients to improve their abilities, especially in the lower extremities because it is related to walking ability and mobility.

Descriptions related to post-stroke disability and the importance of lower extremity ability in mobility require serious attention in efforts to improve the abilities of post-stroke patients. Previous studies that show differences in the effectiveness of selected exercise programs certainly require proof with other studies. The purpose of this study was to compare the effectiveness of MRP interventions with other interventions. This study focuses on comparing the concept of motor relearning programs with functional training exercises. The formulation and formulation of the problem, namely with clinical questions using the PICO format so that the literature search process is more focused. The PICO formulation in this analysis study is presented in Table 1.



Table 1. PICO Formulation

Population	Intervention (I)	Comparison (C)	Outcome (O)
Subjects experiencing post-stroke	<i>Motor Relearning Program (MRP)</i>	<i>Functional training</i>	Improves walking ability
Types of clinical questions	Therapy		
Study Design	Randomized controlled trial, without systematic review and meta-analysis		

METHODS

Literature study search was conducted on 1 database, namely Google Scholar®. The keywords used were "motor relearning program", "stroke" and "randomized controlled trial". A total of 7 research articles have been included in the study in the form of a meta-analysis "Effectiveness of Motor Relearning Program in Improving Walking Ability of Post-Stroke Patients". This study involved a total of 306 research subjects.

The inclusion criteria used were (1) studies with a randomized controlled trial design, (2) research with a total of at least 22 subjects, (3) research subjects were post-stroke patients, (4) literature published in the 2010-2024 period. Meanwhile, the exclusion criteria for literature not used in this study were (1) studies with systematic reviews, meta-analyses, and quasi-experiments, (2) subjects below a total of 22, (3) research subjects who were not stroke patients, (4) literature published below the 2010 period.

The study measured in this study used instrument tools, namely TUG (Timed Up Go), Motor Assessment Scale (walking), BBS (Berg Balance Scale), and FIM (Functional Independence Measurement). From the use of these instrument tools, the outcome that will be produced is an increase in walking ability.

The data that has been collected will be processed and analyzed using the Review

Manager Application (RevMan 5.3) released by the Cochrane Collaboration by calculating the standard mean deviation value. The data processing process involves calculating the effect size and evaluating heterogeneity with random effect model data analysis.

RESULTS

Based on Figure 1, the number of excluded journals is 1,451 and 139 studies were obtained which were then analyzed and screened, in conducting screening and creating PRISMA flow. Furthermore, 30 journals were assessed for eligibility. Of the 30 journals selected, 19 journals were in accordance with the research objectives, and 12 journals were excluded because they did not meet the inclusion criteria and 7 journals were reviewed after being eliminated with research topics.

A total of 7 research articles have been included in the study in the form of a meta-analysis "Effectiveness of Motor Relearning Program in Improving the Walking Ability of Post-Stroke Patients". These studies involved a total of 306 research subjects. The 7 articles are spread across various continents. There are 5 articles from the Asian continent, namely 1 article from the UAE, 3 articles from India, and 1 article from Pakistan. Then, there are 2 articles from the European continent, namely 1 article from Norway, and 1 article from Spain.



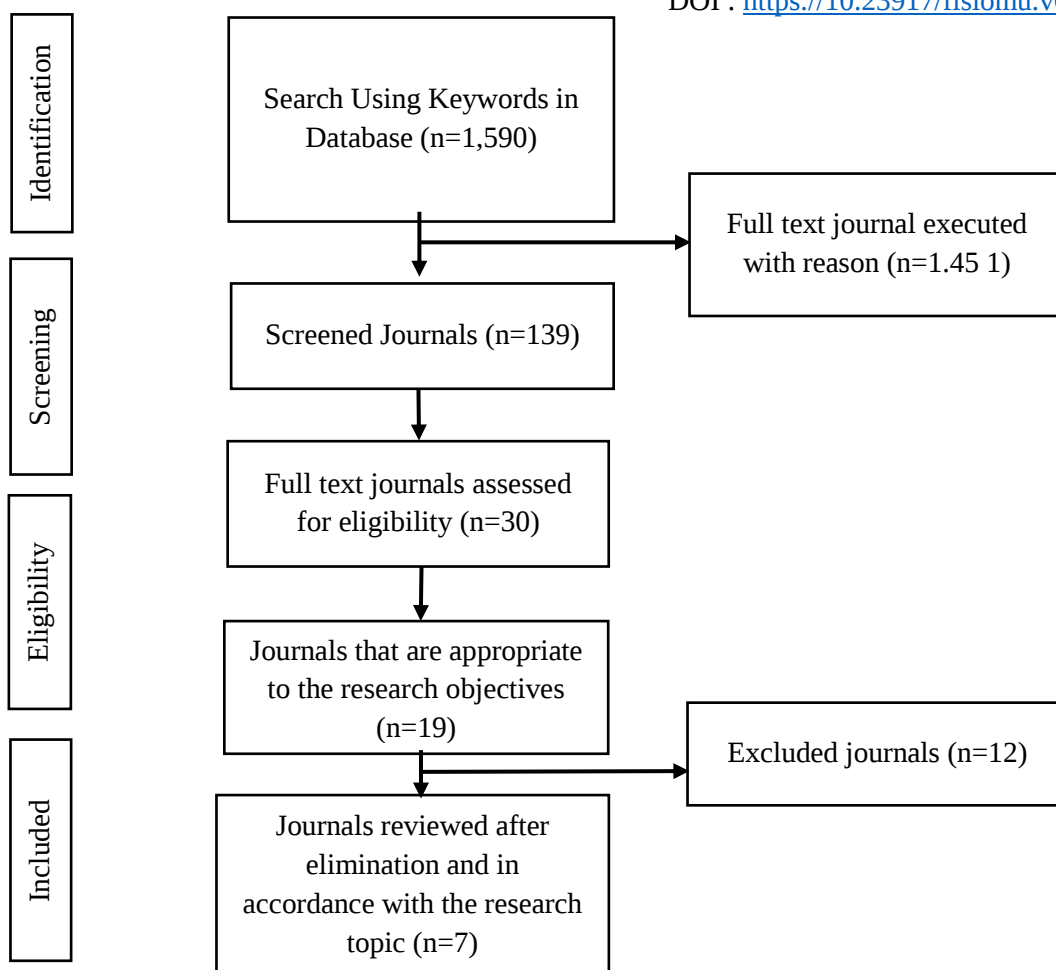


Figure 1. Journal Search Flow Chart

Table 2. Characteristics of Each Journal

No	Title	Writer	Year	Number of Respondents	MRP Intervention	Functional Training
1	Motor Relearning Program Versus Proprioceptive Neuromuscular Facilitation Technique for Improving Basic Mobility in Chronic Stroke Patients-A Comparative Study	Ranjeet Singha	2017	30	n = 15 (TUG) 27.06(2.46)	n = 15 (TUG) 37.266(5.65)
2	Effect of Motor Relearning Programme and Conventional Training on Functional Mobility in Post-Stroke Patients	Suraj Kanase	2020	30	n = 15 (Walking) 4.92(0.47)	n = 15 (Walking) 3.4(0.82)
3	The Effect of A Motor Relearning on Balance and Postural Control in Patients After Stroke: An Open-Label Randomized Controlled Trial	Amer Ghrouz, Anna Guillen-Sola, Andrea Morgado-Perez, Elena Muñoz-Redondo, Cindry Ramírez-Fuentes, Yulibeth Curbelo Peña, Esther Duarte	2023	63	n = 32 (BBS) 36.94(5.53)	n = 31 (BBS) 37.42(5.01)
4	Effectiveness of Motor Relearning Program on Balance And Upright Mobility in Sub-acute Stroke Patients: A Randomized Control Trial	Afsheen Naz, Sana Batool, Ashfaq Ahmad, Kashif Siddique	2022	68	n = 34 (TUG) 17.91(3.495)	n = 34 (TUG) 28.41(6.085)
5	Comparison of Motor Relearning Program Versus Bobath Approach at Every Two Weeks Interval for Improving Activities of Daily Living and Ambulation in Acute Stroke Rehabilitation	Gajanan Bhalerao, Vivek Kulkarni, Chandali Doshi, Savita Rairikar, Ashok Shyam, Parag Sancheti	2013	32	n = 17 (FIM) 52(6.17)	n = 15 (FIM) 49.8(10.11)
6	Comparison of Two Physiotherapy Approaches in Acute Stroke Rehabilitation: Motor Relearning Program Versus Bobath Approach	Gajanan V Bhalerao, Vivek Kulkarni, Dhara Kapoor	2011	22	n = 12 (FIM) 102(9.58)	n = 10 (FIM) 79.62(16.37)
7	Can Physiotherapy after Stroke Based on the Bobath Concept Result in Improved Quality of Movement Compared to the Motor Relearning Programme	Birgitta Langhammer & Johan K. Stanghelle	2010	61	n = 33 (Walking) 4.0 (1.6)	n = 28 (Walking) 3.8 (2.0)

Based on Table 2, there are 7 articles included in the meta-analysis of the effectiveness of motor relearning programs in improving the walking ability of post-stroke patients. The 7 articles have a total of 306 post-stroke patients,

158 Motor Relearning Program (MRP) groups and 148 functional training groups. The research subjects in each article used were post-stroke patients with impaired walking ability.



DISCUSSION

In assessing the quality of research studies of the Randomized Controlled Trial (RCT) type, an assessment method is used in the form of the PEDro Scale which has 11 assessment points including: (1) Eligibility criteria and source, (2) Random allocation, (3) Concealed allocation, (4) Baseline comparability, (5) Blinding of participants, (6) Blinding of therapists, (7) Blinding of assessors, (8) Adequate follow-up (85%), (9) Intention-to-treat analysis, (10)

Between-group statistical comparisons, (11) Reporting of point measures and measures of variability (Cashin & McAuley, 2020). Foley said that studies with a PEDro scale score of 9–10 are considered to have excellent quality, studies with scores of 6–8 and 4–5 are good and fair quality respectively, and studies with scores below 4 are considered to have poor quality (Nguyen et al., 2022). The PEDro Scale results from the 7 articles obtained are as in Table 3.

Table 3. PEDro Scale Results

PEDro Scale	Singha (2017)	Kanase (2020)	Ghrouz <i>et al.</i> , (2023)	Naz <i>et al.</i> , (2022)	Bhalerao <i>et al.</i> , (2017)	Bhalerao <i>et al.</i> , (2011)	Langhamm <i>et al.</i> , (2010)
Eligibility	yes	yes	yes	yes	yes	yes	yes
Random allocated	1	1	1	1	1	1	1
Concealed allocation	1	1	1	1	1	1	1
Baseline Comparability	1	1	1	1	1	1	1
Blinding all subjects	0	0	1	1	0	0	0
Blinding all therapist	0	0	1	1	0	0	0
Blinding all assessors	0	0	0	0	0	0	1
Adequate follow-up	1	0	0	1	1	0	0
Intention-to-treat analysis	1	1	1	1	1	1	1
Between-group comparisons	1	1	1	1	1	1	1
Point estimated variability	1	1	1	1	1	1	1
Score	7/10	6/10	8/10	9/10	7/10	6/10	7/10
Quality	good	good	good	excellent	good	good	good

Based on Figure 2, the results of the analysis in this study show an increase in walking ability

in stroke patients who were given the Motor Relearning Program of 1.83 Units compared to



patients who were given the Motor Relearning Program. given Functional Training (SMD= 1.83; 95% CI= 0.01 to 3.65) and the results were

statistically significant ($p < 0.00001$). The heterogeneity of the research data showed $I^2 = 97\%$ (random effect model).

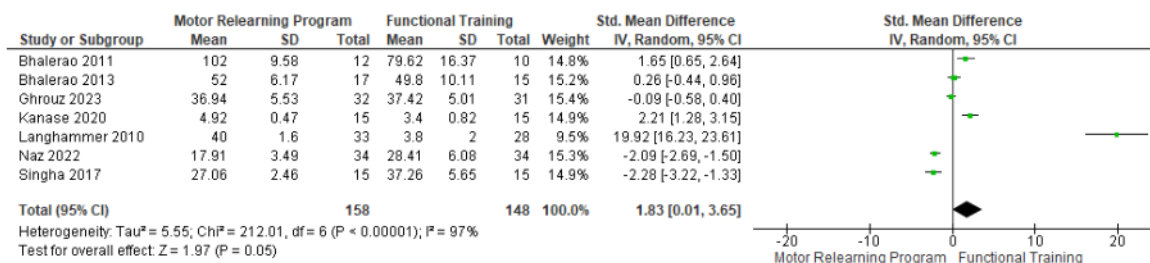


Figure 2. Forest plot

Based on Figure 3, the funnel plot results show that the distribution of effect estimates from primary studies with the RCT meta-analysis design is more located to the left of the vertical line of the average estimate than to the right, which indicates that there is publication bias.

Because the publication bias tends to be to the left the average vertical line is in a different direction from the position of the diamond shape in the forest plot, then the publication bias tends to reduce the effect of the actual MRP on improving walking ability in stroke patients (underestimate).

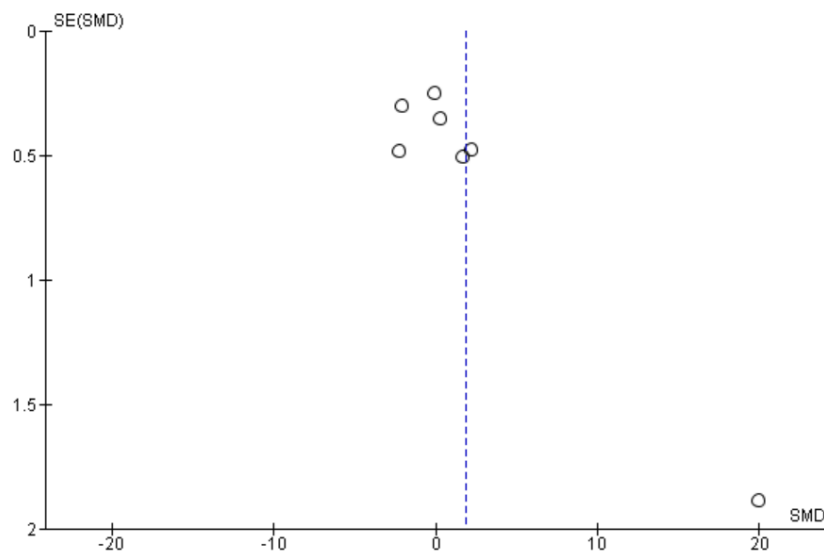


Figure 3. Standard Mean Result

In the study "Motor Relearning Program Versus Proprioceptive Neuromuscular Facilitation Technique for Improving Basic Mobility in Chronic Stroke Patients-A Comparative Study" conducted by Singha (2017) using the division of groups into 2. Group A

received intervention in the form of MRP for 30 minutes in one session with a time division of 10 minutes to train sitting to standing and sitting, and 20 minutes for walking exercises. Group B received PNF intervention for 30 minutes in 1 session with a time division of 10 minutes each



for rhythmic initiation, then slow reversals, and finally agonistic reversals. The movement patterns used were anterior pelvic elevation and posterior depression of the hemiplegic side with a side-lying position with the affected lower extremity facing upwards. This study produced better TUG results in the MRP group than the PNF group. MRP for three weeks which was carried out for half an hour each session, and was carried out 3 times a week was effective in improving basic mobility from sitting to standing, standing to sitting, and walking in stroke patients. Therefore, MRP is highly recommended to improve basic movement in patients in this study.

The study entitled "Effect of Motor Relearning Program and Conventional Training on Functional Mobility in Post Stroke Patients" conducted by Kanase (2020) was conducted by dividing the groups into 2. Group A received MRP while group B received conventional training for 6 weeks (4 times/week). Changes were measured by MAS and the modified Barthel index. The results showed that MRP and conventional training were effective in improving functional movement. However, when compared between the two groups, MRP had very significant results in improving functional mobility.

Based on research conducted by Ghrouz et al. (2023) entitled "The Effect of A Motor Relearning on Balance and Postural Control in Patients After Stroke: An Open-Label Randomized Controlled Trial", the research group was divided into MRP and conventional physical therapy groups for 8 weeks, (3 sessions per week; 1 hour per session; 24 sessions). Each MRP session contains 5 exercises, namely bed mobility and sitting upright, sitting balance, standing and sitting, standing balance, and walking exercises. In the conventional physical therapy group, there are 5 exercise components, namely progressive stretching of the extremities, active-assisted range of motion of the extremities, strengthening exercises (hip abductors, quadriceps, hamstrings), balance, and walking exercises. The results obtained with a measuring instrument in the form of BBS, namely in the

MRP group showed significantly greater results than conventional physical therapy, making MRP superior to conventional physical therapy in improving balance and postural control. Yoo et al. said that walking patterns include stride length, stride speed, and gait line length related to balance (Nastiti et al., 2023).

According to a study entitled "Effectiveness of Motor Relearning Program on Balance and Upright Mobility in Sub-acute Stroke Patients: A Randomized Control Trial" conducted by Naz et al. (2022) the study was conducted by dividing the group into an MRP group in the form of sit to stand combined with Routine Physical Therapy (RPT) in the form of gait, balance, stretching, and strengthening exercises as an experimental group, and a control group given only RPT. The exercise was carried out for 8 weeks with sit to stand performed 100 times, namely 10 sets with 10 repetitions with rest intervals. The TUG results of this study, namely the MRP intervention combined with RPT, were proven to be more effective and clinically feasible when compared to RPT alone for stroke patients aged 20-50 years.

In a study conducted by Bhalerao et al. (2013) entitled "Comparison of Motor Relearning Program Versus Bobath Approach at Every Two Weeks Interval for Improving Activities of Daily Living and Ambulation in Acute Stroke Rehabilitation", the study was conducted by dividing the subjects into MRP groups (upper limb function, oro-facial function, sitting up from supine, sitting, standing up and sitting down, standing, walking) and Bobath groups (positioning, handling, transfer training, and trunk and extremity control) for 1 hour/day for 6 days/week for a period of six weeks. The FIM results showed a difference that the MRP intervention was more effective than Bobath in improving Activities of Daily Living (ADL) and early ambulation.

Based on the study entitled "Comparison of Two Physiotherapy Approaches in Acute Stroke Rehabilitation: Motor Relearning Program Versus Bobath Approach" conducted by Bhalerao et al. (2011) divided into MRP (sitting up from supine, sitting, standing, sit-to-stand, walking, &



upper limb function) and Bobath (Bobath Approach using ten reflex inhibition patterns combined with inhibition and facilitation methods) groups with a dose of both groups of 1 hour / day, 6 days / week for 6 weeks (total therapy dose is 36 hours) inpatient training. After that, the subjects continued the training program as set outpatient or given therapy at their homes. After therapy, both groups showed significant improvements in motor function and functional mobility. However, the comparison between groups showed better results in the MRP group such as the FIM measurement comparison of pre and post exercise with the bobath group, namely 52 versus 34.25 ($p < 0.001$). This study showed that physiotherapy treatment using MRP improved patients' functional mobility and activities of daily living earlier and better than the Bobath approach. The MRP group was also able to walk earlier.

Langhammer & Stanghelle (2010) in their study entitled "Can Physiotherapy after Stroke Based on the Bobath Concept Result in Improved Quality of Movement Compared to the Motor Relearning Programme" used a method by dividing into MRP and bobath groups for five days a week with a minimum of 40 minutes for 3 months. Measurements with MAS include walking ability in the MRP group better than bobath. However, MRP supports the function of the arms, hands, and legs, as well as moving from a lying position to a sitting position. In addition, there were significant changes in balance and walking, but there were no significant changes in moving from a lying position to a side-lying position. Therefore, the quality of movement of the MRP group was better with the MAS item score compared to the bobath group.

The seven studies are in line with the research of Chen et al. (2018) entitled "Comparison of Motor Relearning Program versus Bobath Approach for Prevention of Post-stroke Apathy: A Randomized Controlled Trial" where MRP provides more significant results in preventing apathy. Post-stroke apathy can have negative effects on functional recovery, activities of daily living, general health, and quality of life

(Yang et al., 2015). Stroke has problems in the brain, so patients are prone to apathy. Therefore, preventing apathy after stroke can significantly improve physical, emotional, and cognitive recovery. In this study, the results obtained were that the MRP group had a much lower level of apathy compared to Bobath participants from the 1st month to the 12th month. This active participation and independence reduces apathy after stroke and helps in learning movement patterns. One reason may be because, although apathy is closely related to motivation, the MRP approach aims to increase motivation. MRP is more effective than Bobath in preventing post-stroke apathy because Bobath does not emphasize active patient participation (Chen et al., 2018). Preventing apathy in patients will also prevent the emergence of obstacles in patients in improving their walking ability.

Recovery of limb function in patients who have undergone stroke treatment, the rehabilitation process is very important. To implement rehabilitation techniques, family, advanced health facilities, and the use of the latest treatment techniques are some options. Upper and lower extremity exercises are the main focus of post-stroke rehabilitation programs (Purnamayanti et al., 2020). By educating patients and families regarding their treatment, it can accelerate patients in achieving their targets such as increasing walking ability. So, after being given intervention with physiotherapy, patients can still do it themselves at home so that there is no decrease in quality.

CONCLUSION

The conclusion of this study is that the effect of providing the Motor Relearning Program (MRP) is more effective than functional training in improving walking ability in post-stroke patients.

REFERENCES

- Adi, D. P., Herawati, I., & Ariyani, A. (2023). Fisioterapi untuk Meningkatkan Keseimbangan Pasien Hemiparese Pasca Stroke Non Hemoragik: Studi Kasus.



- Journal of Innovation Research and Knowledge*, 2(9), 3371-3378.
<https://doi.org/10.53625/jirk.v2i9.5028>
- Bhalerao, G., Kulkarni, V., & Kapoor, D. (2011). Acute Stroke Rehabilitation: Motor Relearning Program Versus Bobath Approach. *Journal of Orthopaedics and Rehabilitation*, 1(1), 79–88.
- Bhalerao, G., Kulkarni, V., Doshi, C., Rairikar, S., Shyam, A., & Sanchet, P. (2013). Comparison of Motor Relearning Program Versus Bobath Approach At Every Two Weeks Interval for Improving Activiti. 3(3), 70–77.
- Cashin, A. G., & McAuley, J. H. (2020). Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. *Journal of Physiotherapy*, 66(1), 59.
<https://doi.org/10.1016/j.jphys.2019.08.005>
- Chen, L., Xiong, S., Liu, Y., Lin, M., Zhu, L., Zhong, R., Zhao, J., Liu, W., Wang, J., & Shang, X. (2018). ARTICLE IN PRESS Comparison of Motor Relearning Program versus Bobath Approach for Prevention of Poststroke Apathy: A Randomized Controlled Trial. *Journal of Stroke and Cerebrovascular Diseases*.
<https://doi.org/10.1016/j.jstrokecerebrovasdis.2018.11.011>
- Feigin, V. L., Brainin, M., Norrving, B., Martins, S., Sacco, R. L., Hacke, W., Fisher, M., Pandian, J., & Lindsay, P. (2022). World Stroke Organization (WSO): Global Stroke Fact Sheet 2022. *International Journal of Stroke*, 17(1), 18–29.
<https://doi.org/10.1177/17474930211065917>
- Ghrouz, A., Guillen-Sola, A., Morgado-Perez, A., Muñoz-Redondo, E., Ramírez-Fuentes, C., Curbelo Peña, Y., & Duarte, E. (2023). The effect of a motor relearning on balance and postural control in patients after stroke: An open-label randomized controlled trial. *European Stroke Journal*.
<https://doi.org/10.1177/23969873231220218>
- Hasbiah, H., & Ahmad, H. (2021). Beda Efek Pemberian Motor Relearning Program Dan Pemberian Proprioceptive Neuromuskular Facilitation Terhadap Peningkatan Kemampuan Fungsional Penderita Post Stroke. *Media Kesehatan Politeknik Kesehatan Makassar*, 16(1), 17.
<https://doi.org/10.32382/medkes.v16i1.1988>
- Johnson, W., Onuma, O., Owolabi, M., & Sachdev, S. (2016). Stroke: A global response is needed. *Bulletin of the World Health Organization*, 94(9), 634A-635A.
<https://doi.org/10.2471/BLT.16.181636>
- Kanase, S. B. (2020). Effect of Motor Relearning Programme and Conventional Training on Functional Mobility in Post Stroke Patients. *Indian Journal of Public Health Research & Development*, 11(5), 496–501.
<https://doi.org/10.37506/ijphrd.v11i5.9375>
- Langhammer, B., & Stanghelle, J. K. (2010). Can Physiotherapy after Stroke Based on the Bobath Concept Result in Improved Quality of Movement Compared to the Motor Relearning Programme. *Physiotherapy Research International*, 16(2), 69–80.
<https://doi.org/10.1002/pri.474>
- Liu, D., Hu, K., Schmidt, M., Müntze, J., Maniuc, O., Gensler, D., Oder, D., Salinger, T., Weidemann, F., Ertl, G., Frantz, S., Wanner, C., & Nordbeck, P. (2018). Value of the CHA 2 DS 2 -VASc score and Fabry-specific score for predicting new-onset or recurrent stroke/TIA in Fabry disease patients without atrial fibrillation. *Clinical Research in Cardiology*, 107(12), 1111–1121.
<https://doi.org/10.1007/s00392-018-1285-4>
- Maratis, J., Fatria, I., Meidian, A. C., Abdurrasyid, A., & Syah, L. O. M. G. (2020). Pelatihan Rhythmic Auditory Stimulation (RAS) dan Visual Cue Training (VCT) Memperbaiki Kemampuan Berjalan Pasien Stroke. *FISIO MU: Physiotherapy Evidences*, 1(2), 68–75.
<https://doi.org/10.23917/fisiomu.v1i2.11428>



- Nastiti, A. D., Rahayu, U. B., & Maghfiroh, R. A. (2023). The Use of Treadmills to Improve Post-stroke Walking Patterns: A Literature Review. *Atlantis Press International BV*. https://doi.org/10.2991/978-94-6463-184-5_27
- Naz, A., Batool, S., Ahmad, A., & Siddique, K. (2022). Effectiveness of Motor Relearning Program on Balance and Upright Mobility in Sub-acute Stroke Patients: A Randomized Control Trial. *Pakistan BioMedical Journal*, 5(1), 313–317. <https://doi.org/10.54393/pbmj.v5i1.316>
- Nguyen, P. T., Chou, L. W., & Hsieh, Y. L. (2022). Proprioceptive Neuromuscular Facilitation-Based Physical Therapy on the Improvement of Balance and Gait in Patients with Chronic Stroke: A Systematic Review and Meta-Analysis. *Life*, 12(6). <https://doi.org/10.3390/life12060882>
- Pristianto, A., Raminda, S., & Nadia, Z. (2022). The Effect of Early Mobilization and Body Positioning on Functional Ability in Patients with Acute Ischemic Stroke. *Journal of Health Sciences*, 15(03), 262–269. <https://doi.org/10.33086/jhs.v15i03.2845>
- Pristianto, A., Nadeputri, A. E. S. M., Susilo, T. E., & Santoso, T. B. (2024). Pilot Study: Different Leg Muscle Activation When Walking on Stable, Unstable & Slippery Floors: (Parameters Using Surface Electromyograph). *FISIO MU: Physiotherapy Evidences*, 5(1). 78-84. <https://doi.org/10.23917/fisiomu.v5i1.2715>
- Purnamayanti, N. K. D., Usemahu, N. Y. P., Haris M. F., & Layun, M. K. (2020). Aplikasi Latihan Rentang Gerak dengan Berbagai Pendekatan Pada Pasien Stroke. *Jurnal Kesehatan*, 13(1), 22–34. <https://doi.org/10.23917/jk.v13i1.11098>
- Sahin, I. E., Guclu-Gunduz, A., Yazici, G., Ozkul, C., Volkan-Yazici, M., Nazliel, B., & Tekindal, M. A. (2019). The Sensitivity and Specificity of the Balance Evaluation Systems test-BESTest in determining risk of Fall in Stroke Patients. *NeuroRehabilitation*, 44(1), 67–77. <https://doi.org/10.3233/NRE-182558>
- Singha, R. (2017). Motor Relearning Program Versus Proprioceptive Neuromuscular Facilitation Technique for Improving Basic Mobility in Chronic Stroke Patients-a Comparative Study. *International Journal of Physiotherapy and Research*, 5(6), 2490–2500. <https://doi.org/10.16965/ijpr.2017.235>
- van Vliet, P. M., Lincoln, N. B., & Foxall, A. (2005). Comparison of Bobath Based and Movement Science Based Treatment for Stroke: a Randomised Controlled Trial. *J Neurol Neurosurg Psychiatry*, 76(4), 503–8. [10.1136/jnnp.2004.040436](https://doi.org/10.1136/jnnp.2004.040436)
- Yang, S., Shang, X., Tao, J., Liu, J., & Hua, P. (2015). *Voxel-Based Analysis of Fractional Anisotropy in Post-Stroke Apathy*. 1–9. <https://doi.org/10.1371/journal.pone.0116168>

