Indian Journal of Physiotherapy and Rehabilitation Science

e-ISSN 2583 4304 Vol:4, Issue:1 Jan.2025

TO COMPARE THE EFFECT OF MIRROR THERAPY AND MOTOR RELEARNING PROGRAMME ON BALANCE AND GAIT SPEED IN CHRONIC STROKE PATIENTS: AN EXPERIMENTAL STUDY

[1] **Dr. Disha Dave**
Masters in Neurophysiology and Psycosomatic Disorder,
Gujarat University, Clinical Practitioner, Mumbai.
[2] **Dr. Megha Soni**
Assistant Professor Pioneer Physiotherapy College, Vadodara.
[3]**Dr. Sahil Rathod**
Phd Scholar, Gujarat University, Assistant Professor,
Pioneer Physiotherapy College, Vadodara
Emailid- dishadave2318@gmail.com

Received: 9th Aug.2024
Revised: 9th Jan. 25
Accepted: 16th Jan. 25

ABSTRACT

Background: Stroke is rapidly developing clinical sign of focal disturbance of cerebral function. Mirror therapy is a form of mental practice, and it excites the primary motor cortex and evokes movement of the paralyzed side as mirror therapy allows an individual to have an experience of normal movement, also helps in improving balance and gait. The Motor Relearning approach was developed based on motor learning theory and in promoting physical function for stroke patients. The MRP was found to be effective for enhancing functional recovery as this drive neural plasticity for retraining functional skills useful for balanced sitting, sitting and standing, gait.

Objective: To compare the effect Mirror Therapy and Motor Relearning Programme on balance and gait speed by BBS, TUG and 10MWT in chronic stroke patients.

Methods: 22 Subjects according to inclusion criteria were recruited into two groups. Group A was given MT while Group B was given MRP for 4 weeks. Outcome measures such as BBS, TUG and 10MWT were assessed before and after intervention.

Result: Paired t-test was used for within group analysis for BBS (Berg Balance Scale) and Mann Whitney test was used for TUG (Timed Up and GO) and 10MWT (Meter Walk Test) which showed significant difference in Mirror Therapy group, while BBS and TUG were significant and 10MWT was not significant in Motor Relearning Programme. Independent sample t-test was used for between group analysis for BBS which showed significant difference while Wilcoxon test was used for TUG and 10MWT with significant difference.

Conclusion: This study shows that Mirror Therapy is more effective in improving balance and gait speed then Motor Relearning Programme.

Keywords: Mirror Therapy, Motor Relearning Programme, Balance, Gait speed, Chronic stroke.

INTRODUCTION

Stroke is rapidly developing clinical sign of focal (or global) disturbance of cerebral function with symptoms lasting 24 hours and longer, without an evident cause except that of vascular origin. Stroke is an essential reason for disability and early death. In India, modified stroke prevalence rate in rural areas is 84–262/100,000 and in urban areas 334–424/100,000. The prevalence rate is 119–145/100,000 studies in India. The risk of stroke after 55 years of age is 1 in 5 for women and 1 in 6 for men.

Post-stroke impairments in strength, coordination, and balance lead to complications and recovery is the major goal for individuals with stroke. The brain regulates motor activation, muscle tone, selective joint

movement and balance, while the spinal cord regulates gait. Hence, for people with stroke, paralysis in the lower limbs can lead to motor function impairment and balance deficits associated with gait dysfunction, coordination disorder, and associated reactions, hemiplegic patients experience a considerable decrease of motor function in affected limbs.

Balance is an ability to control centre of gravity (COG) over the base of support (BOS) in a given sensory environment. Maintenance of balance needs the co-ordination of sensory, neural and musculoskeletal system. Many of these undergo deterioration as people age. This has the possibility to affect balance, limit safe mobility, increase the chances of a fall and negatively affecting the quality of life.

Changes in muscle firing patterns activate a abnonrmal gait post stroke, thus the considerable goals of rehabilitation for hemiplegic patients are to attain a fast and systematic gait and to achieve almost normal gait pattern.The lower-limb paresis leading to gait impairment is one of the key manifestations poststroke. The disability further causes dependent, unsafe, and inefficient transfer and ambulation A hemiparetic subject walks with a synergistic pattern of the affected lower limb instead of selective control of the individual joint in stroke, lower-limb rehabilitation comprises various aspects such as inducing motor recovery, balancecoordination training, orthosis, and assistive devices. 10 Unlike upper-limb functions, the walking and transfers are purely bilateral performances. Thus, the major focus of lower-limb rehabilitation is ambulation, which may be achieved by utilising compensatory techniques .

Sang Gu Ji1 and Myoung Kwon Kim2 et al18 in 2014 conducted study on "The effects of mirror therapy on the gait of subacute stroke patients: a randomized controlled trial" concluded that mirror therapy may be beneficial in improving the effects of stroke on gait ability. Sirajahemad H Bhoraniya et al19 in 2018 conducted study on "The effect of mirror therapy on the gait of chronic stroke patients: A randomized controlled trial" and concluded that Mirror therapy was helpful in improving the gait ability in chronic stroke patient compared to conventional therapy.

Mirror therapy is a type of mental practice, and it excites the primary motor cortex and evokes movement of the paralytic aspect as patients confirmed movement of the non-paralyzed side visually. A mirror neuron is neuron that responds to observation of a person's movement and may be activated through mirror therapy. The Mirror therapy mechanism is based on the concept of visual illusion. The motion of the non-paretic part in front of the mirror (reflective side) is recognised as that of the paretic body part (hidden beside the mirror).[15]

Motor learning mechanisms are operative throughout spontaneous stroke recovery and move with rehabilitative training. For optimal results, rehabilitation techniques should be geared towards patients' specific motor deficits and possibly combined Motor relearning programme (MRP) for stroke framed by them is a good example of Task Oriented Approach. [21]

The Motor Relearning Approach (MRP) in approaching physical function and task performance for stroke patients. The MRP was found to be effective for enhancing functional 4 recovery of stroke patients research has suggested that task-specific exercises would be most beneficial for stroke individuals, because this approach is thought to drive neural plasticity. This approach includes many aspects of Motor learning theory and provides practical guidelines for retraining functional skills (e.g., balanced sitting, sitting and standing, transfer skills, gait, etc.). 21 Their approach focuses on task specific learning and through effective use of feedback and practice development of active movement control. Facilitation techniques are

e-ISSN 2583 4304 Vol:4, Issue:1 Jan.2025

de-emphasized whereas verbal instruction, demonstration, and manual guidance are emphasized.

Studies with stroke populations have shown that Motor Relearning Program (MRP)/ task specific training /Task-related training (TRT) with specific strengthening exercises for paretic muscles leads to improvement in locomotion, lower limb weight bearing in sitting, and standing up. 23 Functional mobility is largely affected and needs to take care of as it is a challenging part for any physiotherapist. Present study focuses of comparing the concepts of motor relearning with conventional approach.24 Dora YL Chan et al25 in 2010 concluded study on "Motor relearning programme for stroke patients: a randomized controlled trial" concluded that the motor relearning programme was found to be productive for enhancing functional recovery of patients who had a stroke. Both 'sequential' and 'function-based' concepts are important in applying the motor relearning approach to the rehabilitation of stroke patients.

According to my knowledge there is comparison on Motor relearning programme and Mirror therapy but less comparison between Motor relearning programme and Mirror therapy on Balance and Gait, so this study is comparison between the two for lower extremity.

To check the effect of Mirror therapy on balance and gait speed by BBS, TUG and 10MWT in chronic stroke patients. 2. To check the effect of Motor relearning Programme on balance and gait speed by BBS, TUG and 10MWT in chronic stroke patients. 3. To compare the effect Mirror Therapy and Motor Relearning Programme on balance and gait speed by BBS, TUG and 10MWT in chronic stroke patients.

Anatomy: Blood supply of the Brain: The brain is supplied by the two internal carotid and the two vertebral arteries. The four arteries lie within the subarachnoid space, and their branches anastomose on the inferior surface of the brain to form the circle of Willis. Circle of Willis: Extra cranial blood supply to the brain is provided by the right and left internal carotid arteries and by the right and left vertebral arteries. The internal carotid artery begins at the bifurcation of the common carotid artery and ascends in the deep portions of the neck to the carotid canal. It turns rostromedially and ascends into the cranial cavity. It then pierces the dura mater and gives off the ophthalmic and anterior choroidal arteries before bifurcating into the middle and anterior cerebral arteries. The anterior communicating artery communicates with the anterior cerebral arteries of either side, giving rise to the rostral portion of the circle of Willis.59 The vertebral artery arises as a branch off the subclavian artery. It enters the vertebral foramen of the sixth cervical vertebra and travels through the foramina of the transverse processes of the upper six cervical vertebrae to the foramen magnum and into the brain. There it travels in the posterior cranial fossa ventrally and medially and unites with the vertebral artery from the other side to form the basilar artery at the upper border of the medulla. At the upper border of the pons, the basilar artery bifurcates to form the posterior cerebral arteries and the posterior portion of the circle of Willis. Posterior communicating arteries connect the posterior cerebral arteries with the internal carotid arteries and complete the circle of Willis.

Thrombotic Infarction: Atherosclerotic plaques and hypertension interact to produce cerebrovascular infarcts. These plaques form at branching and curves of the arteries. Plaques usually form in front of the first major branching of the cerebral arteries. These lesions can be present for 30 years or more and may never become symptomatic. Intermittent blockage may proceed to permanent damage.

Embolic Infarction: The embolus that causes the stroke may come from the heart, from an internal carotid artery thrombosis, or from an atheromatous plaque of the carotid sinus. It is usually a sign of cardiac disease. The infarction may be of pale, haemorrhagic, or mixed type. The branches of the middle cerebral artery are infarcted most commonly as a result of its direct continuation from the internal carotid artery.

Haemorrhagic Infarction: The most common intracranial haemorrhages causing stroke are those resulting from hypertension, ruptured saccular aneurysm, and arteriovenous malformation. Massive haemorrhage frequently results from hypertensive cardiac-renal disease; bleeding into the brain tissue produces an oval or round mass that displaces midline structures. The exact mechanism of haemorrhage is not known. This mass of extravasated blood decreases in size over 6 to 8 months.

Mirror Therapy: Mirror therapy (MT) has been used as an intervention for the rehabilitation of stroke survivors. Mirror therapy is an intervention in which a stroke survivor watches their limbs on the non-affected side in a mirror to recover movement of the paralyzed side by creating a visual illusion. MT can exert a strong influence on the motor network, mainly through increased cognitive penetration in action control. Altschuler et al.10 demonstrated the effectiveness of MT on range of motion, movement speed, and accuracy of the upper limb joints post-stroke. Stevens and Stoykov11 also reported improvements in the Fugl-Meyer Assessment Scale scores, range of motion, movement speed, and agility after MT for the upper limb. In a novel study, Sütbeyaz et al.8 used MT for the lower limbs and reported that it was effective for motor recovery and motor function improvement. A study by Ji and Kim12 also reported a significant improvement in spatiotemporal gait variables after MT for the lower limbs of stroke survivors. The use of mirror therapy after stroke has predominantly cantered around the hemiparetic upper limb.

Additionally, several randomized controlled trials (RCTs) have found mirror therapy to have efficacy for reducing pain in the upper limb for stroke patients with complex regional pain syndrome.

Motor Relearning Programme: The motor relearning approach was developed based on motor learning theory.' 5 Carr and Shepherd9"' proposed that training in motor control requires anticipatory actions and ongoing practice. To further enhance relearning, the motor tasks involved are practised within a context that can be task or environment specific. A review of the literature revealed that only a few clinically controlled trial studies on the application of the motor relearning approach have been conducted. The results of these studies suggested that patients tended to have a short hospital stay and high functional independence.'4 Patients also showed a significant increase in gait velocity. However, 16 these studies did not provide detailed information on how task-oriented strategies were developed and used. Motor Relearning Approach (MRP) in promoting physical function and task performance for stroke patients. The MRP was found to be effective for enhancing functional recovery of stroke patients.

Study Design- An experimental study

Sampling Design- Convenience sampling

Study Population- Patient with Chronic Stroke patients more than 6 months

Study Setting- OPD based

Study Duration- 5days/week, for 4 weeks

Study Period- 1 year (2021-2022)

Indian Journal of Physiotherapy and Rehabilitation Science

e-ISSN 2583 4304 Vol:4, Issue:1 Jan.2025

Sample Size- The sample size was calculated using G power software version 3.1.9.4 The main outcome variable taken into consideration for sample size collection is rated of perceived exertion. From the previous study conducted by Dora YL Chan and Ranjeet Singha et al. Physiological responses to mirror therapy and motor relearning Programme. The TUG values were (mean=36.4, SD=15.5) (mean= 37.26, SD= 5.65). Keeping value of α error as 0.1 (since 95% confidence interval) and β error as 0.2 (power of the study 80%) the calculated sample size is 22.

SAMPLING CRITERIA

Inclusion Criteria-

- Both male and female
- 40-60 years
- First episode of Ischemic and Hemorrhagic unilateral stroke with hemiparesis (onset > 6 months)
- Able to walk 10 meters with or without assistance
- Spasticity grade < 3(according to modified Ashworth scale)
- ≥24 score in Mini Mental Scale
- Brunnstorm grade ≥ 3
- Willing to participate

Exclusion Criteria-

- Transient Ischemic Attack
- Neurological disorder other than stroke such as (Parkinson, tremors, etc)
- Musculoskeletal disorder affecting locomotion
- Uncontrolled hypertension and peripheral arterial occlusion disease.
- Surgery of lower limb
- Gross visual spatial and visual deficit
- Diabetic retinopathy
- Apraxia
- Congenital deformity

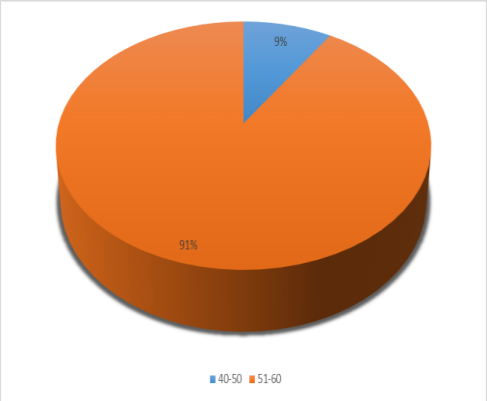
Procedure: After taking approval from institutional ethical committee the study was started. COVID19 guidelines like wearing mask, using hand sanitizer and maintaining social distancing were followed during data collection. Before starting the procedure, proper understanding and demonstration was given to each participant and Screening (ANNEXURE II) was done for each participant. Participants were selected who fulfil the inclusion criteria. They were briefed about the nature of the study. Written consent (ANNEXURE I) form was signed by the subjects prior giving the treatment. Outcome measures were taken before and after the program schedule. As per convenient sampling distribution patient were divided into 2 groups: Group A: Mirror Therapy. Group B: Motor Relearning Programme.

Paired t-test was used for within group analysis for BBS and Mann Whitney test was used for TUG and 10MWT which showed significant difference in Mirror Therapy group, while BBS and TUG were significant and 10MWT was not significant in Motor Relearning Programme. Independent sample t-test was used for between group analysis for BBS which showed significant difference while Wilcoxon test was used for TUG and 10MWT with significant difference.

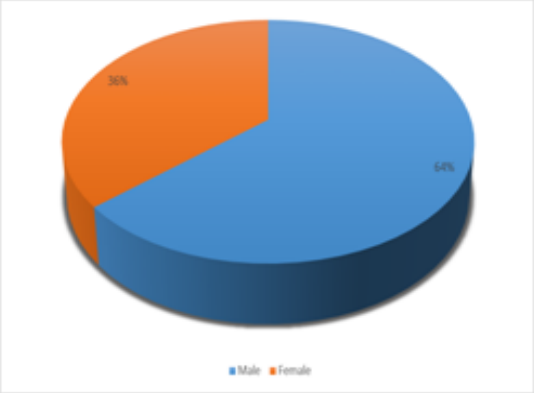
Indian Journal of Physiotherapy and Rehabilitation Science

e-ISSN 2583 4304 Vol:4, Issue:1 Jan.2025

Age distribution of MT and MRP:



Gender Distribution of MT and MRP:



The below table shows the Mean value and SD for age, MMSE, Brunnstorm (VCG) and MMT distribution among 22 subjects with 11 each group. Baseline data are equal in both the groups before the intervention.

BASELINEDATA	Group1(MirrorTherapy) (n=11)	Group2(MotorRelearning Programme) (n=11)	SIGNIFICANCE
	MEAN±SD	MEAN±SD	
AGE	55±4.3	55±5.9	1
MMSE	29.09±0.701	29.27±0.786	0.573
BRUNNSTORMGRADING(VCG)	3.45±0.522	3.73±0.467	0.211
MMT	3.45±0.522	3.73±0.467	0.211

OUTCOMEMEASURES (Group1)	PRE		POST		t -V A L U E / Z -Value	SIGNIFICANCE
	MEAN	SD	MEAN	SD		
BBS	43.091	2.5477	51.636	1.206	-11.316	<0.001
TUG	37.667	18.1157	29.909	14.8557	-2.941	0.003
10MWT	53.121	21.3012	39.924	15.408	-2.934	0.003

Paired t-test was used for Pre and Post BBS which shows significant difference in MT group (t = -11.316, p = <0.001)

Mann Whitney test was used for Pre and Post TUG which shows significant difference in MT group (t = -2.941, p = 0.003)

Mann Whitney test was used for Pre and Post 10MWT which shows significant difference in MT group (t = -2.934, p = 0.003)

The below table shows Independent sample t-test was used for between group comparison for BBS (p = -0.892, t=0.385) it shows no statistically significant difference in MT and MRP groups

Wilcoxon test was used for Between group comparison for TUG and 10MWT and Results shows significance difference in TUG (U = 92.50, t= 0.034) and 10MWT (U = 93.50, t=0.028) which is more in Mirror Therapy than Motor Relearning Programme.

OUTCOMEMEASURE	MT	MRP	tVALUE/UValue	SIGNIFICANCE
	MEAN±SD	MEAN±SD		
BBS	8.545±2.5045	7.364±3.613	-0.892	0.385
TUG	8.436±7.2322	6.009±5.65	92.5	0.034
10MWT	13.191±9.2740	6.700±6.512	93.5	0.028

Mirror Therapy and Motor Relearning Programme both were individually effective in improving BBS (static balance) and TUG (dynamic balance) whereas in Mirror Therapy improvement was found in 10MWT (gait speed).

In inter group comparison both Mirror Therapy and Motor Relearning Programme was equally effective in improving BBS whereas Mirror Therapy was found to be effective in TUG and 10MWT than Motor Relearning Programme. Still further investigation is needed.

LIMITATIONS

- Randomization was not done
- Blinding was not done for both assessor and therapist
- Long term follow-up was not taken
- Sample size was small Future Recommendation:
- Long term effect of Mirror Therapy and Motor Relearning Programme are currently unknown so further studies can be done.
- Combine effect of Mirror Therapy and Motor Relearning Programme can be done

Mirror Therapy and Motor Relearning Programme both were individually effective in improving BBS (static balance) and TUG (dynamic balance) whereas in Mirror Therapy improvement was found in 10MWT (gait speed).

In inter group comparison both Mirror Therapy and Motor Relearning Programme was equally effective in improving BBS whereas Mirror Therapy was found to be effective in TUG and 10MWT than Motor Relearning Programme. Still further investigation is needed.

REFERENCES

1. Sang Gu Ji1 and Myoung Kwon Kim2 the effects of mirror therapy on the gait of subacute stroke patients: a randomized controlled trial. https://doi.org/10.1177/0269215514542356
2. Sang-Goo Ji, PT, PhD1), Hyun-Gyu Cha, PT, MS1), Myoung-Kwon Kim, PT, PhD2), Chang-Ryeol Lee, PT, PhD3) The Effect of Mirror Therapy Integrating Functional Electrical Stimulation on the Gait of Stroke Patients. https://doi.org/10.1589/jpts.26.497
3. Sirajahemad H Bhoraniya, Daxa G Mishra, Shweta M Parikh the effect of mirror therapy on the gait of chronic stroke patients: A randomized controlled trial . (njppp.com)
4. Donggeon LEE 1, Gyuchang LEE 2 Effect of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors: a randomized controlled trial. https://doi.org/10.23736/s1973-9087.19.05334-6
5. Sang Gu Ji1 and Myoung Kwon Kim2 the effects of mirror therapy on the gait of

subacute stroke patients: a randomized controlled trial. https://doi.org/10.1177/0269215514542356

6. Sang-Goo Ji, PT, PhD1), Hyun-Gyu Cha, PT, MS1), Myoung-Kwon Kim, PT, PhD2), Chang-Ryeol Lee, PT, PhD3) The Effect of Mirror Therapy Integrating Functional Electrical Stimulation on the Gait of Stroke Patients. https://doi.org/10.1589/jpts.26.497
7. Sirajahemad H Bhoraniya, Daxa G Mishra, Shweta M Parikh The effect of mirror therapy on the gait of chronic stroke patients: A randomized controlled trial.. (njppp.com)
8. Donggeon LEE 1, Gyuchang LEE 2 Effect of afferent electrical stimulation with mirror therapy on motor function, balance, and gait in chronic stroke survivors: a randomized controlled trial. https://doi.org/10.23736/s1973-9087.19.05334-6
9. Dora YL Chan Chetwyn CH Chan Motor relearning programme for stroke patients: a randomized controlled trial. https://doi.org/10.1191/0269215506cr930oa
10. Shafqatullah Jan1, Aatik Arsh2, Haider Darain3, Shehla Gul4 A randomized control trial comparing the effects of motor relearning programme and mirror therapy for improving upper limb motor functions in stroke patients.
11. Ranjeet Singha Motor relearning program versus proprioceptive neuromuscular facilitation technique for improving basic mobility in chronic stroke patients- A comparative study.
12. Gajanan Bhalerao1, Vivek Kulkarni1 , Chandali Doshi1 , Savita Rairikar1 , Ashok Shyam and Parag Sancheti 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. https://www.academia.edu/download/43711490/JMS-11-031
13. Suraj B. Kanase Effect of Motor Relearning Programme and Conventional Training on Functional Mobility in Post Stroke Patient
14. Kamal Narayan Arya, Shanta Pandian Effect of activity-based mirror therapy on lower limb motorrecovery and gait in stroke: A randomised controlled trial(8) https://doi.org/10.1080/09602011.2017.1377087
15. R. M. Singaravelan2 , Subhash M. Khatri Mirror Therapy to Improve Upper Limb Function in Subacute Stroke Patients https://doi.org/10.1016/j.apmr.2007.08.162
16. Sneha S. Khandare Comparison of Task Specific Exercises and Mirror Therapy to Improve Upper Limb Function in Subacute Stroke Patients.
17. Dr. Shweta Ingale & Dr. Shamla Pazare A comparative study between the effect of Functional Limb Overloading and Conventional therapy on gait parameters, balance and functional independence in Chronic Stroke patients https://doi.org/10.1016/j.gaitpost.2020.10.012
18. Keh-Chung Lin a,b , Yu-Ting Chen c,d Effect of mirror therapy combined with somatosensory stimulation on motor recovery and daily function in stroke patients: A pilot study https://doi.org/10.1016/j.jfma.2012.08.008
19. Qurat-ul-Ain, 1 Arshad Nawaz Malik, 2 Imran Amjad3 Effect of circuit gait training vs traditional gait training on mobility performance in stroke
20. Dorcas BC Gandhi 1,2 Albert Sterba3 Himani Khatter2 Mirror Therapy in Stroke Rehabilitation: Current Perspectives
21. Karthikeyan G.1, Shamim. G. Sheikh Test-retest reliability of short form of berg balance scale in elderly people https://www.researchgate.net/publication/269092894_Test-retest_reliability_of_short_form_of_berg_balance_scale_in_elderly_people
22. Ahmad H. Alghadir1, Einas S. Al-Eisa Reliability, validity, and responsiveness of three scales for measuring balance in patients with chronic stroke https://doi.org/10.1186/s12883-018-1146-9

23. Amanda C. Fuzaro1 , Carlos T. Guerreiro Modified constraint-induced movement therapy and modified forced-use therapy for stroke patients are both effective to promote balance and gait improvements RBFis_220_2011_IN.indd (scielo.br)

24. Peggy P.K. Chan,1 MSc; Joyce I.F. Si Tou, The Reliability and Validity of the Timed Up & Go (Motor) Test for People with Chronic Stroke https://doi.org/10.1016/j.apmr.2017.03.008

25. Jaclyn Megan Sions Test–retest reliability for performance-based outcome measures among individuals with arthrogryposis multiplex congenita

26. Ross A Clark1*, Stephanie Vernon1 Instrumenting gait assessment using the Kinect in people living with stroke: reliability and association with balance tests https://doi.org/10.1186/s12984-015-0006-8

27. Jin Parka,∗ and Tae-Ho Kim The effects of balance and gait function on quality of life of stroke patients https://doi.org/10.1186/s12984-015-0006-8

28. Catherine M. Dean, Carol L. Richards, Task-Related Circuit Training Improves Performance of Locomotor Tasks in Chronic Stroke: A Randomized, Controlled Pilot Trial https://doi.org/10.1053/mr.2000.3839

29. Jennifer A. Stevens, Mary Ellen Phillips Stoykov Using Motor Imagery in the Rehabilitation of Hemiparesis https://doi.org/10.1016/S0003-9993(03)00042-X

30. Patel M1 , Gomez S2 , Lush D2 , Fransson PA1 . Adaptation and vision change the relationship between muscle activity of the lower limbs and body movement during human balance perturbations https://doi.org/10.1016/j.clinph.2008.11.026

31. Giovanni Buccino, MD, PhD,* Ana Solodkin, PhD,w and Steven L. Small, MD, PhD Functions of the Mirror Neuron System: Implications for Neurorehabilitation Cognitive and Behavioral Neurology (lww.com)

32. Jessica L. Allen a , Steven A. Kautz Step length asymmetry is representative of compensatory mechanisms used in post-stroke hemiparetic walking https://doi.org/10.1016/j.gaitpost.2011.01.004

33. Serap Sütbeyaz, MD, Gunes Yavuzer, MD, PhD, Nebahat Sezer, MD, B. Füsun Koseoglu, MD Mirror Therapy Enhances Lower-Extremity Motor Recovery and Motor Functioning After Stroke: A Randomized Controlled Trial https://doi.org/10.1016/j.apmr.2007.02.034

34. Ta-Shen Kuan, MD, Jui-Yi Tsou, MS, PT, Fong-Chin Su, PhD Hemiplegic Gait of Stroke Patients: The Effect of Using a Cane 4. https://doi.org/10.1016/S0003-9993(99)90227

35. Sinikka H. Peurala, MSc, PT, Ina M. Tarkka, PhD, Kauko Pitkänen, MD, PhD, Juhani Sivenius, MD, PhD The Effectiveness of Body Weight–Supported Gait Training and Floor Walking in Patients With Chronic Stroke https://doi.org/10.1016/j.apmr.2005.02.005

36. Roberta B. Shepherd Exercise and Training to Optimize Functional Motor Performance in Stroke: Driving Neural Reorganization https://doi.org/10.1155/NP.2001.121

37. John W. Krakauer Motor learning: its relevance to stroke recovery and neurorehabilitation https://journals.lww.com/coneurology/Fulltext/2006/02000/Motor_learning__its_rel e vance_to_stroke_recovery.14.aspx

38. Jennifer A. Stevens, PhD, Mary Ellen Phillips Stoykov, MS, OTR/L Using Motor Imagery in the Rehabilitation of Hemiparesis 10.1016/S0003-9993(03)00042-X

39. Serap Sütbeyaz, MD, Gunes Yavuzer, MD, PhD, Nebahat Sezer, MD, B. Füsun Koseoglu, Mirror Therapy Enhances Lower-Extremity Motor Recovery and Motor Functioning After Stroke: A Randomized Controlled Trial 10.1016/j.apmr.2007.02.034

40. Andreas R. Luft,1,2* Gerald V. Smith,3 Larry Forrester,3 Jill Whitall,3 Richard F. Macko,4,6 TillKarsten Hauser, Comparing

Brain Activation Associated With Isolated Upper and Lower Limb Movement Across Corresponding Joints 10.1016/j.apmr.2007.02.034