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Original Article

Evaluating the Impact of Active vs Passive Physiotherapy Techniques on Post-Stroke Motor Recovery in Adults

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ABSTRACT

Background: Stroke is a major cause of long-term adult disability and commonly results in weakness, impaired coordination, poor balance, and reduced functional mobility. Physiotherapy is central to post-stroke rehabilitation, but the comparative effectiveness of active versus passive approaches remains insufficiently defined in many local clinical settings. Objective: To compare the effects of active and passive physiotherapy techniques on motor recovery among adult post-stroke patients. Methods: This randomized controlled trial was conducted at a tertiary care hospital in Northwestern Punjab, Pakistan. Sixty adult post-stroke patients were randomly allocated into active physiotherapy and passive physiotherapy groups, with 30 participants in each group. The active group received voluntary movement exercises, task-based training, balance activities, and mobility practice, while the passive group received passive range-of-motion exercises, stretching, positioning, and therapist-assisted limb movement. Both groups received treatment five days per week for eight weeks. Muscle strength, coordination, and functional mobility were assessed before and after treatment using Manual Muscle Testing, clinical coordination assessment, and the Timed Up and Go Test. Results: Active physiotherapy produced greater improvement than passive physiotherapy in muscle strength (1.5 ± 0.5 vs 0.8 ± 0.4), coordination (3.3 ± 1.0 vs 1.5 ± 0.8), and Timed Up and Go performance (10.9 ± 3.1 vs 5.2 ± 2.6 seconds), with statistically significant between-group differences. Conclusion: Active physiotherapy demonstrated superior short-term improvement in post-stroke motor recovery compared with passive physiotherapy. Keywords: stroke rehabilitation, active physiotherapy, passive physiotherapy, motor recovery, functional mobility, coordination, randomized controlled trial

INTRODUCTION

Stroke remains one of the leading causes of long-term adult disability worldwide, producing persistent impairments in motor control, postural stability, coordination, gait, and independence in activities of daily living. Motor deficits after stroke commonly arise from disruption of descending motor pathways and impaired integration of sensory feedback, resulting in hemiparesis, abnormal movement patterns, reduced balance control, and delayed functional recovery. These impairments place a substantial burden on patients, caregivers, and rehabilitation services, particularly in low- and middle-income settings where access to structured neurological rehabilitation may be inconsistent. Because recovery after stroke is influenced by therapy intensity, task specificity, voluntary participation, and repeated practice, physiotherapy remains a central component of post-stroke rehabilitation programs (1–3).

Active and passive physiotherapy techniques are both widely used in stroke rehabilitation, but they differ substantially in their therapeutic mechanisms. Passive physiotherapy involves therapist-assisted limb movement, stretching, positioning, and range-of-motion exercises, primarily aiming to preserve joint mobility, prevent contracture, reduce stiffness, and prepare the neuromuscular system for later functional training. This approach is especially useful when patients are medically stable but unable to generate sufficient voluntary movement. In contrast, active physiotherapy requires patient participation through voluntary or active-assisted movements, task-oriented practice, balance activities, weight shifting, reaching, sit-to-stand training, and gait-related activities. These techniques are thought to promote experience-dependent neuroplasticity by repeatedly engaging motor planning, sensory feedback, muscle activation, and functional motor relearning (4–7).

Previous evidence suggests that rehabilitation approaches emphasizing active movement, task-specific training, and sufficient therapy intensity may improve strength, mobility, and functional independence after stroke. However, passive techniques continue to be used frequently in routine clinical practice, particularly in early rehabilitation or low-resource settings where standardized stroke protocols may not be consistently implemented. Although both approaches have recognized clinical roles, the comparative benefit of active versus predominantly passive physiotherapy remains insufficiently defined in many local rehabilitation contexts, especially when outcomes such as muscle strength, coordination, and functional mobility are evaluated together using a structured randomized design (5,6,8–10).

In Pakistan, the growing burden of stroke and the limited availability of standardized post-stroke rehabilitation pathways create a need for locally generated evidence to guide clinical decision-making. Many rehabilitation centers use a combination of active and passive methods, but treatment selection is often influenced by therapist preference, patient tolerance, institutional routine, and resource availability rather than locally validated comparative evidence. Establishing whether active physiotherapy provides superior short-term motor recovery compared with passive physiotherapy can help physiotherapists, hospital rehabilitation departments, and policymakers design more effective and reproducible stroke rehabilitation protocols.

Therefore, this randomized controlled trial was conducted to compare the effect of active versus passive physiotherapy techniques on motor recovery among adult post-stroke patients in a tertiary hospital in Northwestern Punjab, Pakistan. The PICO framework comprised adult post-stroke patients as the population, active physiotherapy as the intervention, passive physiotherapy as the comparator, and changes in muscle strength, coordination, and functional mobility as the main outcomes. The study hypothesized that active physiotherapy would produce greater improvement in post-stroke motor recovery than passive physiotherapy after eight weeks of supervised rehabilitation.

MATERIALS AND METHODS

This randomized controlled trial was conducted to compare the effects of active and passive physiotherapy techniques on motor recovery in adult patients after stroke. The study was carried out in the physiotherapy department of a tertiary care hospital in Northwestern Punjab, Pakistan, over a six-month period. A randomized controlled design was selected because it permits direct comparison of two rehabilitation approaches while reducing selection bias and improving internal validity. The trial followed a parallel-group structure in which eligible participants were allocated in a 1:1 ratio to either an active physiotherapy group or a passive physiotherapy group.

Adult male and female patients aged 18 years or above with a physician-confirmed diagnosis of ischemic or hemorrhagic stroke were screened for eligibility. Stroke diagnosis was based on clinical evaluation supported by available imaging reports. Patients were eligible if they were medically stable, had unilateral motor weakness, demonstrated impaired coordination or mobility after stroke, and were able to understand and follow basic physiotherapy instructions. Patients were excluded if they had severe cognitive impairment, unstable cardiac status, major orthopedic conditions limiting movement,

additional neurological disorders such as Parkinson's disease, complete inability to follow instructions, or a history of long-term structured physiotherapy before enrollment. These criteria were applied to ensure that participants were clinically suitable for supervised rehabilitation and that motor recovery outcomes could be reasonably attributed to the allocated intervention.

A total of 60 eligible post-stroke patients were enrolled and equally allocated into two groups, with 30 participants in the active physiotherapy group and 30 participants in the passive physiotherapy group. The sample size was selected as a feasible and clinically manageable number for a supervised single-center rehabilitation trial, allowing equal group allocation while maintaining consistency in therapist supervision, treatment exposure, and follow-up assessment over the eight-week intervention period. After baseline screening and consent, participants were assigned to groups using simple randomization through a lottery method. Allocation was performed after enrollment to reduce selection influence, and the same eligibility criteria were applied before group assignment.

Recruitment was conducted among patients referred to the hospital physiotherapy department for post-stroke rehabilitation. Eligible patients and, where appropriate, their attendants were informed about the purpose, procedures, expected benefits, and voluntary nature of participation. Written informed consent was obtained before data collection and treatment initiation. Participants were informed that refusal or withdrawal would not affect their routine clinical care. Ethical approval was obtained from the relevant hospital ethical review committee before commencement of the study, and confidentiality of participant information was maintained throughout the research process.

Baseline assessment was performed before the start of treatment using a structured assessment form. Demographic and clinical variables included age, sex, type of stroke, affected side, duration since stroke, and relevant medical history. The primary outcome was motor recovery after eight weeks of rehabilitation, assessed through changes in muscle strength, coordination, and functional mobility. Muscle strength was measured using Manual Muscle Testing, recorded as an ordinal clinical strength score.

Coordination was assessed using standardized clinical coordination tasks appropriate for post-stroke patients, with higher scores indicating better controlled movement. Functional mobility was assessed using the Timed Up and Go Test, where lower completion time indicated better mobility performance. The same outcome measures were applied at baseline and after eight weeks to ensure comparability of pre- and post-treatment changes.

Participants in the active physiotherapy group received a supervised rehabilitation program emphasizing voluntary movement and task-oriented motor practice. Treatment included active-assisted movement progressing to active free exercises according to patient tolerance, repeated upper- and lower-limb functional movements, sit-to-stand training, weight-shifting activities, balance exercises, reaching tasks, mobility practice, and assisted gait-related activities.

The therapist provided verbal instruction, correction of abnormal movement patterns, safety supervision, and progression based on participant performance. The intervention was designed to encourage active patient participation and repeated functional practice to support motor relearning.

Participants in the passive physiotherapy group received therapist-assisted rehabilitation focused on passive limb movement and supportive positioning. Treatment included passive range-of-motion exercises for the upper and lower limbs, gentle stretching, safe joint mobilization within available limits, limb positioning, and therapist-assisted movement to maintain joint flexibility and reduce stiffness. Participants in this group were not required to generate substantial voluntary movement during the prescribed exercises. The protocol was designed to represent a predominantly passive physiotherapy approach commonly used for patients with limited active motor control.

Both groups received treatment five days per week for eight consecutive weeks, and each session lasted approximately 40–45 minutes. Treatment frequency, session duration, therapist supervision, and follow-up timing were kept similar between groups to reduce performance bias related to unequal therapy exposure. All sessions were delivered by qualified physiotherapists working in the hospital rehabilitation department. To improve intervention consistency, treatment procedures were discussed before the trial, and the same general protocol structure was followed throughout the study. Participants were reassessed at the end of the eighth week using the same measurement tools applied at baseline.

Potential sources of bias were addressed by applying uniform eligibility criteria, using random group allocation, maintaining equal treatment duration in both groups, using the same assessment tools at baseline and follow-up, and standardizing treatment frequency across participants. Contamination between groups was minimized by delivering group-specific treatment plans and maintaining clear distinction between active and passive intervention components.

Data integrity was supported through structured data collection forms, consistent outcome definitions, direct entry of collected data into the analysis sheet, and verification of entered values before statistical analysis.

Data were analyzed using SPSS version 25. Descriptive statistics were used to summarize demographic and clinical characteristics. Means and standard deviations were calculated for continuous variables such as age, duration since stroke, muscle strength score, coordination score, and Timed Up and Go Test time. Frequencies and percentages were calculated for categorical variables such as sex, stroke type, and affected side.

Baseline comparability between groups was assessed using independent-sample t-tests for continuous variables and chi-square tests for categorical variables where appropriate. Within-group pre- and post-treatment changes were analyzed using paired-sample t-tests.

Between-group differences in post-treatment scores and mean improvement were assessed using independent-sample t-tests. A p-value of less than 0.05 was considered statistically significant. Where appropriate, results were planned to be presented with mean differences, 95% confidence intervals, and effect-size estimates to improve clinical interpretation beyond statistical significance.

RESULTS

A total of 60 adult post-stroke patients completed the study, with 30 participants in the active physiotherapy group and 30 in the passive physiotherapy group. Baseline characteristics were comparable between groups, including age, sex distribution, stroke type, affected side, and duration since stroke, supporting reasonable pre-intervention group balance.

Table 1. Baseline Characteristics of Study Participants

Variable	Active Physiotherapy (n=30)	Passive Physiotherapy (n=30)	p-value
Age, years, mean ± SD	56.8 ± 9.7	57.9 ± 10.2	0.670
Male, n (%)	18 (60.0)	17 (56.7)	0.793
Female, n (%)	12 (40.0)	13 (43.3)	0.793
Ischemic stroke, n (%)	22 (73.3)	21 (70.0)	0.774
Hemorrhagic stroke, n (%)	8 (26.7)	9 (30.0)	0.774
Right-sided weakness, n (%)	16 (53.3)	15 (50.0)	0.796
Left-sided weakness, n (%)	14 (46.7)	15 (50.0)	0.796
Duration since stroke, weeks, mean ± SD	5.8 ± 1.9	6.1 ± 2.1	0.565

At baseline, muscle strength was similar between groups, with mean Manual Muscle Testing scores of 2.4 ± 0.6 in the active group and 2.3 ± 0.5 in the passive group. After eight weeks, both groups improved, but the active physiotherapy group demonstrated a greater increase, reaching 3.9 ± 0.7 compared with 3.1 ± 0.6 in the passive group. The between-group difference in mean improvement was 0.70 points, with a large standardized effect size.

Table 2. Muscle Strength Before and After Treatment

Muscle Strength Outcome	Active Physiotherapy (n=30)	Passive Physiotherapy (n=30)	Mean Difference	95% CI	Effect Size	p-value
Pre-treatment MMT score, mean ± SD	2.4 ± 0.6	2.3 ± 0.5	0.10	—	—	0.521
Post-treatment MMT score, mean ± SD	3.9 ± 0.7	3.1 ± 0.6	0.80	0.46 to 1.14	1.23	0.001
Mean improvement, mean ± SD	1.5 ± 0.5	0.8 ± 0.4	0.70	0.47 to 0.93	1.55	0.001

Coordination improved in both groups, but the magnitude of improvement was substantially greater among participants receiving active physiotherapy. The active group improved from 4.8 ± 1.3 to 8.1 ± 1.4, whereas the passive group improved from 4.7 ± 1.2 to 6.2 ± 1.3. The mean improvement difference between groups was 1.80 points, indicating a strong comparative advantage for active rehabilitation.

Table 3. Coordination Scores Before and After Treatment

Coordination Outcome	Active Physiotherapy (n=30)	Passive Physiotherapy (n=30)	Mean Difference	95% CI	Effect Size	p-value
Pre-treatment score, mean ± SD	4.8 ± 1.3	4.7 ± 1.2	0.10	—	—	0.744
Post-treatment score, mean ± SD	8.1 ± 1.4	6.2 ± 1.3	1.90	1.20 to 2.60	1.41	0.001
Mean improvement, mean ± SD	3.3 ± 1.0	1.5 ± 0.8	1.80	1.33 to 2.27	1.99	0.001

Functional mobility, measured using the Timed Up and Go Test, improved in both groups, as reflected by reduced completion time after treatment. The active group improved from 29.6 ± 4.8 seconds to 18.7 ± 3.9 seconds, while the passive group improved from 29.1 ± 4.5 seconds to 23.9 ± 4.2 seconds. The active group achieved a mean improvement of 10.9 seconds compared with 5.2 seconds in the passive group, producing a between-group improvement difference of 5.70 seconds.

Table 4. Functional Mobility Before and After Treatment

Timed Up and Go Outcome	Active Physiotherapy (n=30)	Passive Physiotherapy (n=30)	Mean Difference	95% CI	Effect Size	p-value
Pre-treatment time, seconds, mean ± SD	29.6 ± 4.8	29.1 ± 4.5	0.50	—	—	0.681
Post-treatment time, seconds, mean ± SD	18.7 ± 3.9	23.9 ± 4.2	-5.20	-7.29 to -3.11	-1.28	0.001
Mean improvement, seconds, mean ± SD	10.9 ± 3.1	5.2 ± 2.6	5.70	4.22 to 7.18	1.99	0.001

Overall, active physiotherapy produced larger improvements across all three motor recovery domains. The greatest comparative effects were observed for coordination and Timed Up and Go improvement, both showing effect sizes of approximately 1.99, followed by muscle strength improvement with an effect size of 1.55. These findings indicate that active participation, task-based movement, balance practice, and mobility training were associated with clinically meaningful gains beyond those achieved with passive therapist-assisted movement alone.

Table 5. Summary of Comparative Treatment Effects

Outcome	Active Group Mean Improvement	Passive Group Mean Improvement	Between-Group Difference	95% CI	Effect Size	Better Performing Group
Muscle strength, MMT score	1.5 ± 0.5	0.8 ± 0.4	0.70	0.47 to 0.93	1.55	Active physiotherapy
Coordination score	3.3 ± 1.0	1.5 ± 0.8	1.80	1.33 to 2.27	1.99	Active physiotherapy
TUG improvement, seconds	10.9 ± 3.1	5.2 ± 2.6	5.70	4.22 to 7.18	1.99	Active physiotherapy

In summary, both rehabilitation approaches improved post-stroke motor outcomes over eight weeks; however, active physiotherapy demonstrated consistently superior gains in muscle strength, coordination, and functional mobility. The baseline similarity between groups strengthens the

interpretation that the greater post-treatment improvements were associated with the active rehabilitation protocol rather than initial group differences.

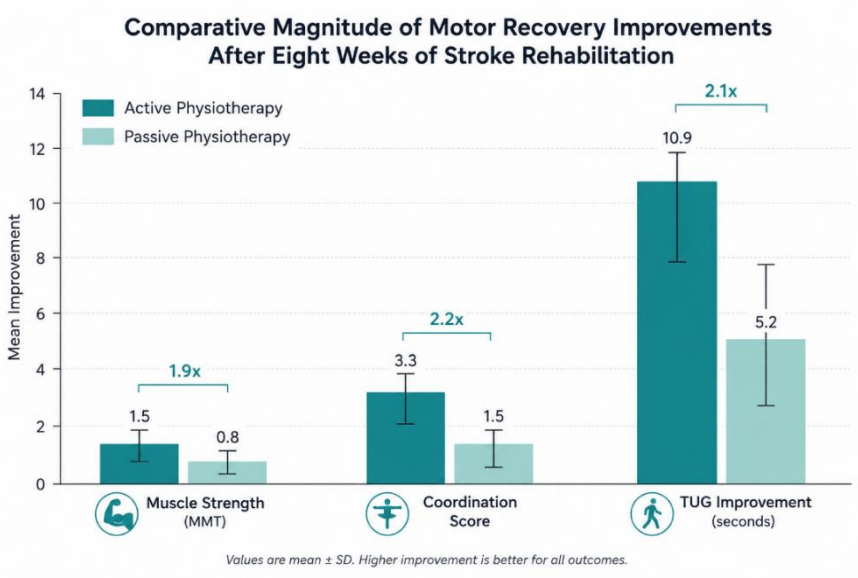

Figure 1. Comparative Magnitude of Motor Recovery Improvements After Eight Weeks of Stroke Rehabilitation

The integrated comparative analysis demonstrated consistently greater rehabilitation gains in the active physiotherapy group across all principal motor recovery outcomes. Mean muscle strength improvement reached 1.5 ± 0.5 points in the active group compared with 0.8 ± 0.4 points in the passive group, representing approximately 1.9-fold greater recovery. Coordination improvement was 3.3 ± 1.0 versus 1.5 ± 0.8 points, corresponding to a 2.2-fold higher functional gain with active rehabilitation. The largest between-group separation was observed in Timed Up and Go performance, where active physiotherapy achieved a 10.9 ± 3.1 second reduction compared with 5.2 ± 2.6 seconds in the passive group, indicating more than twofold greater mobility recovery. The wider separation of mean improvement values across all domains, together with limited overlap of variability intervals, supports a clinically meaningful advantage of active task-oriented rehabilitation for post-stroke motor recovery.

DISCUSSION

The present randomized controlled trial found that both active and passive physiotherapy improved motor recovery in adult post-stroke patients after eight weeks of supervised rehabilitation, but active physiotherapy produced consistently greater gains in muscle strength, coordination, and functional mobility. The active group showed a mean Manual Muscle Testing improvement of 1.5 ± 0.5 points compared with 0.8 ± 0.4 points in the passive group, while coordination improved by 3.3 ± 1.0 versus 1.5 ± 0.8 points. Functional mobility also improved more substantially in the active group, with Timed Up and Go performance improving by 10.9 ± 3.1 seconds compared with 5.2 ± 2.6 seconds in the passive group. These findings support the hypothesis that rehabilitation requiring voluntary patient participation and repeated task-specific movement produces superior short-term motor recovery compared with therapist-assisted passive movement alone.

The greater improvement observed with active physiotherapy is biologically plausible because voluntary, repetitive, and task-oriented movement directly engages motor planning, sensory feedback, postural control, and neuromuscular activation. Stroke recovery depends not only on preventing stiffness and preserving range of motion but also on promoting experience-dependent neuroplasticity through meaningful movement practice. Active rehabilitation may strengthen residual corticospinal pathways, enhance motor relearning, and improve coordination by repeatedly linking intention, movement execution, and sensory feedback. This interpretation is consistent with previous evidence emphasizing

the importance of task-specific training, movement repetition, rehabilitation intensity, and active motor engagement in post-stroke recovery (3–6,11–13).

The improvement in functional mobility is particularly important because Timed Up and Go performance reflects clinically relevant abilities such as standing from a chair, walking, turning, and sitting down safely. The active physiotherapy group achieved more than twice the improvement observed in the passive group, suggesting that active mobility training may translate into more meaningful functional recovery than passive limb movement alone. This finding aligns with rehabilitation literature indicating that repetitive functional practice and gait-related training are associated with better mobility outcomes after stroke (14–18). The larger gains in coordination further suggest that active task-oriented exercises may improve not only isolated strength but also controlled movement sequencing, balance, and functional motor integration.

Passive physiotherapy also produced measurable improvement, indicating that it retains clinical value in post-stroke rehabilitation. Passive range-of-motion exercises, stretching, positioning, and therapist-assisted limb movement may help prevent contracture, reduce stiffness, maintain joint mobility, and prepare patients for later active training. These benefits are especially relevant in patients with marked weakness, poor voluntary control, early-stage immobility, or reduced exercise tolerance. However, the smaller improvement in the passive group suggests that passive treatment should not remain the main rehabilitation strategy once patients are medically stable and capable of participating in active movement. Instead, passive techniques may be best used as supportive components within a progressive rehabilitation model.

The findings have practical implications for rehabilitation services in Pakistan and similar low-resource settings. In many hospitals, post-stroke rehabilitation may rely heavily on passive movements because they are easier to deliver, require less patient participation, and are often perceived as safer in weak patients. However, the present results suggest that structured active rehabilitation should be introduced as early as clinically appropriate. Physiotherapy protocols should emphasize progressive voluntary movement, task-based practice, balance activities, sit-to-stand training, assisted walking, and functional mobility exercises. Training physiotherapists in standardized active rehabilitation protocols may improve consistency of care and functional outcomes.

This study has several limitations. It was conducted at a single tertiary hospital with a relatively small sample size, which may limit generalizability. The intervention period was limited to eight weeks, and long-term retention of motor gains was not assessed. Stroke severity was not stratified in detail, and adjusted analyses for potential confounders such as age, stroke type, time since stroke, and baseline impairment were not performed. The use of clinical outcome measures improved feasibility but may have limited sensitivity compared with more detailed neurological or biomechanical assessments. Assessor blinding and allocation concealment were not fully detailed, which should be strengthened in future trials. Future multicenter randomized studies with larger samples, concealed allocation, blinded assessment, standardized severity classification, long-term follow-up, and adverse-event monitoring are recommended.

Despite these limitations, the study provides useful local evidence that active physiotherapy may offer superior short-term improvement in post-stroke motor recovery compared with passive physiotherapy alone. The consistency of benefit across strength, coordination, and mobility outcomes strengthens the clinical interpretation that active patient participation is central to meaningful rehabilitation. These findings support the integration of active, task-oriented, and progressive rehabilitation strategies into routine post-stroke physiotherapy practice.

CONCLUSION

Active physiotherapy was more effective than passive physiotherapy in improving short-term motor recovery among adult post-stroke patients treated in a tertiary hospital setting. Although both interventions produced measurable gains, patients receiving active physiotherapy demonstrated greater improvement in muscle strength, coordination, and functional mobility after eight weeks of supervised rehabilitation. Passive physiotherapy remains useful for maintaining joint mobility and supporting patients with limited voluntary movement, particularly during early recovery; however, active task-oriented rehabilitation should be prioritized whenever patients are medically stable and able to participate. These findings support the use of structured, progressive, and patient-engaged physiotherapy protocols to improve functional recovery after stroke.

REFERENCES

1. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. Lancet. 2011;377(9778):1693-1702. doi:10.1016/S0140-6736(11)60325-5.
2. Feigin VL, et al. Global burden of stroke. Lancet Neurol. 2017. doi:10.1016/S1474-4422(17)30299-5.
3. Winstein CJ, et al. Guidelines for adult stroke rehabilitation and recovery. Stroke. 2016. doi:10.1161/STR.0000000000000098.
4. Kleim JA, Jones TA. Principles of experience-dependent neural plasticity. J Speech Lang Hear Res. 2008. doi:10.1044/1092-4388(2008/018).
5. Pollock A, et al. Physical rehabilitation approaches for the recovery of function and mobility following stroke. Cochrane Database Syst Rev. 2014. doi:10.1002/14651858.CD001920.pub3.
6. Veerbeek JM, et al. Effects of physical therapy interventions after stroke. PLoS One. 2014. doi:10.1371/journal.pone.0087987.
7. Ada L, Dorsch S, Canning CG. Strengthening interventions increase strength after stroke. Stroke. 2006. doi:10.1161/01.STR.0000221709.14531.91.
8. Kwakkel G, et al. Intensity of rehabilitation after stroke. Stroke. 2004. doi:10.1161/01.STR.0000121648.98720.02.
9. Teasell R, et al. Evidence-based review of stroke rehabilitation. Top Stroke Rehabil. 2014. doi:10.1310/tsr2101-1.
10. Bernhardt J, et al. Early rehabilitation after stroke. Lancet. 2015. doi:10.1016/S0140-6736(15)60690-0.
11. Lang CE, et al. Observation of upper-limb use after stroke. Arch Phys Med Rehabil. 2009. doi:10.1016/j.apmr.2008.09.559.
12. Nudo RJ. Mechanisms for recovery of motor function after stroke. Curr Opin Neurobiol. 2006. doi:10.1016/j.conb.2006.10.004.
13. Krakauer JW. Motor learning and stroke recovery. Curr Opin Neurol. 2006. doi:10.1097/01.wco.0000227043.26352.0b.
14. Langhorne P, Coupar F, Pollock A. Motor recovery after stroke. Lancet Neurol. 2009. doi:10.1016/S1474-4422(09)70150-4.
15. Dobkin BH. Rehabilitation after stroke. N Engl J Med. 2005. doi:10.1056/NEJMra043511.
16. Duncan PW, et al. Management of adult stroke rehabilitation care. Stroke. 2003. doi:10.1161/01.STR.0000089921.61654.9F.

17. Hatem SM, et al. Rehabilitation of motor function after stroke. Neural Plast. 2016. doi:10.1155/2016/7319735.

18. Lohse KR, et al. Dose-response relationship in stroke rehabilitation. Stroke. 2014. doi:10.1161/STROKEAHA.113.004157.

19. Mehrholz J, et al. Electromechanical-assisted gait training after stroke. Cochrane Database Syst Rev. 2017. doi:10.1002/14651858.CD006185.pub4.

20. French B, et al. Repetitive task training for improving functional ability after stroke. Cochrane Database Syst Rev. 2016. doi:10.1002/14651858.CD006073.pub3.

21. Shumway-Cook A, Woollacott M. Motor Control: Translating Research into Clinical Practice. Philadelphia: Lippincott Williams & Wilkins; 2007.

22. Ward NS. Restoring brain function after stroke. Nat Rev Neurosci. 2017. doi:10.1038/nrn.2017.34.

23. Cramer SC, et al. Harnessing neuroplasticity for clinical applications. Brain. 2011. doi:10.1093/brain/awr039.

24. Buma F, Kwakkel G, Ramsey N. Understanding upper limb recovery after stroke. Neurosci Biobehav Rev. 2013. doi:10.1016/j.neubiorev.2013.05.014.

25. Katan M, Luft A. Global burden of stroke. Semin Neurol. 2018. doi:10.1055/s-0038-1649503.