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Mobility after combined range-of-motion and neck exercises in patients with stroke

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Abstract

Background: Stroke frequently results in impaired physical mobility and dependence in activities of daily living. Range-of-motion (ROM) and neck exercises may support recovery by maintaining joint mobility, muscle activity, postural control, and functional performance.
Purpose: To compare mobility changes between stroke patients receiving combined ROM and neck exercises and those receiving standard hospital therapy.
Method: This quasi-experimental study used a pretest–posttest design with a control group and involved 52 patients with non-hemorrhagic stroke, comprising 26 participants in the intervention group and 26 in the control group. Allocation was sequential rather than randomized. The intervention group received a 30-minute combined ROM and neck-exercise program, whereas the control group received standard hospital therapy. Mobility was measured using the Barthel Index. Within-group changes were analyzed using the Wilcoxon signed-rank test, and post-test mobility was compared between groups using the Mann–Whitney U test.
Results: The mean Barthel Index score increased from 7.8 to 12.6 in the intervention group and from 7.9 to 8.4 in the control group. Mobility improved significantly within the intervention group ($p < 0.001$) but not within the control group ($p = 0.066$). Post-test mobility differed significantly between groups ($p < 0.001$).
Conclusion: Combined ROSM and neck exercises were associated with greater short-term mobility improvement than standard hospital therapy in this non-randomized sample.

Keywords: Barthel Index; Mobility; Neck Exercise; Range of Motion; Stroke.

INTRODUCTION

Stroke is a leading cause of death and long-term disability worldwide, and many survivors require sustained rehabilitation to address motor impairment and limitations in activities of daily living (Feigin, Brainin, Norrving, Martins, Sacco, Hacke, Fisher, Pandian, & Lindsay, 2022; Winstein, Stein, Arena, Bates, Cherney, Cramer, Deruyter, Eng, Fisher, Harvey, Lang, MacKay-Lyons, Ottenbacher, Pugh, Reeves, Richards, Stiers, & Zorowitz, 2016). Long-term stroke care also includes evidence-based secondary prevention to reduce recurrent stroke risk (Kleindorfer, Towfighi, Chaturvedi, Cockroft, Gutierrez, Lombardi-Hill, Kamel, Kernan, Kittner, Leira, Lennon, Meschia, Nguyen, Pollak, Santangeli, Sharrief, Smith, Turan, & Williams, 2021). Contemporary stroke-recovery frameworks emphasize standardized definitions, reproducible rehabilitation interventions, and functional outcomes (Bernhardt, Hayward, Kwakkel, Ward, Wolf, Borschmann, Krakauer, Boyd, Carmichael, Corbett, & Cramer, 2017; Kwakkel, Stinear, Essers, Munoz-Novoa, Branscheidt, Cabanas-Valdés, Lakičević, Lampropoulou, Luft, Marque, Moore, Solomon, Swinnen, Turolla, Alt Murphy, & Verheyden, 2023).

Impaired mobility is common after stroke and may result from weakness, impaired selective motor control, spasticity, reduced balance, and loss of coordinated gait. Evidence-based rehabilitation therefore combines task-specific practice,

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progressive exercise, mobility training, and individualized strategies to improve functional independence (Stinear, Lang, Zeiler, & Byblow, 2020; Hatem, Saussez, Della Faille, Prist, Zhang, Dispa, & Bleyenheuft, 2016). Systematic reviews have found beneficial effects from structured physical therapy, repetitive task practice, physical-fitness training, and assisted gait training after stroke (Laver, Lange, George, Deutsch, Saposnik, & Crotty, 2017; Veerbeek, van Wegen, van Peppen, van der Wees, Hendriks, Rietberg, & Kwakkel, 2014; French, Thomas, Coupe, McMahon, Connell, Harrison, Sutton, Tishkovskaya, & Watkins, 2016; Saunders, Sanderson, Hayes, Johnson, Kramer, Carter, Jarvis, Brazzelli, & Mead, 2020; Mehrholz, Thomas, & Elsner, 2020).

Range-of-motion exercise and movement practice are commonly incorporated into stroke rehabilitation to maintain joint mobility, limit stiffness, facilitate motor practice, and support the return to functional activity. Clinical guidelines recommend repetitive, task-oriented, progressively challenging rehabilitation rather than passive movement alone (Winstein et al., 2016; Hornby, Reisman, Ward, Scheets, Miller, Haddad, Fox, Fritz, Hawkins, Henderson, Hendron, Holleran, Lynskey, Walter, & Locomotor CPG Appraisal Team, 2020). A recent meta-analysis of randomized trials found that exercise interventions improved modified Barthel Index, balance, and upper-limb motor outcomes after stroke (Zou, Liu, Zhang, Zhao, & Gu, 2026).

Neck-focused exercise may complement general rehabilitation by addressing cervical and trunk control, postural stability, and proprioceptive input. In chronic stroke, combined neck and trunk stabilization produced immediate improvements in balance and gait measures (Choe & Kim, 2020), while neck stabilization training has also been associated with improved respiratory function (Kim & Cho, 2021). Proprioceptive neuromuscular facilitation-based neck exercise has been studied for swallowing function after stroke, although that outcome differs from mobility (Kim, Lee, Lee, & Ryu, 2015). These findings provide mechanistic support but do not establish that neck exercise alone improves Barthel Index mobility. This study therefore aimed to compare mobility changes between patients with stroke who received combined ROM and neck exercises and those who received standard hospital therapy.

RESEARCH METHOD

This study used a quantitative quasi-experimental design with a pretest–posttest control-group approach and was conducted in the internal medicine inpatient ward of Mitra Bangsa Pati Hospital, Central Java, Indonesia. The population comprised 60 patients with non-hemorrhagic stroke, of whom 52 met the eligibility criteria and were included, with 26 participants allocated to the control group and 26 to the intervention group.

Group allocation was non-random and sequential: participants numbered 1–26 were assigned to the control group and participants numbered 27–52 to the intervention group. The inclusion criteria were willingness to participate, a diagnosis of non-hemorrhagic stroke with hemiparesis, and commencement of assessment two days after stroke onset.

The intervention group received a 30-minute combined ROM and neck-exercise program, whereas the control group received the standard therapy provided by the hospital.

Mobility was assessed before and after treatment using the Barthel Index, a widely used measure of activities of daily living after stroke that has demonstrated strong inter-rater reliability (Duffy, Gajree, Langhorne, Stott, & Quinn, 2013). In this study the 20-point version was used, and total scores were classified into five dependency categories: independent, mild dependence, moderate dependence, severe dependence, and total dependence.

Categorical variables were summarized using frequencies and percentages, and continuous variables were summarized using means, standard deviations, and ranges. Within-group changes were assessed using the Wilcoxon signed-rank test, and post-test mobility was compared between groups using the Mann-Whitney U test. Statistical significance was set at $p < 0.05$.

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RESEARCH RESULTS

A total of 52 patients were included, with 26 participants in each group. Table 1 presents the baseline characteristics of the participants.

Table 1. Baseline characteristics of the study participants (N = 52)

Variable	Control (n = 26)	Intervention (n = 26)
Age, mean ± SD (range), years	52.8 ± 5.86 (42–62)	54.2 ± 6.25 (45–64)
18–30 years	0/0.0	0/0.0
31–40 years	0/0.0	0/0.0
41–50 years	9/34.6	6/23.1
51–60 years	15/57.7	14/53.8
>60 years	2/7.7	6/23.1
Education Level		
Primary school	5/19.2	6/23.1
Junior high school	8/30.8	9/34.6
Senior high school	11/42.3	10/38.5
Higher Education	2/7.7	1/3.8
Employment status		
Unemployment	6/23.1	8/30.8
Farmer	4/15.4	5/19.2
Private-sector employee	9/34.6	5/19.2
Civil servant	1/3.8	1/3.8
Trader	6/23.1	7/26.9
Systolic blood pressure, mean (range), mmHg	108.1 (90–130)	108.4 (90–130)
Diastolic blood pressure, mean (range), mmHg	86.1 (80–90)	85.0 (80–90)

As presented in Table 1, most participants in both groups were male. The mean age was 52.8 ± 5.86 years in the control group and 54.2 ± 6.25 years in the intervention group, and senior high school was the most common level of educational attainment in both groups. Table 2 demonstrates the distribution of Barthel Index scores and dependency categories before and after treatment in each group.

Table 2. Mobility before and after treatment by study group (N = 52)

Group/time	Mean Barthel Index	Independent	Mild dependence	Moderate dependence	Severe dependence	Total dependence
Control: pre-test	**7.9**	**0/0.0**	**2/7.7**	**10/38.5**	**13/50.0**	**1/3.8**
Control: post-test	8.4	0/0.0	3/11.5	13/50.0	10/38.5	0/0.0
Intervention: pre-test	7.8	0/0.0	2/7.7	9/34.6	13/50.0	2/7.7
Intervention: post-test	12.6	1/3.8	13/50.0	12/46.2	0/0.0	0/0.0

As shown in Table 2, the control group demonstrated only a small increase in the mean Barthel Index score, from 7.9 at pre-test to 8.4 at post-test, and this within-group change was not statistically significant ($p = 0.066$). In the intervention group, the mean score increased from 7.8 to 12.6, and no participant remained in the severe- or total-dependence categories at post-test. The intervention-group change was statistically significant ($p < 0.001$). Post-test mobility differed significantly between the intervention and control groups ($p < 0.001$).

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DISCUSSION

The findings indicate greater short-term mobility improvement in the intervention group than in the control group. The mean Barthel Index score increased substantially after combined ROM and neck exercise, whereas only a small and non-significant change occurred in the control group. This result is consistent with the broader stroke-rehabilitation literature indicating that structured exercise and repetitive rehabilitation can improve functional activity and mobility (French et al., 2016; Saunders et al., 2020; Zou et al., 2026). The present study nevertheless evaluated one specific combined program and should therefore not be regarded as a direct replication of those broader interventions. Evidence based on Barthel Index outcomes across other neurorehabilitation approaches is heterogeneous, which further supports interpreting functional effects in relation to the particular intervention and study design (Polo-Ferrero, Torres-Alonso, Sánchez-González, Hernández-Rubia, Agudo Juan, Pérez-Elvira, & Oltra-Cucarella, 2026).

ROM exercise and active movement practice may support recovery by maintaining available joint movement, limiting stiffness, encouraging neuromuscular activation, and creating opportunities for task practice. Current rehabilitation guidance emphasizes adequate dose, repetition, progression, and functional relevance (Winstein et al., 2016; Hornby et al., 2020). Intervention sessions in the present study were occasionally paused because of fatigue or pain, which highlights the importance of adapting exercise intensity to each patient's tolerance and clinical condition.

Neck exercise may provide complementary benefits through cervical stabilization, postural control, and proprioceptive input. Choe and Kim (2020) reported improvements in balance and gait after adding neck stabilization to trunk stabilization in chronic stroke, and Kim and Cho (2021) reported improved respiratory function after neck stabilization training. Kim et al. (2015) also demonstrated effects of neck exercise on swallowing-related outcomes. These studies used outcomes other than the Barthel Index, and they therefore support biological plausibility rather than providing direct evidence for the magnitude of mobility improvement observed in the present study.

The between-group result should not be interpreted as definitive evidence of treatment efficacy, because allocation was non-random. Sequential assignment may introduce selection bias and baseline imbalance between groups. Stroke-recovery research standards emphasize clearly defined intervention dose, timing, comparator treatment, and outcome assessment (Bernhardt et al., 2017; Kwakkel et al., 2023).

Several additional limitations should be acknowledged. The study was conducted in a single inpatient ward with a small sample, which limits precision and generalizability. Neither participants nor assessors were blinded, which may introduce performance and measurement bias. The follow-up period was short, and the durability of the observed mobility gains is therefore unknown. The analysis did not adjust for stroke severity, lesion characteristics, concurrent rehabilitation, comorbidities, or other potential confounders. The Barthel Index is reliable for stroke assessment, but differences in scoring versions and ceiling/floor properties make explicit reporting important (Duffy et al., 2013; Quinn, Langhorne, & Stott, 2011).

CONCLUSION

Combined ROM and neck exercises were associated with greater short-term improvement in Barthel Index mobility scores than standard hospital therapy among patients with non-hemorrhagic stroke. The intervention group improved significantly from pre-test to post-test, whereas the control group showed no statistically significant within-group change. Because allocation was non-random and baseline comparability between groups was not formally tested, these findings should be interpreted cautiously.

SUGGESTION

Future studies should use randomized allocation where feasible, together with larger multicenter samples, standardized and fully described ROM and neck-exercise protocols, blinded outcome assessment, and longer follow-up. Baseline group comparability and clinically meaningful effect sizes should be reported, and analyses should account for stroke severity, time since onset, and concurrent rehabilitation. Rehabilitation protocols should report

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dose, progression, task specificity, and standard-care comparators clearly in line with contemporary stroke rehabilitation guidance (Winstein et al., 2016; Stinear et al., 2020).

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