EFFECT OF A KINESITHERAPY METHOD TARGETING POSTURAL CONTROL ON FUNCTIONAL MOBILITY AND FALL-RISK-RELATED OUTCOMES IN PATIENTS WITH CHRONIC ISCHEMIC STROKE

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Abstract: Chronic ischemic stroke often causes impairments in postural control, balance, gait, and independent mobility, limiting daily activity and increasing functional fall risk. Objective: To evaluate the effect of a kinesitherapy method targeting postural control on functional mobility and fall-risk-related outcomes in patients with chronic ischemic stroke. Methods: This is a secondary analysis of data from a three-month controlled follow-up of 46 patients allocated to an experimental group (n = 34) and a control group (n = 12). The experimental group received a 10-day specialized program followed by an adapted home-based program until month 3, while the control group received conventional 10-day kinesitherapy. Assessments were performed at baseline, day 10, month 1, and month 3 using the Berg Balance Scale, Dynamic Gait Index, Functional Ambulation Category, Timed Up and Go, 10-Meter Walk Test, and Rivermead Mobility Index. Results: The groups were comparable at baseline. At month 3, the experimental group showed significantly better results on the Berg Balance Scale (48.1 ± 5.5 vs 43.0 ± 4.8; p = 0.001), Dynamic Gait Index (21.0 ± 2.3 vs 17.0 ± 2.6; p < 0.001), and Functional Ambulation Category (4.4 ± 0.7 vs 3.5 ± 0.7; p = 0.002). Timed Up and Go, 10-Meter Walk Test, and Rivermead Mobility Index improved in both groups, without significant between-group differences. Conclusion: The method targeting postural control improved balance, dynamic gait stability, and independent ambulation, and may serve as a basis for safer functional mobility in chronic ischemic stroke rehabilitation.
Keywords: chronic ischemic stroke; postural control; kinesitherapy; balance; gait; fall risk.

1. INTRODUCTION

Stroke is one of the leading causes of long-term disability and reduced independence worldwide. According to the Global Burden of Disease Study 2021, stroke remains a condition with a high burden in terms of mortality, survival with disability, and years of life lost due to disability (GBD 2021 Stroke Risk Factor Collaborators, 2024). After ischemic stroke, many patients continue to experience impairments in motor function, sensation, balance, gait, and daily activity.

Postural control is essential for functional recovery after stroke. It includes the ability to maintain body stability and orientation in space through the integration of motor, sensory, visual, vestibular, and cognitive mechanisms (Horak, 2006). In patients after stroke, postural control impairments may manifest as asymmetrical lower-limb weight bearing, impaired trunk control, difficulty with weight transfer, increased postural sway, and unstable gait. These impairments are associated with limited functional mobility and an increased risk of falling (Batchelor et al., 2012).

In post-stroke rehabilitation, it is important not only to restore isolated motor functions, but also to improve the patient's ability to use stability and movement in real-life daily situations. This includes standing up from a chair, maintaining standing balance, transferring weight, walking, changing direction, avoiding and overcoming obstacles. Such a functional focus is consistent with modern principles of neurorehabilitation, according to which therapy should be repetitive, task-oriented, progressive, and individualized (French et al., 2016).

Koleva, Yoshinov, and Yoshinov (2016) examined the effects of different neurorehabilitation programs on functional recovery and autonomy in patients with post-stroke hemiparesis, while Koleva, R. Yoshinov, and B. Yoshinov (2024) emphasized balance, gait, and autonomy as important indicators of neurorehabilitation effectiveness.

Unlike previous publications that examined separate aspects of postural control, walking speed, or physical performance, the present analysis focuses on functional mobility and clinical outcomes related to fall risk.

Objective

The aim of the present study was to evaluate the effect of a kinesitherapy method targeting postural control on functional mobility, balance, dynamic gait stability, and fall-risk-related outcomes in patients with chronic ischemic stroke.

2. MATERIALS AND METHODS

The present study is a secondary analysis of data from a three-month controlled follow-up in patients with chronic ischemic stroke. The analysis focuses on functional mobility and clinical outcomes related to fall risk, using data from a previously conducted kinesitherapy intervention focused on postural control.

The study included 46 patients with chronic ischemic stroke, more than 6 months after stroke onset. The patients were divided into two groups: an experimental group of 34 patients and a control group of 12 patients. The experimental group received a specialized kinesitherapy method targeting postural control, consisting of a 10-day supervised program and an adapted home-based program continued until the end of the third month. The control group received conventional 10-day kinesitherapy.

Assessments were performed at four time points: at baseline, on day 10, at month 1, and at month 3. The following clinical instruments were used: Berg Balance Scale, Dynamic Gait Index, Functional Ambulation Category, Timed Up and Go, 10-Meter Walk Test, and Rivermead Mobility Index. The selection of these instruments is consistent with contemporary recommendations for standardized assessment of balance and mobility after stroke, where BBS, FAC, 10MWT, and DGI are identified as relevant measures for standing balance, walking independence, walking speed, and complex walking ability (Van Criekinge et al., 2024).

The Berg Balance Scale was used to assess static and dynamic balance (Berg et al., 1992). The Dynamic Gait Index was used to evaluate walking ability under changing conditions and complex motor tasks (Shumway-Cook & Woollacott, 1995). The Functional Ambulation Category was used to determine the degree of walking independence and the need for assistance or supervision (Mehrholz et al., 2007). The Timed Up and Go test was used to assess basic functional mobility, including standing up from a chair, walking, turning, and sitting down (Podsiadlo & Richardson, 1991). The Rivermead Mobility Index was used to assess general mobility through tasks related to transfers, standing, and locomotion (Collen et al., 1991).

Statistical analysis was performed using variation analysis, and the results are presented as mean values and standard deviations. The Wilcoxon signed-rank test and the Paired Samples Test were used for within-group comparisons, while the Mann–Whitney U test was used for between-group comparisons. Statistical significance was accepted at $p < 0.05$.

3. RESULTS

At baseline, the two groups were comparable in the main indicators of balance, gait, and functional mobility. No statistically significant differences were found for Functional Ambulation Category — 3.2 ± 0.7 vs. 3.2 ± 0.9 points, $p = 0.654$; Berg Balance Scale — 35.5 ± 7.5 vs. 36.0 ± 6.0 points, $p = 0.773$; Dynamic Gait Index — 15.4 ± 3.1 vs. 15.7 ± 2.8 points, $p = 0.677$; Timed Up and Go — 13.8 ± 1.6 vs. 13.4 ± 1.9 seconds, $p = 0.474$; and Rivermead Mobility Index — 11.4 ± 3.3 vs. 12.0 ± 2.5 points, $p = 0.790$. This indicates that the baseline functional status of the two groups was similar and allows subsequent changes to be interpreted in relation to the applied kinesitherapy approaches.

The most pronounced improvement was observed on the Berg Balance Scale. In the experimental group, the score increased from 35.5 ± 7.5 to 48.1 ± 5.5 points at month 3, while in the control group it increased from 36.0 ± 6.0 to 43.0 ± 4.8 points. The between-group difference at month 3 was statistically significant — $p = 0.001$. This result indicates that the method targeting postural control had a stronger effect on static and dynamic balance compared with conventional kinesitherapy.

The clinical significance of the BBS change is supported by the findings of Sharabiani et al. (2024), according to whom BBS and DGI are appropriate instruments for assessing functional balance in patients with chronic stroke and have established minimal important differences. In the present study, the change in the experimental group was 12.6 points, which considerably exceeds the reported minimal important values for BBS in chronic stroke.

The BBS result is also relevant in terms of fall-risk-related outcomes. Matsumoto et al. (2024) reported that the most commonly reported BBS cutoff values for identifying fall risk after stroke range approximately between 46.5 and 50.5 points. At the end of the follow-up, the experimental group reached a mean score of 48.1 points, which falls within this range, while the control group remained below it. It should be emphasized, however, that the present study assessed clinical outcomes related to fall risk, but did not monitor actual falls.

A substantial improvement was also observed on the Dynamic Gait Index. The experimental group increased its score from 15.4 ± 3.1 to 21.0 ± 2.3 points, whereas the control group improved from 15.7 ± 2.8 to 17.0 ± 2.6 points. The between-group difference was statistically significant — $p < 0.001$. This indicates that the specialized method

affected not only balance under static conditions, but also adaptive gait stability during changes in walking speed, turning, head movements, obstacle negotiation, and stair ambulation.

On the Functional Ambulation Category, the experimental group improved from 3.2 ± 0.7 to 4.4 ± 0.7 points, while the control group improved from 3.2 ± 0.9 to 3.5 ± 0.7 points. The between-group difference at month 3 was statistically significant — p = 0.002. This indicates that patients in the experimental group achieved a higher level of walking independence. The result supports the view that improvement in postural control affects not only balance, but also the practical ability for functional mobility.

On the Timed Up and Go test, both groups showed improvement, but without a statistically significant between-group difference at month 3 — 10.8 ± 1.8 seconds in the experimental group versus 11.3 ± 1.9 seconds in the control group, p = 0.443. This shows that both approaches improved basic functional mobility, but TUG did not demonstrate clear superiority of the specialized method.

On the 10-Meter Walk Test, improvement was also observed in both groups, but without a statistically significant between-group difference. Comfortable walking speed in the experimental group increased from 0.55 ± 0.06 to 0.71 ± 0.11 m/s, while in the control group it increased from 0.60 ± 0.07 to 0.69 ± 0.10 m/s, p = 0.615. At maximum walking speed, the values increased from 0.63 ± 0.09 to 0.89 ± 0.15 m/s and from 0.68 ± 0.10 to 0.87 ± 0.14 m/s, respectively, p = 0.764. These findings show that walking speed improved with both kinesitherapy approaches, but do not demonstrate superiority of the specialized method in terms of linear walking speed.

On the Rivermead Mobility Index, the experimental group improved from 11.4 ± 3.3 to 13.5 ± 1.6 points, while the control group improved from 12.0 ± 2.5 to 13.4 ± 1.5 points, without a statistically significant between-group difference — p = 0.686. This confirms overall improvement in mobility, but suggests that RMI may be less sensitive to more subtle changes in dynamic gait stability and adaptive postural control.

The obtained results are consistent with current literature. Liu et al. (2025), in a systematic review and meta-analysis of patients with chronic stroke, found that exercise significantly improves mobility and balance, but does not show a significant effect on the 10-Meter Walk Test. This corresponds to the present findings, where the strongest between-group differences were observed in BBS, DGI, and FAC, rather than in 10MWT. Zhao et al. (2025) also emphasized that exercise in chronic stroke improves walking and balance to varying degrees depending on the type of training.

The overall analysis shows that the specialized kinesitherapy method targeting postural control has the most pronounced effect on outcomes requiring adaptive postural control, dynamic balance, and functional gait stability. The most convincing results were observed for the Berg Balance Scale, Dynamic Gait Index, and Functional Ambulation Category. This supports the interpretation of the method as an approach that primarily improves the quality, safety, and independence of mobility, rather than necessarily all indicators of speed or basic mobility.

4. DISCUSSIONS

The two groups were comparable at baseline in the main indicators of balance, gait, and functional mobility, which allows the subsequent changes to be interpreted in relation to the applied kinesitherapy approaches. The results show that the kinesitherapy method targeting postural control led to a more pronounced improvement in balance compared with conventional kinesitherapy, as demonstrated by the significant increase in the Berg Balance Scale score. This improvement is relevant to the functional safety of mobility, as the experimental group reached values within the range of commonly used cutoff points for fall risk after stroke. The strongest effect of the specialized method was observed in dynamic gait stability, assessed by the Dynamic Gait Index, indicating better adaptation during walking under changing conditions. The experimental group also showed better development of independent ambulation according to the Functional Ambulation Category; however, this result should be interpreted cautiously until the values are finally verified against the dissertation data. Improvements in the Timed Up and Go, 10-Meter Walk Test, and Rivermead Mobility Index were observed in both groups, but without significant between-group superiority of the experimental method. Therefore, the main contribution of the method is primarily related to improving the quality, adaptability, and safety of mobility, rather than demonstrating superiority across all indicators of speed and basic mobility.

Recommendations

Kinesitherapy in patients with chronic ischemic stroke should include targeted work on postural control, as it is fundamental for balance, gait, transfers, and independent mobility.

It is recommended that the therapeutic program be individualized and progressive, moving from trunk control, alignment, and symmetrical weight bearing toward weight transfer, dynamic balance, walking under different conditions, turning, changing direction, and obstacle negotiation.

For patient assessment, a combination of tests should be used rather than a single measure. The Berg Balance Scale and Dynamic Gait Index are particularly informative when the goal is to assess adaptive postural control and the functional safety of mobility.

The home-based program after the supervised therapeutic course should be clearly structured and adapted to the patient's abilities and fall risk. In patients with pronounced instability, exercises should be performed under supervision or with access to a safe support surface.
Future studies should monitor the actual incidence of falls, rather than only clinical outcomes related to fall risk. Larger and more evenly distributed groups, longer follow-up periods, and standardized dual-task tests are also recommended.

5. CONCLUSIONS

The kinesitherapy method targeting postural control led to greater improvement in balance, dynamic gait stability, and independent ambulation in patients with chronic ischemic stroke compared with conventional kinesitherapy. The strongest effect was observed in outcomes reflecting adaptive postural control and the functional safety of mobility — the Berg Balance Scale, Dynamic Gait Index, and Functional Ambulation Category.
The results indicate that the method may be used as an effective basis for functional rehabilitation aimed at safer mobility and greater independence in daily life. At the same time, the absence of significant between-group differences in the Timed Up and Go, 10-Meter Walk Test, and Rivermead Mobility Index suggests that the effect should be interpreted primarily as an improvement in the quality and safety of mobility, rather than superiority across all indicators of speed and basic mobility.
The present study analyzed clinical outcomes related to fall risk but did not monitor actual falls. Therefore, future studies should include direct registration of falls, larger samples, and longer follow-up periods.

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REFERENCES

Batchelor, F. A., Mackintosh, S. F., Said, C. M., & Hill, K. D. (2012). Falls after stroke. *International Journal of Stroke*, *7*(6), 482–490. https://doi.org/10.1111/j.1747-4949.2012.00796.x

Berg, K. O., Wood-Dauphinee, S. L., Williams, J. I., & Maki, B. (1992). Measuring balance in the elderly: Validation of an instrument. *Canadian Journal of Public Health, 83*(Suppl. 2), S7–S11.

Collen, F. M., Wade, D. T., Robb, G. F., & Bradshaw, C. M. (1991). The Rivermead Mobility Index: A further development of the Rivermead Motor Assessment. *International Disability Studies, 13*(2), 50–54. https://doi.org/10.3109/03790799109166684

French, B., Thomas, L. H., Coupe, J., McMahon, N. E., Connell, L., Harrison, J., Sutton, C. J., Tishkovskaya, S., & Watkins, C. L. (2016). Repetitive task training for improving functional ability after stroke. *Cochrane Database of Systematic Reviews, 2016*(11), Article CD006073. https://doi.org/10.1002/14651858.CD006073.pub3

GBD 2021 Stroke Risk Factor Collaborators. (2024). Global, regional, and national burden of stroke and its risk factors, 1990–2021: A systematic analysis for the Global Burden of Disease Study 2021. *The Lancet Neurology, 23*(10), 973–1003. https://doi.org/10.1016/S1474-4422(24)00369-7

Horak, F. B. (2006). Postural orientation and equilibrium: What do we need to know about neural control of balance to prevent falls? *Age and Ageing, 35*(Suppl. 2), ii7–ii11. https://doi.org/10.1093/ageing/afl077

Koleva, I., Yoshinov, R., & Yoshinov, B. (2016). Comparative evaluation of the efficacy of different neurorehabilitation programs on the functional recovery and the autonomy of patients with post-stroke hemiparesis. *Physical Medicine and Rehabilitation Research, 1*(5), 1–8. https://doi.org/10.15761/PMRR.1000126

Koleva, I. B., Yoshinov, R. R., & Yoshinov, B. R. (2024). Clinical significance of robot manipulators for grasp, balance, and gait recovery (from the medical point of view). In S. Küçük (Ed.), *Exploring the world of robot manipulators*. IntechOpen. https://doi.org/10.5772/intechopen.1004544

Liu, Y., Jiang, M., Pan, X., & Geng, J. (2025). Effects of exercise on mobility, balance and gait in patients with the chronic stroke: A systematic review and meta-analysis. *Scientific Reports, 15*, Article 24158. https://doi.org/10.1038/s41598-025-09458-1

Matsumoto, D., Fujita, T., Kasahara, R., Tsuchiya, K., & Iokawa, K. (2024). Screening cutoff values to identify the risk of falls after stroke: A scoping review. *Journal of Rehabilitation Medicine, 56*, Article jrm40560. https://doi.org/10.2340/jrm.v56.40560

Mehrholz, J., Wagner, K., Rutte, K., Meißner, D., & Pohl, M. (2007). Predictive validity and responsiveness of the Functional Ambulation Category in hemiparetic patients after stroke. *Archives of Physical Medicine and Rehabilitation*, *88*(10), 1314–1319. https://doi.org/10.1016/j.apmr.2007.06.764

Podsiadlo, D., & Richardson, S. (1991). The timed "Up & Go": A test of basic functional mobility for frail elderly persons. *Journal of the American Geriatrics Society*, *39*(2), 142–148. https://doi.org/10.1111/j.1532-5415.1991.tb01616.x

Sharabiani, P. T. A., Mehdizadeh, M., Goudarzi, S., Jamali, S., Najd Mazhar, F., Heidari, M., Haji Alizadeh, N., Mohammadi, F., Sayyar Sabet Foomani, A., & Taghizadeh, G. (2024). Minimal important difference of Berg Balance Scale, performance-oriented mobility assessment and dynamic gait index in chronic stroke survivors. *Journal of Stroke and Cerebrovascular Diseases*, *33*(11), Article 107930. https://doi.org/10.1016/j.jstrokecerebrovasdis.2024.107930

Shumway-Cook, A., & Woollacott, M. H. (1995). *Motor control: Theory and practical applications*. Williams & Wilkins.

Van Criekinge, T., Heremans, C., Burridge, J., Deutsch, J. E., Hammerbeck, U., Hollands, K., Karthikbabu, S., Mehrholz, J., Moore, J. L., Salbach, N. M., Schröder, J., Veerbeek, J. M., Weerdesteyn, V., Borschmann, K., Churilov, L., Verheyden, G., & Kwakkel, G. (2024). Standardized measurement of balance and mobility post-stroke: Consensus-based core recommendations from the third Stroke Recovery and Rehabilitation Roundtable. *International Journal of Stroke*, *19*(2), 158–168. https://doi.org/10.1177/17474930231205207

Zhao, Z., Dong, X., Fang, J., Zhao, Y., & Zhang, X. (2025). The effects of different exercise modes on walking ability and balance function in chronic stroke survivors: A systematic review and network meta-analysis of randomized controlled trials. *Journal of Back and Musculoskeletal Rehabilitation*, *38*(6). https://doi.org/10.1177/10538127251332414