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The Effect of Heel Raise and Sit-to-Stand (STS) Exercises on the Balance of Post-Stroke Patients: A Quasi-Experimental Study

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ORIGINAL ARTICLES

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ABSTRACT

Brain blood vessels block or rupture in cerebrovascular disease (CVD), limiting oxygen and nutrient delivery to brain tissue. An untreated stroke can cause lasting brain damage, disability, or even death. Common complications include muscle weakness, coordination issues, difficulty swallowing, slurred speech, reduced sensitivity, facial or bodily paralysis, and balance problems. Stroke survivors are advised to engage in physical exercises such as heel raises and sit-to-stand (STS) movements to address balance impairments. This study aimed to evaluate the effect of heel raise and STS exercises on improving balance in post-stroke patients at the Sawah Lebar Public Health Center in Bengkulu Municipality. A quasi-experimental design was employed with 52 participants split evenly into intervention and control groups. Participants were selected using purposive sampling, and balance was measured using the Berg Balance Scale (BBS). The Mann-Whitney test revealed a significant difference in balance scores between groups (p-value = 0.000, $p \leq 0.05$, indicating a positive effect of the intervention). Before intervention, both groups experienced balance impairments, with the intervention group scoring 33.04 (SD 6.095) and the control group 31.54 (SD 4.933). After the intervention, scores improved more notably in the intervention group (scored by 38.04, SD 5.744) compared to the control group (scored by 32.65, SD 5.012), p-value = 0.000 (Mann-Whitney). Intervention increased the average score by +5.00 and control by +1.12. Heel raise and sit-to-stand (STS) exercises significantly improved balance in post-stroke patients and may serve as effective rehabilitation strategies, although further larger randomized controlled trials are needed to confirm these findings.

Key Messages:

- Heel raise and sit-to-stand (STS) exercises can be part of a stroke rehabilitation program to improve balance, mobility, and physical recovery in post-stroke patients.

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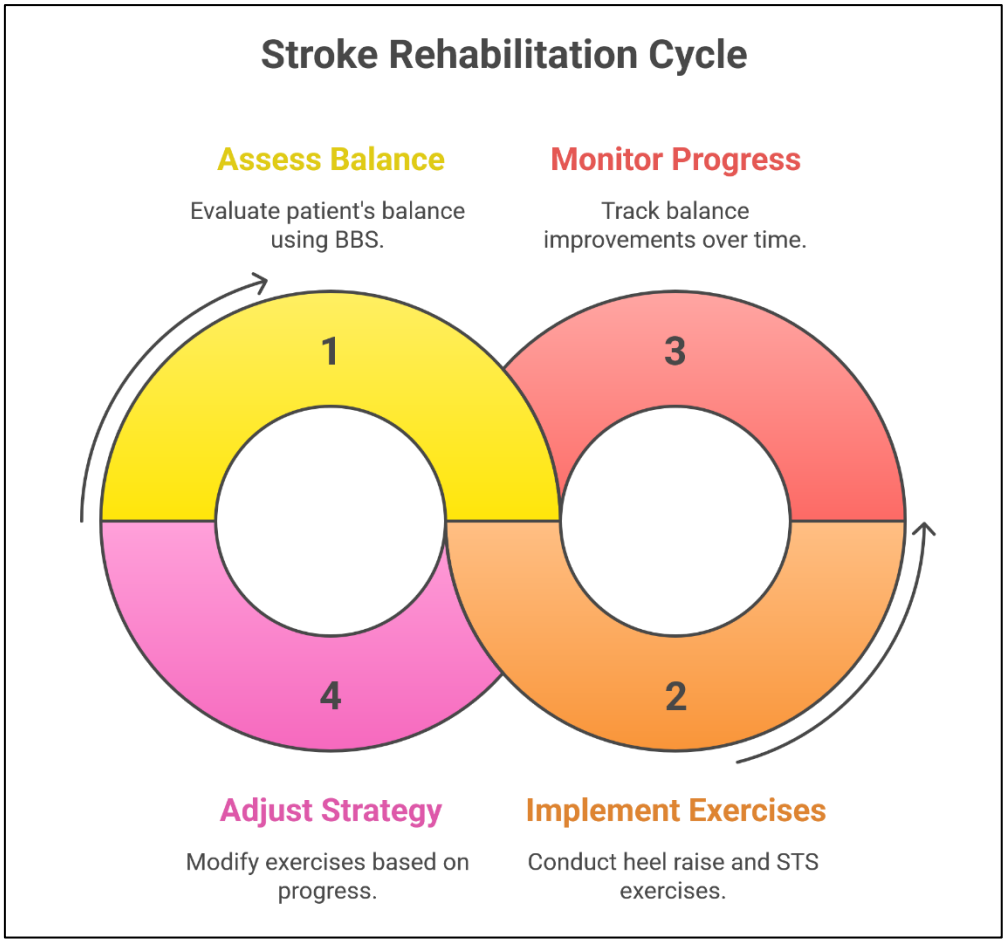
GRAPHICAL ABSTRACT



INTRODUCTION

Non-communicable diseases (NCDs) are a significant health issue of concern both nationally and globally. Coronary heart disease, stroke, and diabetes mellitus were identified as the top three non-communicable diseases (1). The pattern of non-communicable diseases has experienced a shift, as evidenced by an increase in both mortality and morbidity rates, with stroke being a significant example (2). Moreover, cerebrovascular disease, commonly referred to as stroke, occurs when a blood vessel in the brain becomes blocked or ruptured, leading to a rapid decrease in the flow of blood and oxygen to the brain. Failure to treat a stroke promptly can lead to long-term disability, brain damage, or potentially fatal outcomes (3).

In 2023, the prevalence of stroke in Indonesia increased by 8.3 per mile or 1,000 population, resulting in a total of 638,178 stroke cases, with data in Bengkulu Province indicating that there were 4,687 stroke patients (4). Moreover, the number of stroke cases in Bengkulu Municipality in 2023 amounted to 11,534. Telaga Dewa Public Health Center reported the highest number of stroke cases, totaling 965 people. followed by Jembatan Kecil Public Health Center, which recorded 903 cases, while Kandang Public Health Center had 732 cases, and lastly Sawah Lebar Public Health Center reported 698 cases.

Balance impairment is one of the most common and disabling sequelae in post-stroke patients. Muscle weakness, sensory-motor dysfunction, and impaired proprioception hinder patients' ability to perform daily activities safely (5). Stroke patients who experience balance disorders often struggle with walking (6). This is due to the sensory-motor disorders they experience, which can cause muscle weakness, decreased soft tissue flexibility, and impaired motor and sensory control. Consequently, there is a reduction in activity among stroke patients, resulting in a decline in their muscle strength, balance, and coordination

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of motion. Reduced or loss of motor function significantly increases the susceptibility of stroke patients to falls, as they are unable to maintain body balance and control movement and posture. This affects mobility activities such as walking, maintaining balance, grasping objects, and shifting positions (7).

Various therapeutic interventions exist to improve the balance of patients who have experienced a stroke, such as heel raise and sit-to-stand (STS) exercises, both of which can be used to improve the balance of post-stroke patients. The heel raise exercise is a beneficial activity for stroke patients, designed to prevent balance disorders (8). The heel raise exercise involves lifting the body by resting on the toes as high as possible without leaning forward. This exercise teaches the sensorimotor ability to control postural stability by reducing the area of support. Moreover, it sends proprioceptive afferent input to the central nervous system, which can alter efferent nerve responses by improving neuromuscular control of muscles and joints, thereby influencing body balance (9). Sit-to-stand (STS) exercise refers to the movement from a seated to a standing position. This action is often performed before engaging in various activities. Additionally, the sit-to-stand (STS) exercise is a change in position from a more stable position to a less stable one with a higher center of mass (COM) (10).

The heel raises and sit-to-stand (STS) exercises demonstrate a positive effect on the balance of post-stroke patients. These exercises are beneficial for enhancing balance and body stabilization in stroke patients who experience limited movement during activities, joint pain, and other diseases, such as vertigo. Such interventions are expected to improve the balance of post-stroke patients. Therefore, this study focused on heel raise exercises and sit-to-stand (STS) exercises as benchmarks for improving balance in post-stroke patients. The combination of therapies administered to post-stroke patients was expected to provide benefits for maintaining and improving postural balance. This includes the activation of internal trunk muscles, such as the abdominal, paraspinal, and pelvic floor muscles, as well as the improvement of ankle stabilization and trunk muscle coordination, ultimately contributing to enhanced postural control and improved balance.

METHODS

This study employed a quasi-experimental pre- and post-test control group design to evaluate the effect of heel raise and sit-to-stand (STS) exercises on post-stroke balance. This study was conducted at the Sawah Lebar Public Health Center, Bengkulu Municipality, Indonesia, in 2023. A total of 52 participants were selected through the purposive sampling method. The sample size was determined based on feasibility and the number of eligible patients available during the study period, as no prior pilot data were available. A post-hoc power analysis indicated that this sample size was sufficient to detect a medium-to-large effect size (Cohen's d ≈ 0.8) with 80% statistical power at a 5% significance level.

Participants were assigned to either the intervention group (n = 26, heel raise + STS) or the control group (n = 26, single leg stand). Furthermore, randomization was not employed due to the quasi-experimental design, and allocation concealment was not implemented. However, to minimize assessment bias, data collection and outcome measurement were conducted by an assessor who was not involved in delivering the intervention. Inclusion criteria were (1) adults diagnosed with stroke for at least three months, (2) experiencing balance impairment as indicated by Berg Balance Scale (BBS) scores < 45, (3) able to follow simple instructions, and (4) willing to participate with informed consent. Meanwhile, the exclusion criteria included (1) adults diagnosed with acute stroke (< 3 months), (2) experiencing severe cognitive or communication impairment, (3) suffering comorbidities that affect balance (e.g., vertigo, orthopaedic injury, unstable cardiac condition), and (4) those who refused or were unable to participate.

Data collection instruments included:

1. Demographic questionnaire: age, sex, education, type and frequency of stroke, body mass index, and family medical history.
2. Observation sheet: to record pre- and post-test balance scores.
3. Stopwatch: to measure the duration of interventions.
4. Berg Balance Scale (BBS): a validated tool to assess balance in post-stroke patients. The BBS consists of 14 items, each scored from 0 to 4, with a maximum total score of 56. It has demonstrated excellent inter-

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rater reliability (ICC > 0.95) and internal consistency (Cronbach's α > 0.90), making it a widely accepted instrument for clinical and research use.

The intervention was delivered by trained physiotherapists using standardized protocols. The heel raise exercise involves lifting the heels off the ground while maintaining an upright posture, targeting the strength of the gastrocnemius and soleus muscles. The sit-to-stand (STS) exercise trains patients to transition from a seated to a standing position without external assistance, thereby enhancing functional mobility and postural stability. The control group performed the single-leg stand exercise. All interventions were performed under professional supervision three times per week for four weeks.

Statistical analysis was performed to evaluate the efficacy of the interventions. Descriptive statistics, including mean and standard deviation (SD) for continuous variables and frequency distributions for categorical variables, were used to summarize the demographic characteristics of the participants. The homogeneity of baseline characteristics between the intervention and control groups was assessed using the chi-square test. To determine the effectiveness of the exercises, the Mann-Whitney U test was employed to compare the differences in balance scores between the two groups, given the non-parametric distribution of the data. All statistical tests were two-tailed, and a p-value of $p < 0.05$ was considered statistically significant.

CODE OF HEALTH ETHICS

This study has received approval and ethical eligibility from the Ethics Commission of the Bengkulu Ministry of Health Polytechnic on January 26, 2025, No. KEPK.BKL/073/01/2025.

RESULTS

Table 1 shows that the average age of respondents in the intervention group was 62.08 years, with most respondents in the group being male (52.0%). Moreover, 86.7% of the respondents in the intervention group had an elementary school education. It was also shown that most of the stroke types in the intervention group were non-hemorrhagic strokes (52.1%), a small proportion of the first stroke incidence in the intervention group (45.0%), nearly all of the Body Mass Index (BMI) respondents in the intervention group were overweight (76.5%), and most of the family health history was absent in the intervention group (55.3%). Meanwhile, in the control group, the average age was 62.58 years, most of the control group were female (51.9%), most of the control group were high school graduates (75.0%), a small proportion of the control group had non-hemorrhagic stroke (47.9%), most of the control group had a first stroke attack (55.0%), all respondents in the control group were normal (100.0%), and a small proportion of the control group had no history of stroke (44.7%).

Table 1 Distribution of Respondent Characteristics Based on Age, Gender, Education, Type of Stroke, Frequency of Stroke Attacks, Family Health History, and Body Mass Index (BMI) in Post-Stroke Patients

Variable	Group		*P Value*
	Intervention	Control	
Age	**62.08**	**62.58**	**0.883*** **
Gender			
Male	13 (52.0%)	12 (48.0%)	**0.781***
Female	13 (48.1%)	14 (51.9%)	
Education			
Elementary School	13 (86.7%)	2 (13.3%)	**0.001***
Junior High School	7 (63.6%)	4 (36.4%)	
Senior High School	5 (25.0%)	15 (75.0%)	
University	1 (16.7%)	5 (83.3%)	
Type of Stroke			
Hemorrhagic	1 (25.0%)	3 (75.0%)	**0.298***
Non-Hemorrhagic	25 (52.1%)	23 (47.9%)	
Stroke Incidence			
First	18 (45.0%)	22 (55.0%)	
Second	8 (66.7%)	4 (33.3%)	**0.188***

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Family Medical History			
None	26 (55.3%)	21 (44.7%)	**0.019***
Exist	0 (0.0%)	5 (100.0%)	
Body Mass Index			
Obesity	0 (0.0%)	5 (100.0%)	
Overweight	26 (76.5%)	8 (23.5%)	**0.000***
Normal	0 (0.0%)	13 (100.0%)	

****** Man-Whitney test, *chi-square test***

Table 2 Balance Scale Before and After Heel Raise and Sit-to-stand (STS) Exercises in the Intervention Group and Single Leg Stand in the Control Group of Post-Stroke Patients

Before and After Treatment Intervention Group						**P-Value**
Variabel	n	Mean	Min-Max	SD	CI for Mean 95%	
Pre-Intervention	26	33.04	20-42	6.095	30.53-35.50	0.000
Post-Intervention	26	38.04	25-46	5.744	35.72-40.36	
Before and After Treatment Control Group						
Pre-Control	26	31.54	25-41	4,933	29.55-33.53	0.000
Post-Control	26	32.65	25-41	5.012	3063-34.63	

The analysis of Table 2 reveals that the mean balance before treatment in the intervention group was 33.04, indicating the presence of balance disorders, with a standard deviation of 6.095 and 95% confidence interval results believed to be 30.53-35.50. Following the treatment in the intervention group, the mean score was 38.04, indicating balance problems, with a standard deviation of 5.744 and 95% confidence interval results believed to be in the range of 35.72-40.36. The results indicated an increase in the mean pre-post balance in the intervention group from 33.04 to 38.04. The mean balance prior to treatment in the control group was 31.54, indicating impaired balance, with a standard deviation of 4.933, and the estimated interval obtained was 29.55-33.53. Following the treatment in the control group, the mean balance was 32.65, indicating impaired balance, with a standard deviation of 5.012. The estimated interval obtained was 30.63-34.63. The results indicated an increase in the mean pre- and post-balance in the control group from 31.54 to 32.65.

Table 3 The Effect of Heel Raise and Sit-to-Stand (STS) Exercises on the Balance of Post-Stroke Patients

Group	**n**	**Median (Min-Max)**	**U**	***P value***
Balance Value				
Intervention	26	5.00 (3-7)	22.000	0.000***
Control	26	1.12 (0-5)		

*** Mann-Whitney test

According to the findings presented in Table 3, there is an effect of heel raise and sit-to-stand (STS) exercises, as indicated by a p-value of 0.000 ≤ α 0.05 from the Mann-Whitney statistical test. In conclusion, the heel raises and sit-to-stand (STS) exercises demonstrated greater influence and effectiveness than the single-leg stand in improving the balance of post-stroke patients. This study was expected to make a significant contribution to improving the balance of post-stroke patients.

DISCUSSION

The primary findings of this study demonstrate a significant improvement in balance among post-stroke patients following the implementation of heel raise and sit-to-stand (STS) exercises. Statistical analysis of the intervention group revealed a notable increase in the mean balance score from a baseline of 33.04 to 38.04 post-intervention, with the 95% confidence interval shifting significantly upward. The statistical significance of this improvement ($p < 0.000$) indicates that the specific regimen of heel raises and STS exercises effectively addresses balance disorders, enabling patients to transition from a state of lower stability to improved postural control.

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The physiological mechanism underlying these results can be attributed to the targeted re-education of neuromuscular control provided by the intervention. The heel raise component specifically strengthens the plantar flexor muscles, such as the gastrocnemius and soleus (11). Strengthening these muscles is critical for enhancing the "ankle strategy," which is the body's primary mechanism for maintaining upright stability against small perturbations (12). Simultaneously, the sit-to-stand (STS) exercise facilitates dynamic weight-shifting and functional motor control (13).

In contrast, while the control group engaged in single-leg stand exercises, it also exhibited a mean increase from 31.54 to 32.65; however, the magnitude of improvement was markedly distinct between the two groups. The Mann-Whitney comparative analysis confirmed that the intervention group achieved a superior outcome, with a median improvement value of 5.00, compared to 1.12 in the control group. This disparity highlights the limitation of static balance training (single-leg stand) in restoring functional mobility compared to dynamic, multi-joint movements (14). Therefore, this study concludes that integrating heel lift and STS exercises into a rehabilitation protocol provides a beneficial and effective strategy for improving balance disorders in post-stroke patients.

Exercises that raise the heel send proprioceptive afferent input to the central nervous system, which can change the efferent nerve response by increasing neuromuscular control in muscles and joints (9). The analysis of data obtained from the heel raise exercise indicates an effect on balance in the intervention group, with a p-value of 0.000, indicating a significant effect of the intervention provided. Sit-to-stand (STS) therapy in stroke patients has an effect due to increased dorsiflexion on the affected side; the heel of the foot touches the floor or ground in a sitting position so that the right foot sensory input to support the load is forwarded to the brain, thereby improving the body's balance ability (15). Additionally, there was a significant increase in walking speed and balance following the intervention ($p < 0.05$) (16).

Despite the significant positive outcomes observed, this study has several limitations that should be acknowledged. First, the study employed a quasi-experimental design rather than a randomized controlled trial (RCT). While this design is practical in clinical settings, it may not completely eliminate selection bias or control for all confounding variables as effectively as randomization. Second, the study focused on the immediate effects of the intervention (pre- and post-test) without a long-term follow-up. Consequently, it remains unclear whether the improvements in balance gained from the heel raise and sit-to-stand exercises are sustained over a prolonged period after the intervention ceases. Finally, the study did not strictly control for the participants' daily activities outside of the therapy sessions, which could have served as a confounding factor influencing the balance recovery process. Future research is recommended to address these issues by utilizing larger sample sizes, randomized designs, and longitudinal follow-ups to assess the long-term retention of the therapeutic benefits.

CONCLUSION

This study concludes that the combination of heel raises and sit-to-stand (STS) exercises is significantly more effective in improving balance among post-stroke patients compared to static training (single-leg stand), as evidenced by a substantial increase in mean balance scores within the intervention group ($p = 0.000$). Consequently, these dynamic exercises are recommended as a supplementary rehabilitation strategy under professional supervision; however, future studies should employ a Randomized Controlled Trial (RCT) design with larger sample sizes and long-term follow-up to more comprehensively validate their clinical efficacy.

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CONFLICTS OF INTEREST

Researchers declare no conflict of interest

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