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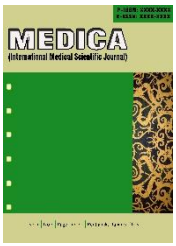

Effects of Stability Ball Core Exercises on Gluteus Maximus, Hamstring, Gastrocnemius, and Soleus Muscle Strength Among Post-Stroke Patients

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Abstract

Indonesia is the first rank of people with stroke in Asia and contribute 4.62% of all causes of mortality. It was predicted that in 2030, the number will increase to 23.3 million mortalities due to stroke. In Indonesia, in 2021, 12 people out of 1000 were diagnosed with stroke. Most of these conditions resulted in muscle weaknesses, especially in the lower extremities. This condition is a barrier to daily activities related to physical movement. The aim of this study is to test the effect of stability ball core exercises on gluteus maximus, hamstring, gastrocnemius, and soleus muscle strength among post-stroke patients. This study is a quasi-experiment pre and post-test with intervention and control groups. The sample size in this study consisted of 20 patients for each group selected by purposive sampling. The Mann-Whitney statistical test analyzed the data. The result found that stability ball core exercise significantly improved the muscle strength of the Gluteus Maximus and Hamstring, but found no significance with the gastrocnemius and soleus muscles. The future study could add a follow-up study to evaluate the long-term impact of this treatment.

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1. INTRODUCTION

Indonesia has the highest number of patients with stroke in Asia (Suwanwela & Poungvarin, 2016). The figure is anticipated to climb up to 23.2 million deaths in 2030 (Misganaw et al., 2023). The existing data reported that in 2021, 12 of 1000 people in Indonesia had signs and symptoms of stroke (Ministry of Health Indonesia, 2019). In general, the majority of stroke patients have muscle weakness, especially in the lower extremities. This condition could limit the mobility of them to do daily activities. The limited mobility to do daily activity will impact to improving dependency ratio which the productive family members have responsibility to take care them every day.

There is one treatment to increase muscle strength, which is stability ball core exercises. This treatment has been extensively studied around the world, especially for stroke rehabilitation. The investigations discovered significant improvements in trunk control, standing balance, dynamic sitting balance, gait, and activities of daily living in stroke survivors (Cabanas-Valdés et al., 2016; Cabanas-Valdés et al., 2017). Additionally, other studies have been found to enhance trunk function, standing balance, movement, and quality of life among post-stroke patients (Haruyama et al., 2016; Mahmood et al., 2022).

Among stroke patients, the gluteus maximus, hamstring, gastrocnemius, and soleus muscles are important in various movements and functions, especially in individuals recovering from a stroke. Existing studies have shown that muscle activation patterns and strength in these muscles can be significantly affected in stroke patients. Nam et al. (2014) found that foot position during sit-to-stand tasks influences the activation of gluteus maximus muscles and the erector spine in stroke patients. Additionally, Sidiq et al. (2020) mentioned the association between insufficiency of gluteus maximus muscle and chronic low back pain, emphasizing the importance of addressing muscle weaknesses in patients. There are limited existing studies examined the effectiveness of Stability Ball Core Exercises on strength muscles, especially focusing on stroke patients. In terms of the rehabilitation program in Indonesia, there is lack of health promotion to provide this kind of intervention to reduce the morbidity among stroke patients.

Post-stroke patients are often unable to walk fast and symmetrically and it might impact on their functional walking speed (Hall et al., 2011). In terms of each muscle function on walking, paretic leg muscles (soleus, gastrocnemius, and gluteus medius) contributed to forward propulsion for improving functional walking and non-paretic leg muscles (hamstring) contributed to reduce paretic leg propulsion (Rhee & Kim, 2015; Yu & Park, 2013). Improvement of both paretic and non-paretic leg muscles could improve walking subtasks of continuing propulsion, swing initiation and strength the generation of walking function (Rhee & Kim, 2015). Based on the explanation above, all muscles mentioned are important among post-stroke patients for doing daily activities independently (Hall et al., 2011; Knarr et al., 2013; Park et al., 2024). This study aimed to examine the effect of Stability Ball Core Exercises on these muscles' strength. In specific area of setting, this study focused on the situation in Sawah Lebar primary health care area.

2. METHOD

This study is quasi-experimental with pre and post-test approaches employing intervention and control group. Data was collected from January to March 2023 in Sawah Lebar Primary Health Care working area, Bengkulu City, Bengkulu Province. The population in this study were post-stroke patients in Sawah Lebar's primary healthcare working area. The sample of this study was post-stroke patients. The sample in this study

was the post-stroke patients with a level of medium to severe. The sample selection method used was purposive sampling with inclusion and exclusion criteria. The inclusion criteria were willingness to be respondents, residence at Sawah Lebar Primary Health Care working area, post-stroke patient medium to severe with muscle strength 1 – 3 could be able to sit, compliments awareness and no complication, post-stroke with hemiparesis sinistra or dextra with low extremities for more than 1 year, and aged between 35 to 70 years old. The exclusion criteria to select the sample included respondents who dropped out due to health issues that disturbed the intervention including open sore with hemiplegia and fever. Another exclusion criterion was those who could not finish the intervention for 3 weeks. The sample selection formula follows this:

$$n = \left[\frac{2\,\sigma^2 \left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \right)^2}{(\mu_1 - \mu_2)^2} \right]$$

The total population of this study were 157 patients. According to the formula above, first the formula of:

$$\sigma^2 = \frac{S1^2 + S2^2}{2}$$

The used by using previous study of (S_1 = 0,82), (S_2 = 0,67), ($\mu_1 = 2{,}30$), ($\mu_2 = 1{,}60$) (Rahmadani & Rustandi, 2019). Then the result was used to find n by using formula

$$n = \left[\frac{2\,\sigma^2 \left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta} \right)^2}{(\mu_1 - \mu_2)^2} \right]$$

With the result 17.94. Due to expected 10% of samples drop out, so *n* with drop out was calculated using the formula

$$Do = \frac{n}{1-f}$$

The final step is calculating the n for each intervention and control group by using formula $N = n + Do$. The final sample size based on the formula above was 20 patients for each intervention and control group (see appendix for detail sample size calculations). The main independent variable in this study is the core stability with the ball (CSEWB) and the dependent variables are muscle strengths (gluteus maximus, hamstring, gastrocnemius and soleus).

The intervention started with measuring the lower extremities before giving core stability exercises with a ball that was noted for the intervention group. Additionally, the control group was given the Range of Motion (ROM) (Kardha et al., 2017). Based on the guideline from ROM, both groups were given different treatment for twice a week for 3 weeks. Each treatment took times 10 minutes (for the intervention group) and 7 minutes (for the control group). At the end of treatment, the strengths of the lower extremities were re-measured. The muscle strength in this study was measured by manual muscle testing (MMT) with a scale of 1 to 5. Apart from the primary data that researchers collected, the secondary data to support the data of this study were derived from the medical records for stroke patients in Sawah Lebar Primary Health Care, Bengkulu City in 2021.

The instruments used for this study included pre- and post-questionnaire, gym ball and small ball, stopwatch, standard operational procedure (SOP) of core stability exercise with the ball and for measuring muscle strength, manual muscle testing, and SOP of range of motion (ROM).

The data management includes editing, coding, sorting, entry, processing, and cleaning. The data analysis includes univariate and bivariate. The univariate analysis was presented by mean, standard deviation, maximum, minimum, and 95% Confidence Interval for mean. For categorical data, it was presented by percentage and proportion. Those variables included sex, muscle strength, educational level, stroke type, and frequency of attack. The bivariate analysis in this study was done using Mann Whitney test with a confidence interval of 95%. The statistical software used in this study was SPSS.

The purpose of this study was to examine the effectiveness of core stability with the ball (CSEWB) on muscle strengths (gluteus maximus, hamstring, gastrocnemius and soleus) among post-stroke patients at Sawah Lebar primary health care working area in Bengkulu City. The ethical clearance of all instruments of this study has been approved by the ethical committee of Polytechnic of Health Bengkulu with number KEPK.BKL/089/03/2023.

3. RESULTS AND DISCUSSION

Table 1. The general characteristic of the sample.

Variables	Intervention group	Control group
Age		
Mean	58.30	58.60
Minimum	45	47
Maximum	68	69
Standard deviation	6.70	7.84
Standard error	1.50	1.75
CI 95%	55.16 – 61.44	54.93 – 62.62
Sex		
Female	6 (30%)	7 (35%)
Male	14 (70%)	13 (65%)
Education level		
Elementary	4 (20%)	4 (20%)
Junior high	3 (20%)	5 (25%)
Senior high	9 (45%)	7 (35%)
University	4 (20%)	4 (20%)
Type of stroke		
Hemorrhagic	4 (20%)	6 (20%)
Non-hemorrhagic	16 (80%)	14 (70%)
Attack frequency		
Second or more	5 (25%)	4 (20%)
Second	5 (25%)	6 (30%)
First	10 (50%)	10 (50%)

Table 1 presents the general characteristics of the study sample. It reveals that the mean age for intervention and control groups are similar which is 58 years old. According

to the sex, both groups have a majority male than female (70 and 65% for the intervention and control group, respectively). In terms of the educational level, the highest proportion were those who graduated from senior high school (45% and 35%, respectively). In terms of the type of stroke, the majority of the study sample was non-hemorrhagic (80% and 70%, respectively). The attack frequency reported revealed that half of the study sample faced the first attack (50% for each).

Table 2. The mean distribution of muscle strength before and after treatment for intervention and control group.

Type of muscle	Gluteus Maximus		Hamstring		Gastrocnemius and Soleus	
	I	C	I	C	I	C
Before treatment						
Mean	2.60	2.60	2.75	2.40	2.70	2.55
Minimum	2	2	2	2	2	2
Maximum	3	3	4	3	3	3
Standard deviation	0.503	0.503	0.550	0.503	0.470	0.510
Standard error	0.112	0.112	0.123	0.112	0.105	0.114
CI 95% (upper – lower)	2.36 – 2.84	2.36 – 2.84	2.49 – 3.01	2.16 – 2.64	2.48 – 2.92	2.31 – 2.79
After treatment						
Mean	3.60	3.05	3.50	2.80	3.50	3.05
Minimum	3	2	2	2	3	2
Maximum	4	4	4	4	4	4
Standard deviation	0.503	0.605	0.607	0.523	0.513	0.686
Standard error	0.112	0.135	0.136	0.117	0.114	0.153
CI 95% (upper – lower)	3.36 – 3.84	2.77 – 3.33	3.22 – 3.78	2.56 – 3.04	3.26 – 3.74	2.73 – 3.37

I = Intervention C = Control

Table 2 describes the mean distribution of muscle strength before and after treatment for both groups. For Gluteus Maximum muscle, it reveals the increasing mean of muscle strength before and after intervention from 2.60 to 3.60 for the intervention group and 2.60 to 3.05 for the control group. For the Hamstring muscle, the mean muscle strength increased from 2.75 to 3.50 for the intervention group and 2.40 to 2.80 for the control group. For Gastrocnemius and Soleus muscles, the muscle strength increased from 2.70 to 3.50 for the intervention group and increased from 2.55 to 3.05 for the control group.

Table 3. Normality test result of the effect of the intervention on muscle strength.

Variable	p-value (Shapiro-Wilk)
Pre-Test of Gluteus Maximus	
Intervention	0.000
Control	0.000
Pre-Test of Hamstring	
Intervention	0.000
Control	0.000
Pre-Test of Gastrocnemius and Soleus	

Variable	p-value (Shapiro-Wilk)
Intervention	0.000
Control	0.000
Post-Test of Gluteus Maximus	
Intervention	0.000
Control	0.000
Post-Test of Hemstring	
Intervention	0.000
Control	0.000
Post-Test of Gastrocnemius and Soleus	
Intervention	0.000
Control	0.001

The normality test result for this study was tested using Shapiro-wilk test shown in Table 3. It was found that the p-value for all intervention and control groups were less than 0.05 which means data of muscle strength in this study is not normal. The normality test aimed to check whether the data is normal or not. Based on the result of normality test, the median used to measure the effectiveness of intervention on strength of muscle was tested using Wilcoxon signed rank test with α 5%. This statistical test is non-parametric statistical test to check improvement of muscle strength before and after among intervention and control groups.

Table 4. The median differences in muscle strength before and after treatment for both groups and the Impact of Core Stability Exercises with a Ball (CSEWB) on Muscle Strength.

Type of muscle	Gluteus Maximus		Hamstring		Gastrocnemius and Soleus	
	I	C	I	C	I	C
Before treatment (n = 20)						
Median	3.00	3.00	3.00	2.00	3.00	3.00
Min - Max	2 -3	2 – 3	2 – 4	2 – 3	2 – 3	2 – 3
After treatment (n = 20)						
Median	4.00	4.00	4.00	3.00	4.50	4.00
Min - Max	3 – 4	3 – 4	2 – 4	2 – 4	3 – 4	2 – 4
Z (p-value)	-4.472***	-3.317**	-3.873***	-2.828**	-4.000***	-3.162**
All sample						
Median	0.50	1.00	1.00	0.00	1.00	0.50
Min - Max	0 – 1	0 – 1	0 – 1	0 – 1	0 - 1	0 – 1
U (p-value)	100.000***		130.000*		140.000	

**p-value <0.05., **p-value<0.01, ***p-value<0.001, I=Intervention C=Control*

The effectiveness test of Core Stability Exercises with Ball (CSEWB) on Muscle's Strength is shown in Table 4. For Gluteus Maximus, it described that the median of muscle strength is significantly different for both groups after giving the treatment. However, the intervention group showed a strong correlation compared to the control group. For the hamstring muscle, the median muscle strength for both groups are significantly different. However, the stronger differences were shown by the intervention group than control one.

Moreover, the muscle of Gastrocnemius and Soleus shown that median muscle strength is different for both groups, but the stronger differences were shown by the intervention one.

The impact of Core Stability Exercises with a Ball (CSEWB) on muscle strength for all study samples was shown in Table 4 too. According to the results of the Man Whitney test, it reveals the treatment of CSEWB is strongly significantly effective in improving Gluteus Maximum muscle strength and weakly significantly effective in improving Hamstring muscle strength. However, CSEWB is not considerably effective in improving the Gastrocnemius and Soleus muscle strength. The strong effect was showed to all muscles for after intervention groups. For the all-sample analysis, the strongest effect was shown to Gluteus Maximus muscle compared to Hamstring muscle.

In conclusion, there is effectiveness of Core Stability Exercises with Ball (CSEWB) on improving muscle strength among post-stroke patients, especially for Gluteus Maximus and Hamstring. Those muscles are very important for pre-elderly to do daily activity and reduce the dependence from other family members.

The findings from this study revealed that the stability ball core exercises or Swiss ball exercises effectively improve muscle strength of the Gluteus Maximus and Hamstring muscles. The gluteus maximus and hamstring muscles play a crucial role in post-stroke therapy as they contribute to enhancing stability, balance, and walking capacity. Exercising these muscles can improve pelvic control, decrease the likelihood of falls, and prevent muscular wasting, resulting in improved mobility and increased self-reliance in everyday tasks. Specific workouts that focus on these muscles also have a role in achieving a more typical walking pattern, which is essential for recovering functional mobility. Furthermore, enhancing the muscular power of these specific muscles can effectively decrease the pain and suffering resulting from compensatory movements. In general, a targeted strategy for improving the gluteus maximus and hamstrings can greatly improve the recovery results for those who have had a stroke (Sawtelle et al., 2022).

Instead of that purpose, that exercise was also found to be effective in enhancing balance and stability across diverse populations. These exercises engage muscles like the rectus abdominis, multifidus, and pelvic floor muscles to stabilize the lumbar region, making them valuable for musculoskeletal health (Marani et al., 2020). The mechanism is based on the balancing or stability concept. The stability- ball exercises lead to increased core muscle activation compared to exercises performed on stable platforms, in boosting core strength (Mane, & Rayjade, 2020). While there has been some debate regarding the efficacy of stability ball exercises in core training programs, the consensus from research supports their benefits in enhancing core stability and muscle strength, particularly when compared to traditional exercises (Martuscello et al., 2013). These exercises engage essential core muscles, improve spinal stability, and have been associated with positive outcomes in terms of balance, functional status, and muscle endurance. Incorporating stability ball exercises for post-stroke patients significantly reduces the morbidity of movement.

Furthermore, existing research has highlighted the advantage effects of core stability training on strength of muscle, functionality, psychosocial factors, and overall quality of life in individuals who have experienced a stroke (Han et al., 2017; Samad et al., 2022). In addition, core stabilization exercises have been linked to enhancements in trunk mobility, walking ability, walking patterns, and muscle activation in individuals who have experienced a stroke (Ahn & Kim, 2022; Gul et al., 2021; Lee, n.d.; Mahmood et al., 2022; Renald & Regan, 2016; Rhee & Kim, 2015; Yu & Park, 2013). Stability ball core exercises are important in stroke therapy as they specifically focus on notable enhancements in

dynamic sitting balance, gait, daily life activities, and overall quality of life for those recovering from a stroke (Gul et al., 2021; Karthikbabu et al., 2021; Muniyar & Darade, 2018). Moreover, engaging in rigorous training on unstable surfaces can enhance the stability of the core muscles and expand the cross-sectional area of muscles, resulting in an increase in both the frequency of muscle activation and the number of motor units (Gul et al., 2021).

In order to examine the effects of stability ball core exercises on the strength of the gluteus maximus, hamstring, gastrocnemius, and soleus muscles in post-stroke patients, it is crucial to take into account the influence of core stability exercises on muscular strength and stability. Performing core stability exercises with a Swiss ball can significantly enhance core muscular strength, a critical factor in improving core stability, trunk control, balance, and overall physical function in those recovering from a stroke. Another research indicates that integrating these exercises into rehabilitation programs can result in enhancements in multiple facets of physical function, hence leading to superior outcomes and quality of life for stroke patients (Karthikbabu et al., 2021). Integrating stability ball training into rehabilitation programs might result in improving spinal stability and flexibility (Marani et al., 2020). The long-term impacts of a fixed stretching regimen on the strength of the hamstring muscles, highlighting the significance of the hamstring and gastrocnemius muscles in the movement of knee flexion and hip extension (Nakao et al., 2021). Furthermore, it is also important in maintaining stability and facilitating forward movement while walking (Rosario, 2024).

The study conducted in India examined the efficacy of Bosu ball exercises with Thera Band workouts in the context of core stabilization and balance performance. The study focused on several treatment options for strengthening the core (Sawant et al., 2020). These exercises are particularly beneficial for patients undergoing rehabilitation as they can improve stability and strength (Forster et al., 2022). There is the link between limited hip internal rotation and low back discomfort, highlighting the significance of hip muscle function in preserving musculoskeletal well-being (Tanabe et al., 2023). One study focused on customized exercise therapies that focus on particular muscle groups, such as the gluteus maximus and hamstrings, to enhance rehabilitation results in individuals recovering from a stroke (He et al., 2020; Huynh et al., 2020).

Prior study on the effects of stability ball core workouts on muscle strength in post-stroke patients involves examining recent discoveries that enhance our understanding of rehabilitation approaches for this specific group. The study emphasized the significant impact of physical rehabilitation in enhancing post-stroke quality of life (Mahmood et al., 2022). In addition, a study conducted by (Hasbiah, 2023) examined the impact of bridging exercises and heel rises on balance in individuals who have experienced a stroke. The findings revealed a notable enhancement in balance after engaging in bridging exercises. The comparative study found the effectiveness of Proprioceptive Neuromuscular Facilitation (PNF) techniques and Therapy Hand Ball exercises in improving motor dexterity in non-hemorrhagic among patients with post-stroke (Tongpangmeren et al., 2023).

The effects of hand exercises utilizing a rubber ball on grip strength in individuals who had experienced a non-hemorrhagic stroke (Rahmawati et al., 2021). The study conducted by (Kamatchi et al., 2020) aimed to examine the impact of Swiss ball workouts on developing the core muscles of collegiate cricketers. The efficacy of core stability exercises utilizing a Swiss ball in enhancing the strength of core muscles in young swimming athletes (Amrullah et al., 2022; Marani et al., 2020). There is evidence the effectiveness of core stabilization exercises on athletic performance, as demonstrated

motor function in stroke survivors with significant neurological impairment (Bacho et al., 2023; Oyama & Palmer, 2022).

This study has several limitations. The relatively small sample size and recruitment from a limited setting may restrict the generalizability of the findings. In addition, the short intervention period and absence of follow-up assessments prevented the evaluation of the long-term effects of Core Stability Exercises with Ball (CSEWB). The study focused primarily on muscle strength outcomes and did not assess other important rehabilitation indicators, such as balance, gait performance, functional mobility, activities of daily living, and quality of life. Furthermore, several potential confounding factors, including stroke severity and duration since stroke onset, were not fully controlled.

4. CONCLUSION

The Stability Ball Core Exercises were found to significantly improve the muscle strength of Gluteus Maximus and Hamstring. However, insignificant results were found for the Gastrocnemius and Soleus muscles. possibly due to the short intervention duration and the distal muscle location requiring more targeted stimulation. This study has a limitation of lacking track and follow-up of the treatment. Future studies could use the longitudinal study to see the sustainability of the treatment for long-term effects. Additionally, the larger sample size for the next research might generalize to the population size. These findings support integrating stability ball core exercises into standard post-stroke rehabilitation programs in primary healthcare settings to improve functional mobility and patient independence.

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