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| RESEARCH ARTICLE

Correlation between Improved Balance and Decreased Limb Spasticity and Improved Muscle Strength in Post-Stroke Hemiparesis

Ayu Feratywi[1] ✉ and Anita Candra Dewi[2]
[1]*Fisiologi Keolahragaan, Fakultas Kedokteran, Universitas Udayana, Indonesia*
[2]*Universitas Negeri Makassar, Indonesia*
Corresponding Author: Ayu Feratywi, **E-mail**: ayuferatywi@gmail.com

| ABSTRACT
Approximately 80% of stroke patients experience disability in the form of hemiparesis (weakness of half of the body). Physiotherapy problems that commonly occur in post-stroke hemiparesis include decreased muscle strength, spasticity, and balance disorders. This research is a correlation analysis study with one independent variable and 2 dependent variables, aiming to determine the correlation between balance improvement with decreased leg muscle spasticity and improved leg muscle strength in post-stroke hemiparesis patients, carried out at the Inggit Medical Center Clinic Makassar with a total sample of 12 people who met the inclusion criteria and were given intervention in the form of the bobath method for 10 treatments, the measuring instruments used were functional reach test (FRT) for balance, Asworth scale for spasticity, and chair stand for leg muscle strength. Spearman test between balance and muscle strength obtained a p value of 0.001 ($p < 0.05$) with a positive r of 0.822 which means there is a positive and significant correlation between increasing balance and increasing muscle strength. While between balance and spasticity obtained a p value of 0.04 ($p < 0.05$) with a negative r value of 0.584, which means there is a negative and significant correlation between increasing balance and decreasing spasticity. Improved balance has a significant relationship with increased muscle strength, and improved balance has a significant relationship with decreased spasticity in post-stroke hemiparesis patients.

| KEYWORDS

Balance, Limb Spasticity, Muscle Strength, *Post Stroke Hemiparesis*

| ARTICLE INFORMATION

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1. Introduction

The disability that arises in stroke patients in the form of weakness on half of the body side is known as post-stroke hemiparesis. Hemiparesis is a condition of inability to move the limbs on one side or weakness on one side of the body. About 80% of stroke patients experience disability in the form of weakness in half of the body (Anggraini et al., 2018).

Basic Health Research (RisKesDas) data in 2018 (Kemenkes RI, 2018) showed the results that the prevalence of Indonesian stroke (per mile), which resulted in disability in the form of hemiparesis based on gender, was 11.0% male while 10.9% female. The highest prevalence of stroke that caused hemiparesis was in the ≥75 years age group at 50.2%. The highest prevalence of stroke cases causing hemiparesis was in Riau Islands Province (12.9%), and the lowest was in Papua Province (4.1%), while South Sulawesi Province was 10.6%.

Based on the list of patient visits at the Inggit Medical Center Makassar Clinic for the last 3 months (October-December 2021), there were 120 visits by patients with post-stroke hemiparesis, with the number of patients reaching 24 people per month and

from the results of an interview with one of the physiotherapists at the Inggit Medical Center Makassar Clinic said that post-stroke hemiparesis cases are the most common cases found in this place.
Physiotherapy problems, in general, are usually experienced by post-stroke hemiparesis patients in the form of decreased muscle strength, spasticity, and balance disorders. There are around 36-70% of post-stroke hemiparesis patients experiencing spasticity (Tae et al., 2021). Lower limb muscle strength that is disabled in post-stroke hemiparesis patients is reduced by around 34%-62% when compared to healthy individuals (Vishakha & Suruliraj, 2020). In the first 3 months of post-stroke hemiparesis, 29% of sufferers still experience balance problems (Carlos et al., 2021).

One of the exercise methods that can be given to post-stroke hemiparesis sufferers is the bobath method. The bobath method is a method based on problem solving by means of examination and action on individuals who experience impaired function and movement due to lesions in the central nervous system (CNS). The main goal is to optimise function by improving postural control through facilitation, as stated by the IBITA (International Bobath Instructors Training Association) in 1995.

Based on a number of articles in previous studies, including research by Arzu et al. (2019) and research by Yazici et al. (2017), which explain that the bobath method can show changes in balance, mobility and functional limb movements in post-stroke hemiparesis patients. Kurniawan's research (2016) also shows that the bobath method can significantly improve trunk control ability, which is positively correlated with the level of independence of functional activities of post-stroke patients.

The existence of postural deviations in post-stroke hemiparesis patients is due to inappropriate muscle activity; this is related to spasticity and weakness in the trunk and extremities (Shreen et al., 2018). Through the bobath method approach, post-stroke hemiparesis patients will learn to control posture by involving muscle activity to maintain body stability. The linkage leads to postural control that provides the basis of stability in balance, limb function, mobility and functional body activities. With adequate postural control ability to maintain balance followed by normal muscle tone and increased muscle strength, post-stroke hemiparesis patients are able to carry out activities effectively and efficiently (Kurniawan, 2016).

Based on the description of the problem above, the formulation of this research problem is "Is there a correlation between balance improvement with decreased limb spasticity and improved muscle strength in post-stroke hemiparesis?" and the purpose of this study is to determine the correlation between balance improvement with decreased limb spasticity and improved muscle strength in post-stroke hemiparesis.

2. Methodology

This research is an observational study with a correlation analysis design, namely looking at the relationship between post-test balance with post-test muscle tone and post-test leg muscle strength after being given the Bobath method intervention.

The population of this study were all post-stroke hemiparesis patients who came to visit/seek treatment at the Inggit Medical Center Clinic Makassar. The sample of this study was 12 post-stroke hemiparesis patients who were in accordance with the inclusion and exclusion criteria set by the researcher.

The inclusion criteria in this study are post-stroke hemiparesis patients who experience balance disorders, limb spasticity, and limb muscle weakness, are willing to become research samples and are willing to undergo physiotherapy intervention programs. While the exclusion criteria in this study are post-stroke hemiparesis patients who experience hypotonia or rigidity and patients who are accompanied by diabetes mellitus and/or hypertension.

Data collection was obtained by taking measurements on each sample to serve as pre-test data, then providing physiotherapy intervention programmes 10 times. After being given treatment, the researcher again took measurements on each sample to serve as post-test data. Pre-test and post-test data are balanced using the functional reach test (FRT), muscle tone using the Asworth scale and leg muscle strength using the chair stand test.

The bobath interventions provided in this study include foot core stability, anterior-posterior pelvic tilting, and weight shifting. As for the implementation procedure for exercise 1 (foot core stability), the physiotherapist performs manual stretch on the intrinsic muscles of the foot precisely on the toes using a towel to stimulate the muscle spindle, resulting in abduction and extension movements of the toes. The patient must feel the stimulus and follow the movement. The dose used is as many repetitions as possible until a response appears on the patient's toes. In exercise 2 (anterior-posterior pelvic), both hands of the physiotherapist are on the patient's crista iliaca and direct the patient's pelvic towards anterior-posterior pelvic tilting. The patient must follow the motion. The dose used is as many repetitions as possible until the patient's pelvic response appears. In exercise 3 (weight shifting), both hands of the physiotherapist move the patient's body towards the weak side slowly, and then the patient is instructed to maintain the position. The dose used is as many repetitions as possible until the patient's adaptation to the position appears.

To analyse the research data obtained, the researchers used statistical tests, namely the data normality test, using the Shapiro Wilk test, to determine whether the data was normally distributed ($p>0.05$) or not normally distributed ($p<0.05$). In a correlation analysis test or hypothesis test, if the data is normally distributed from the results of the data normality test, a parametric statistical test is used, namely the Pearson correlation test. If the data is not normally distributed from the results of the data normality test, a non-parametric statistical test, namely the Spearman test, is used.

3. Results and Discussion

3.1 Results

Based on Table 1, the mean balance from the pre test¬ was 18.667 ± 4.036 to 26.75 ± 3.992 in the post test, which means that there is an increase in balance after giving the bobath method with an average increase of 8.083. Mean muscle strength, from the pre-test of 7.25 ± 1.422 to 12.58 ± 2.021 in the post test which, means that there is an increase in muscle strength after administering the bobath method with an average increase of 5.33. The average spasticity from the pre test¬ of 2.167 ± 0.389 to 1.375 ± 0.377 in the post test, which means that there is a decrease in spasticity after giving the bobath method with an average decrease of 0.792.

Based on Table 2, the results of the data normality test with the Shapiro-Wilk test are obtained, namely for the balance variable showing a p value> 0.05 before and after the intervention, which means that the data is normally distributed, for the muscle strength variable showing a p value> 0.05 before the intervention which means that the data is normally distributed. While after the intervention shows a p value <0.05, which means that the data is not normally distributed, and the spasticity variable shows a p value <0.05 before and after the intervention, which means that the data is not normally distributed.

Based on Table 3, the results of the Spearman test (correlation analysis), namely the correlation between balance and muscle strength, obtained a p value of 0.001 ($p <0.05$) with a correlation coefficient of 0.822 This shows a significant correlation between balance and muscle strength, where the correlation obtained is a positive correlation. This means that an increase in balance will be followed by an increase in muscle strength after the bobath method intervention. The correlation between balance and spasticity obtained a p value of 0.04 ($p <0.05$) with a correlation coefficient of -0.584. This shows a significant correlation between balance and spasticity, where the correlation obtained is a negative correlation. This means that an increase in balance will be followed by a decrease in spasticity after the bobath method intervention.

3.2 Discussion

Based on the results of the study using the spearman test, the p value was 0.001 ($p <0.05$), which means that there is a significant correlation between balance and muscle strength with a correlation coefficient of 0.822, which shows a positive correlation which means that if there is an increase in balance, it is followed by an increase in muscle strength.

Balance disorders in post-stroke hemiparesis are related to decreased muscle movement ability, so the body's ability to maintain balance also decreases (Susanti and Irfan 2010). Balance is a complex process that requires interaction between the vestibular, visual, proprioceptive, musculoskeletal and cognitive systems (Karatas et al., 2004). Changes in the body's centre of mass require the coordinated activity of adequate ankle, knee, hip and trunk muscle strength to provide the power to move the lower limbs in performing functional movements. The ability of the muscles to resist gravity and other external loads will affect body position so that patients are able to maintain body position in maintaining balance (Kang and Park 2015).

Postural control balance is an important component that allows a person to perform extremity movements against gravity. Postural control plays an important role in stabilising and increasing the strength of the lower extremities when performing various activities, one of which is the activity of ambulation from sitting to standing or vice versa. The transversus abdominis muscle is a muscle that stabilises the spine, lumbopelvic region, and trunkus-pelvic segment during footfall. The transversus abdominis muscle is the first muscle to be activated when moving the lower extremities. This suggests that the stability of postural control can influence lower extremity movement (Wowiling, Sengkey, and Lolombulan 2016). Balance is needed in changing positions from sitting to standing or from standing to sitting. In addition, leg muscle strength, especially quadriceps and hamstrings, are needed in making these position changes. Hodges and Richardson concluded that the central nervous system creates a stable foundation for lower extremity movement, such as in sitting to standing movements or vice versa, due to the stability of postural control by the transversus abdominis and multifidus muscles in maintaining body balance (Zazulak et al. 2007).

The results of this study are supported by the results of previous research by Karthikbabu and Verheyden (2021), which show that trunk control or balance has a positive correlation with muscle strength in chronic stroke patients. The balance value (TIS 2.0) obtained shows a high correlation with increased muscle strength ($r = 0.61\text{-}0.70$, $p < 0.001$).

Based on the results of research using the Spearman test, a p value of 0.04 ($p < 0.05$) was obtained, which means that there is a significant correlation between balance and spasticity with a correlation coefficient of -0.584, which shows a negative correlation, which means that if there is an increase in balance, it is followed by a decrease in muscle spasticity.

Good body balance is supported by the strength of postural control, namely the body's ability to control position with the aim of stability (Pristianto, Adiputra, and Irfan 2016). Balance is influenced by proprioceptive. If there is a disturbance in the balance due to decreased proprioceptive, there will be an increase in the speed of the muscle stretch reflex, which leads to spastic conditions (Syatibi and Suhardi 2016).

Balance is instrumental in the condition of muscle tone. Balance arises from sensory information in the form of tactile and proprioceptive and then produces motor information that will activate postural muscles (antigravity muscles). If there is a disturbance in the balance due to loss of control from the central nervous system, it can cause tonus disorders in the antigravity muscles (Habut, Nurmawan, and Wiryanthini 2016). Tactile and proprioceptive stimuli can cause reflexes in functional movements through key points of control (balance) so as to produce normal muscle tone function in maintaining position and functional movement patterns (Hazmi, Tirtayasa, and Irfan 2014).

In post-stroke haemiparesis, motor problems that usually arise are increased muscle tone (spasticity). Impaired control of movement and balance can eliminate the function of muscles to work synergistically and tend to create movement patterns that are difficult to avoid; this can progressively lead to spasticity (Sudaryanto and Halimah, 2022). Spasticity has adverse effects on muscles and joints in the lower extremities. Muscles that are often spastic are the gastrocnemius, soleus, hamstring, and rectus femoris muscles (Suharto, Arpandjam'an, and Suriani, 2022).

Previous research has explained that spasticity develops from the hyperexcitability of monosynaptic stretch reflexes. This theory is based on muscle spindle physiology, which is an increase in the output of muscle spindle afferents or sensory receptors that control alpha motor neuron activity in the spinal cord grey matter (Martin and Kessler 2016). The results of this study are in line with the research of Sudaryanto and Andi Halimah (2022) with a p value <0.05, which shows that increasing balance has a significant relationship with decreasing spasticity with a balance value (TUG) obtained an average of 21.38 + 5.062, and spasticity value (Asworth scale) obtained an average of 1.64 + 0.577. Previous research by Pang, Eng, and Dawson (2005) also showed a negative correlation between spasticity and walking speed, which is part of improving body balance, with a correlation level of r (0.373), which means the level of correlation is weak.

4. Conclusion

The study conclusively demonstrates a significant interrelationship between balance, muscle strength, and spasticity in individuals with post-stroke hemiparesis. The findings reveal that enhancements in balance are positively correlated with an increase in muscle strength and concurrently exhibit a negative correlation with the degree of limb spasticity. These correlations underscore the importance of balance as a foundational aspect of rehabilitation in post-stroke recovery, suggesting that targeted interventions to improve balance can yield substantial benefits in reducing spasticity and bolstering muscle strength.

The utilization of the Bobath method as a rehabilitative intervention has shown promising results, contributing to improvements across the measured outcomes. The study's insights highlight the complex interplay between balance and muscle tone, with disturbances in balance potentially exacerbating tonus disorders. Conversely, the amelioration of balance issues can alleviate spasticity, a frequent complication of post-stroke hemiparesis, and enhance the control of movement.

Given the study's outcomes, it is evident that rehabilitation strategies focusing on balance training should be considered a priority in the management of post-stroke hemiparesis. Such approaches may not only directly address balance impairments but also indirectly facilitate muscle strengthening and spasticity reduction, thereby contributing to a more comprehensive and effective recovery process for stroke survivors.

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Appendix

Table 1
Mean Balance, Muscle Strength, and Spasticity based on pretest, posttest, and difference values

Data Group	Mean and Standard Deviation		
	Pre test	*Post test*	Difference
Balance	18,667±4,036	26,75±3,992	8,083±0,848
Muscle Strength	7,25±1,422	12,58±2,021	5,33±0,985
Spasticity	2,167±0,389	1,375±0,377	0,792±0,258

Table 2
Data normality test

Data Group	Normality with Shapiro-Wilk test	
	Sample Group	
	Statistics	p
Balance		
Pre test	0,920	0,284
Post test	0,936	0,446
Muscle Strength		
Pre test	0,957	0,738
Post test	0,828	0,020
Spasticity		
Pre test	0,465	0,000
Post test	0,807	0,011

Table 3
Spearman correlation between balance, muscle strength and spasticity Between balance and spasticity

	Muscle Strength	Spasticity (Asworth)
Balance		
Correlation coefficient	0,822	-0,584
Value p	0,001	0,04