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Exercise-based Rehabilitation to Improve Extremity Muscle Strength in Stroke Survivors: A Study at H. Abdul Manap Regional Hospital (2022–2024)

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ABSTRACT

Background: Exercise therapy is a medical rehabilitation intervention to increase upper and lower extremity muscle strength in post-stroke patients. **Objective:** This study aims to determine the characteristics of stroke patients at H. Abdul Manap Jambi Regional Hospital in 2022–2024, including age, gender, and history of comorbidities (hypertension, diabetes mellitus, dyslipidemia). This study identifies muscle strength before and after exercise therapy and analyses the effect of therapy duration on increasing muscle strength. **Methods:** This study is an observational analytic study with a cross-sectional approach. Secondary data were obtained from the medical records of stroke patients. The sample consisted of 52 patients who met the inclusion and exclusion criteria. Data analysis used the Paired Sample T-test or the Wilcoxon test based on the normality test. **Results:** Exercise therapy significantly increased upper and lower extremity muscle strength after exercise therapy ($p < 0.05$). Most patients experienced improvement on the Manual Muscle Testing (MMT) scale, especially in the lower extremities, with a dominant increase from scores 2 to 3 and 4. **Conclusion:** Exercise therapy significantly increases upper and lower extremity muscle strength in post-stroke patients. Therefore, it can be recommended in rehabilitation to optimize motor function recovery.

Keywords: Muscle strength; Medical rehabilitation; Stroke; Exercise therapy

INTRODUCTION

Stroke is a neurological disorder and one of the leading causes of movement disorders and adult body functions.[1] Rupture of blood vessels in the brain, with symptoms that last for 24 hours or more.

Ischemic stroke occurs due to blockage of the arteries leading to the brain and consists of three types, namely embolic, thrombotic, and hypoperfusion. Meanwhile, hemorrhagic stroke occurs due to rupture of blood vessels in the brain and is generally caused by hypertension or an aneurysm.[2]

Data from the 2018 Basic Health Research (Riskesdas) shows that the incidence of stroke in Indonesia has increased by 15% since 2013. East Kalimantan has the highest prevalence of 15%, while Papua has the lowest prevalence of 4.1%.[3] In Jambi Province, the incidence of stroke reached 6.8%.[4]

Hemorrhagic and non-hemorrhagic strokes can cause problems or disorders in stroke sufferers physically and mentally, depending on the location of the damage.[5] Stroke patients generally experience movement disorders, such as difficulty walking due to loss of muscle strength and balance, which impacts daily activities.[6,7] One of the disorders that is often experienced is hemiparesis, which is weakness on one side of the body, which occurs in around 80% of stroke patients. Unfortunately, only about one-third of patients can fully recover.[8,9] Upper limb weakness causes difficulty moving and coordinating the arms, hands, and fingers, while lower limb disorders affect the patient's gait and mobility.[10]

Rehabilitation efforts are needed to reduce the number of post-stroke disabilities. One method that can be used is exercise therapy, which is physical exercise designed according to the patient's needs to help improve functional abilities independently or with the help of a physiotherapist.[11] Various rehabilitation approaches, such as strength training, range of motion (ROM) exercises, and balance exercises, have improved muscle strength in the upper and lower extremities.[12]

Based on this, this study was conducted to see the effect of exercise therapy on the muscle strength[13] of the upper and lower extremities in stroke patients[14] before and after exercise therapy.

METHODS

The design of this study was observational analytic with a cross-sectional approach. Data analysis was conducted retrospectively using secondary data from medical records of stroke patients undergoing exercise therapy at H. Abdul Manap Jambi Regional Hospital from October 2022 to January 2024. The study subjects were stroke patients who met the inclusion and exclusion criteria, with a sample size of 43 people selected using a purposive sampling technique.

Inclusion criteria included patients with complete medical record data related to upper and lower extremity muscle strength before and after exercise therapy, and subacute stroke patients who underwent exercise therapy at least twice

a week for 12 weeks. Exclusion criteria included patients with initial muscle strength of 4, patients who did not undergo therapy regularly, patients with duplex hemiparesis or tetraparesis, patients who died during treatment, and patients with incomplete or illegible medical record data.

RESULTS

The distribution of patient characteristics indicates that the majority were in the elderly age group, with the highest proportion falling within the late elderly category (ages 56–65), accounting for 40.4%, followed by the early elderly group (ages 46–55) at 30.8%. Regarding gender, male patients constituted a greater proportion at 59.6%. Additionally, most patients were found to have hypertension as a comorbid condition, either alone (57.7%) or in combination with dyslipidemia or diabetes mellitus.

Table 1. Distribution of characteristics of research subjects.

Variable	Frequency (n=52)	Percentage (%)
Age		
Early Adults (26–35 Years)	1	1.9
Late adulthood (36–45 years)	2	3.8
Early Senior Citizens (46–55 Years)	16	30.8
Late Senior Citizens (56–65 Years)	21	40.4
Elderly (> 65 Years)	12	23.1
Gender		
Male	31	59.6
Female	21	40.4
Other comorbidities		
Hypertension	30	57.7
Diabetes mellitus	0	0
Dyslipidemia	0	0
Hypertension + Dyslipidemia	7	13.5
Hypertension + Diabetes Mellitus	15	28.8
Diabetes mellitus + Dyslipidemia	0	0

The results of the normality test presented in Table 2 indicate that the data are not normally distributed; therefore, the Wilcoxon test was used to analyze the difference in muscle strength before and after exercise therapy.[15] The analysis results in Table 2 show an increase in muscle strength of the upper and lower extremities after exercise therapy. All groups' median (Med) and average (Mean) values show an increase after therapy. In addition, the results of the Wilcoxon test[16] show a p value <0.001, which indicates that the increase in muscle strength before and after exercise therapy is statistically significant in all

groups tested. This shows that exercise therapy positively affects muscle strength in the upper and lower extremities.

Table 2. Results of analysis of differences in muscle strength before and after exercise therapy.

Regio	Pre-Post	Mean	Med	Min	Max	Δ Mean	p-value
Upper Extremity Right	Pre	2.14	2.00	0.00	3.00	1.66	< 0.001
	Post	3.81	4.00	3.00	4.00		
Lower Extremity Right	Pre	2.14	2.00	0.00	3.00	1.70	< 0.001
	Post	3.85	4.00	3.00	4.00		
Upper Extremity Left	Pre	2.52	3.00	1.00	3.00	1.32	< 0.001
	Post	3.84	4.00	3.00	4.00		
Lower Extremity Left	Pre	2.52	3.00	1.00	3.00	1.40	< 0.001
	Post	3.92	4.00	3.00	4.00		

Table 3 shows that the duration of exercise therapy did not significantly correlate with the improvement in muscle strength of the right upper extremity (r = 0.415; p = 0.32) and the right lower extremity (r = 0.436; p = 0.23). In contrast, the duration of exercise therapy had a significant relationship with the increase in muscle strength of the left upper extremity (r = 0.641; p < 0.001) and left lower extremity (r = 0.714; p < 0.001). This positive relationship indicates that the longer the duration of therapy, the greater the increase in muscle strength in both parts.

Table 3. Spearman correlation between duration of exercise therapy and changes in extremity muscle strength.

	Duration of Exercise Therapy					
	n	Pre-Post	Mean	Δ Mean	r Value	p-value
Difference of Upper Extremity Right	52	Pre	2.14	1.66	0.415	0.32
		Post	3.81			
Difference of Lower Extremity Right	52	Pre	2.14	1.70	0.436	0.23
		Post	3.85			
Difference of Upper Extremity Left	52	Pre	2.52	1.32	0.641	< 0.001
		Post	3.84			
Difference of Lower Extremity Left	52	Pre	2.52	1.40	0.714	< 0.001
		Post	3.92			

DISCUSSION

The distribution of stroke patient characteristics in this study showed that most patients were in the elderly age group, especially the late elderly (56-65 years), which reached 40.4%, followed by the early elderly group (46-55 years) at 30.8%. These results are in line with previous studies, which noted that the incidence of stroke increases with age, with the age group of 55 years and over being the most vulnerable to stroke.[17]

Age is one factor that influences exercise therapy's effectiveness in increasing muscle strength. Based on the results of this study, younger patients showed a more significant increase in muscle strength than older patients. Research by Benita E, et al. (2022) also found that the late elderly age group is due to a natural physiological process in which muscle elasticity and muscle cell regeneration capacity decrease with age.[18] Along with ageing, there are changes in type II muscle fibres responsible for the strength and speed of muscle contractions, so the response to exercise therapy becomes slower.[19]

The decrease in anabolic hormones such as testosterone and growth factors such as IGF-1 in older individuals also contributes to decreased muscle adaptation to exercise.[20] In exercise therapy, younger patients tend to have better muscle adaptation capacity, including increasing neuromuscular signals that play a role in muscle strength.[21] studies have shown that older patients experience greater muscle atrophy due to reduced physical activity and increased insulin resistance, which can worsen muscle regeneration after exercise therapy.[22] Therefore, elderly patients require a longer duration of exercise therapy and a more intensive approach to obtain optimal muscle strength gains. However, this does not mean that older patients do not experience any improvement at all. Exercise therapy still has a positive effect on their muscle strength, although at a slower rate compared to younger patients. [23]

Regarding gender,[24] this study noted that 59.6% of patients were male, while women were only 40.4%. This finding is consistent with the results of a study by Aulyra et al. (2019), which showed that men have a higher risk of stroke than women.[25] Gender is a factor that can affect the body's response to exercise therapy. This study found that male patients showed a greater increase in muscle strength than women after exercise therapy. This aligns with research stating that men have physiologically greater muscle mass, contributing to increased muscle adaptation to exercise.[26] This difference is mainly due to higher testosterone levels in men. Testosterone plays a role in muscle protein synthesis and hypertrophy of type II muscle fibres, which are responsible for the strength and speed of muscle contractions.[27] Meanwhile, women have higher estrogen levels, increasing body fat accumulation and affecting the muscle composition and strength generated during exercise.[28]

In addition to hormonal factors, muscle fibre distribution also plays an essential role in the response to exercise therapy. Men tend to have a higher proportion of type II muscle fibres, which are more responsive to strength training than the more dominant type I muscle

fibres in women.[29] Type II muscle fibres have a stronger contraction capacity, so muscle strength increases are more significant in male patients than in females after exercise therapy. However, although women respond more slowly to exercise therapy, studies have shown that they can still experience significant increases in muscle strength with consistent and progressive exercise programs.[30] Motivational factors and adherence to exercise therapy also influence rehabilitation outcomes, with women tending to be more consistent in following treatment than men.[31] Previous studies have shown that patients have varying responses to exercise therapy to increase muscle strength.[32]

Hypertension[33] was the most common factor found in this study, and patients with hypertension tended to show better muscle strength gains than patients with[32] diabetes mellitus.[34] This can be explained by the mechanism of hypertension, which directly influences the cardiovascular system more than muscle metabolism.[32] The Joint National Committee (JNC) VII divides blood pressure into normal, prehypertension, and hypertension.[35] Hypertension management strategies include non-pharmacological therapy.[36] In contrast, patients with diabetes mellitus experienced lower muscle strength gains after exercise therapy than other groups. Diabetes can cause peripheral neuropathy and muscle metabolism disorders, which inhibit muscle adaptation to exercise.[37] Advanced Glycation End Products (AGEs). The accumulation of glycation end products in muscle tissue can also interfere with mitochondrial function and muscle regeneration after exercise, thereby reducing the effectiveness of therapy.[38] Research by Zhao et al. (2021) showed that dyslipidemia can also play a role in inhibiting muscle strength recovery after stroke. Increased LDL levels[39] and decreased high-density lipoprotein (HDL) levels[40] can affect blood flow to muscles, limiting the supply of oxygen and nutrients needed for muscle regeneration and hypertrophy after exercise.[39]

The results of Table 2 support the findings by Ristonilassius et al. (2022), which state that physical therapy can gradually improve the physical condition of stroke patients. The effectiveness of exercise therapy in stroke rehabilitation lies not only in increasing physical strength but also in improving the quality of life and independence of patients.[18]

Based on the study's results, the greatest increase occurred in the left lower extremity. Before exercise therapy, most patients had MMT scores of 2 (32.0%) and MMT 3 (60.0%), but after treatment, there was a significant increase, with 92.0% of patients achieving a score of 4. Meanwhile, although there was an increase in the right lower extremity, the distribution was not as large as that of the left. This indicates that exercise therapy has a greater impact on increasing muscle

strength in the left lower extremity than other parts.

Consistent strength training can build new connections between the motor system and activate spinal motor neurons.[41] Acetylcholine triggers contractions, while metabolism in mitochondria produces adenosine triphosphate (ATP), which is utilized by the muscles of the extremities as energy for contraction and increases the tone of smooth muscle in the extremities. In addition, muscle strength training causes stimulation that increases neuromuscular and muscular chemical activity.[42] The increase in strength in the lower extremities after strength training therapy tends to be more significant than in the upper extremities. One of the reasons is the focus of training in rehabilitation programs, which often places greater emphasis on restoring lower extremity function because of the importance of ambulation (ability to walk) and functional independence. More intensive, lower-extremity-focused training may result in greater strength gains. In addition, the brain has the capacity for neural reorganization (plasticity) after stroke. If rehabilitation is focused on the lower extremities, the brain areas controlling lower extremity motor function may undergo greater reorganization than those managing the upper extremities. Daily activities also involve more weight-bearing and locomotion in the lower extremities, so strength training that mimics these activities is more effective in increasing lower extremity muscle strength than upper extremity training.[43]

The greater gains in the left lower extremity after exercise therapy are likely related to lateral brain dominance and compensatory neural mechanisms. The brain's right hemisphere controls the left side of the body, including the left lower limb, and studies have shown that the right hemisphere has better compensatory abilities than the left hemisphere.[44] Therefore, patients with right-hemisphere strokes (which cause left-sided weakness) tend to experience greater improvement after exercise therapy due to the activation of alternative neural pathways that aid motor recovery.[45]

In addition, several studies have shown that lower-extremity function recovers more quickly than upper-extremity function after stroke due to the involvement of the primary motor system and more responsive cortical plasticity mechanisms in the limbs.[46] Rehabilitation factors also play a role, with lower-extremity exercises more often given to improve patient mobility than upper-extremity exercises, thereby maximizing strength recovery in the lower extremities, especially the right side.[47]

Table 3 Results of the study from the duration of exercise therapy showed that most respondents underwent exercise therapy for 12 weeks (19.2%) and 24 weeks (15.4%), while others underwent therapy with varying durations between 13

and 23 weeks. This shows that exercise therapy significantly improves patients' motor skills and muscle strength after regular intervention. The duration of exercise therapy plays a crucial role in influencing muscle strength gains in stroke patients, and this can be explained through several physiological mechanisms. Neuromuscular adaptation is one of the primary mechanisms, where progressive strength training will trigger a series of adaptations in the nervous and muscular systems.

In the early stages of training, strength gains are mainly due to neuromuscular adaptation, which is an increase in the efficiency of recruiting motor units (groups of muscle fibres controlled by one motor neuron) and increasing the firing rate of motor neurons. This process takes time, so a more extended training duration (12 weeks or more) provides a greater opportunity for neuromuscular adaptation to occur optimally. In addition to neuromuscular adaptation, long-term strength training can also trigger muscle hypertrophy, which is an increase in the size of muscle fibres. Muscle hypertrophy occurs because strength training stimulates muscle protein synthesis, which leads to the growth and repair of muscle fibres damaged during training.[48] This process takes a longer time than neuromuscular adaptation, so a longer training duration (such as 24 weeks) can significantly contribute to increasing muscle strength through hypertrophy. In addition, stroke can cause damage to the neural pathways that control movement, so exercise therapy plays a role in triggering brain plasticity, which is the brain's ability to reorganize its neural connections and form new pathways to replace damaged ones.[49]

This process takes time, so longer therapy durations allow brain plasticity to occur and improve motor control. Longer therapy durations can also increase compliance and establish good exercise habits, contributing to successful rehabilitation. High adherence to the rehabilitation program is essential to achieve optimal outcomes, as patients who exercise more frequently over a longer period tend to experience greater muscle strength and function gains.[50] Thus, adequate duration of exercise therapy (at least 12 weeks or more) allows sufficient time for neuromuscular adaptation, muscle hypertrophy, brain plasticity, and the formation of good exercise habits to occur, ultimately contributing to improvements in muscle strength and motor function in stroke patients.[48]

The importance of exercise therapy in stroke rehabilitation is further emphasized by studies showing that appropriate physical interventions can accelerate recovery and improve patients' quality of life.[51] Thus, exercise therapy should be an integral part of the post-stroke care plan to ensure maximum recovery for survivors. The results of this

study provide strong evidence for the effectiveness of exercise therapy in stroke rehabilitation for improving muscle strength and the importance of ongoing monitoring of patients' progress throughout their recovery process.[18]

The strength of this study lies in the use of objective medical record data and a practical approach in measuring muscle strength. However, limitations in the form of the use of subjective MMT methods and limited sample size without a control group need to be considered in interpreting the results.

CONCLUSION

This study shows that exercise therapy positively impacts increasing upper and lower extremity muscle strength in post-stroke patients at H. Abdul Manap Jambi Regional Hospital. The majority of patients who responded were in the 56–65 year age group and were dominated by men, with hypertension as the most common comorbidity. After exercise therapy, muscle strength significantly increased, as measured by manual muscle testing (MMT). The average MMT score of the right upper extremity increased. This increase indicates that exercise therapy intervention is effective in helping restore muscle strength in stroke patients. Further correlation analysis also revealed a significant relationship between the duration of therapy and increased muscle strength on the left side of the patient's body. However, no significant relationship was found on the right side, indicating the possibility of other factors influencing the results.

RECOMMENDATIONS

The findings of this study highlight the importance of implementing exercise therapy as a primary intervention in post-stroke rehabilitation programs. It is recommended that healthcare professionals, particularly physiotherapists, incorporate structured exercise routines tailored to the patient's physical condition to maximise recovery outcomes. Future research should explore optimal therapy duration, effective exercise types, and their impact on functional aspects, such as balance and gait. Studies with larger sample sizes and controlled designs are also encouraged to strengthen the evidence. Furthermore, improving accessibility to rehabilitation services and promoting active family involvement in home-based therapy is essential for achieving sustainable recovery among stroke survivors.

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