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Development of stroke hand gripper innovation as an alternative tool for independent range of motion (ROM) in stroke patients

Susanti[1], Sri Gustini[2], Muhammad Husaini[3], Aiyub[4]
[1,2,3]Prodi Kebidanan, Poltekkes Kemenkes Aceh, Indonesia
[4]FIK, Universitas Syiah Kuala Banda Aceh, Indonesia

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ABSTRACT

Background: Stroke or Cerebral Vascular Accident (CVA) is a condition of rapid loss of neurological function due to impaired blood vessel perfusion. Stroke is caused by factors including: cerebral platelets, Hemorrhage, and Embolism. The impact of stroke is the occurrence of hand drop which is characterized by the inability to lift the wrist, move the fingers or experience weakness in the hand area. One of the treatment efforts to minimize the impact of stroke is to do Range of Motion (ROM) Exercises early. The purpose of this study is to develop a ROM aid as an alternative tool for independent ROM (stroke hand gripper) and assess its efficiency on the strength of the muscles of the fingers. Method: This study involved 30 respondents in the working area of the Cot Seumeureung Community Health Center, West Aceh Regency, using purposive sampling. The research design is a Combined method, namely the research and development method or R&D (Research and development) and Pre-Experiment. The results of the study showed that the average value of muscle strength before ROM exercises using ROM aids was 2.00 and the average muscle strength after ROM exercises using ROM aids was 2.35 with a significance value of 0.008 ($p < 0.05$), thus it can be concluded that there is a significant difference in muscle strength before ROM exercises and after ROM exercises using ROM aids.

Corresponding Author:

Susanti,
Prodi Kebidanan,
Poltekkes Kemenkes Aceh,
Jl. Darussalam, Lambhuk, Kecamatan Darul Imarah, Kabupaten Aceh Besar, Aceh, Indonesia
Email: susanti@polte kkesaceh.ac.id

INTRODUCTION

Stroke, or Cerebral Vascular Accident (CVA), is a rapid loss of neurological function due to impaired blood vessel perfusion in the brain. Stroke is caused by a sudden blockage by a blood clot or narrowing of an artery, which blocks blood flow to the brain.(Retnaningsih, 2023)Stroke is caused by factors including: cerebral thrombosis, hemorrhage, and embolism.(Tunik et al., 2022)According to the World Health Organization (WHO), stroke is classified as a sudden brain dysfunction with clinical signs and symptoms lasting 24 hours or more. Strokes cause

approximately 5.5 million deaths and 13.7 million new stroke cases worldwide each year. The current global prevalence of stroke is approximately 80 million people living with stroke. In Indonesia, stroke prevalence shows a downward trend, with the stroke rate ranging from 10.9 per million in 2018 to 8.3 per million in 2023.(Darmawati et al., 2024)The highest prevalence of stroke is in the Special Region of Yogyakarta (11.4%) and North Sulawesi (11.3%), with the lowest prevalence in Papua (2.0%), and Aceh (8.8%). The highest prevalence of stroke is in the age group 75 years and older (41.3%), but stroke also occurs in patients aged 55-64 years (23.6%).(Ministry of Health of the Republic of Indonesia BKPK, 2023)The problem of high stroke rates worldwide is due to a lack of awareness of stroke risk factors, a lack of knowledge about the signs and symptoms of stroke, and stroke services, suboptimal treatment, and low compliance with treatment programs to prevent recurrence.(Ompusunggu et al., 2022)The physical impacts after a stroke include hemiparesis, hemiplegia, fatigue, aphasia, dysphagia, and decreased muscle strength.(Kariasa, 2022)Another impact is hand drop, which is characterized by the inability to lift the wrist, move the fingers, or experience weakness in the hand area.(Angraini et al., 2022). The results of interviews conducted with 6 stroke patients and their accompanying families during physiotherapy at the Cot Semeureung Community Health Center in Samatiga District stated that post-stroke patient rehabilitation is an obstacle, including the need for time and costs to carry out regular physiotherapy at the Community Health Center. Therefore, assistive devices are needed for stroke patients to carry out physiotherapy through ROM exercises with tools that are easier, cheaper and more effective. Research by reviewing articles on ROM found that ROM exercises performed regularly and routinely have an effect on increasing muscle strength in stroke patients.(Ayuningrum et al., 2022)Breakthroughs in post-stroke therapy have been studied, creating various combinations of therapies for post-stroke patients. Research using Constraint-Induced Movement Therapy (CIMT), or modified CIMT, and mirror therapy, has shown that CIMT intervention, either alone or in combination with other interventions, has an impact on upper extremity function in stroke patients (Putri & Zuhri, 2022; Roboth et al., 2020; Salam et al., 2023). Research on a post-stroke therapy aid for the hand is controlled using an Arduino UNO microcontroller and uses a DC motor to support the patient's hand. The results show that this tool can provide convenience and reduce the risk of disability (Ryan Syareza et al., 2018). Research on robotic glove assembly using a common hand exoskeleton circuit, flex sensors, fuzzy logic, and amplitude stimulus. Data observation results conducted over 6 days showed an increase in muscle strength.(Pratama & Yulianto, 2022). Research using rubber balls with the results of rubber ball exercises can increase grip muscle strength in non-hemorrhagic stroke patients who experience limb weakness (Aliviana & Fajriyah, 2022; Rismawati et al., 2022; Rosyad et al., 2023; Wedri et al., 2017)This study aims to determine the effectiveness of the ROM aid (Stroke Hand Gripper) on independent ROM exercises in stroke patients.

RESEARCH METHOD

The research method used is the combined method, namely the research and development method or R&D (Research and Development) and Pre-Experiment. The R&D method was developed by Borg and Gall (1983) and is a research method used to produce certain products and test the effectiveness of these products.(Sugiyono, 2020)This research is a combined method design research, namely the research and development method or R&D (Research and development) and Pre-Experiment. The research began with the presence of ROM aids, especially on the ROM of the hands and fingers. This study aims to test the effectiveness of the tools used to help stroke patients to perform ROM independently. Previously, the tools to be used will go through a validation stage from physiotherapists as experts to provide input to researchers on the tools used in this study. After the tool is declared ready for use, the tool is tested on the first 10 people (as a small group). This study uses an implementation observation sheet with assessment indicators or measuring tools using the Manual Muscle Test (MMT) with a scale of 0-5. The results of the test carried out are

started with univariate analysis of respondent characteristic data. Next, a pre-assessment (before the action is taken) is measured on the scale of the respondent's muscle strength, then given training using the ROM aid and re-measured changes in the scale of the respondent's muscle strength. Next, after being measured in a small group, this ROM aid will be measured in a large group (20 patients) and a strength scale measurement will be carried out on the patients before and after being given training using this ROM aid. This study was conducted on post-stroke patients experiencing upper extremity weakness in the Cot Semeureung Community Health Center, Samatiga District, West Aceh Regency. The sampling technique used was purposive sampling.

The inclusion criteria for this study are: (a) Patients who are able to communicate well, (b) Stroke patients who experience weakness of the upper limbs (hands and fingers), (c) Post-stroke patients experience weakness of the upper limbs (hands and fingers), (d) The patient is willing to participate in this study

The ROM exercises conducted in this study began by assessing and identifying the patient's ability to perform ROM movements (flexion, extension, adduction, and abduction of the fingers, as well as flexion and extension of the palm) and the ability to touch a rubber ball placed in the middle of the palm. Next, using the Stroke Hand Gripper, the patient was trained to perform flexion, extension, adduction, and abduction of the fingers, as well as flexion and extension of the palm. This exercise was carried out for 30 days, with exercises twice a day (morning and evening) and carried out for 10 minutes each session. Next, the results were analyzed using an indicator of the ability of the fingers to touch the rubber ball. Evaluation of the results of this exercise was carried out every 8 days (every week). Furthermore, within 30 days, the ability of the research subjects was assessed by comparing the evaluation scores each week.

RESULTS AND DISCUSSIONS

Research Result

This assessment uses a combined method design, namely research and development (R&D) and pre-experimentation. The R&D method, developed by Borg and Gall (1983), is a research method used to produce specific products and test their effectiveness (Sugiyono, 2020). This study aims to test the effectiveness of the device used to assist stroke patients in performing ROM independently. The research stages are as follows:

Problem Identification Stage

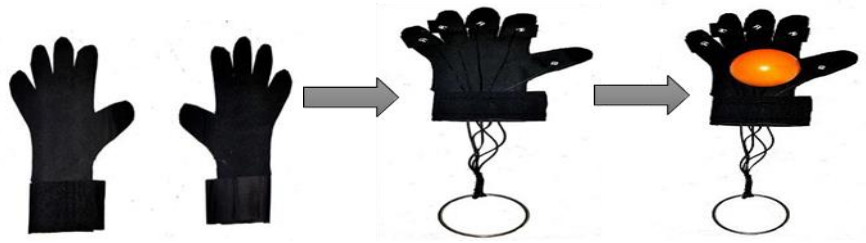
The problems experienced by respondents regarding ROM exercises carried out so far are that respondents are inconsistent in doing ROM exercises, difficulty in doing physiotherapy because PKM Cot Seumeureng does not have a physiotherapy unit so that patients with stroke and post-stroke must be referred to the Regional Hospital for post-stroke physiotherapy. Therefore, a tool is needed that can be used independently and can be done at home actively or passively.

Product Design and Development Stage

One of the ROM physiotherapy measures that can be used is exercise therapy, focusing on both active and passive movement exercises that are systematic, planned, structured and repeated with the correct movement patterns.(Rosyad et al., 2023). (a) The stages in this design begin with designing a hand draft of the ROM, selecting the materials and tools to be used, as follows:

a. Tools and materials

b. How to design: Hand draft (leather material) printed to fit hand size, Rubber is glued to each finger that has been formed, Each rubber is added with a rubber buffer, The string is attached to each rubber band according to the finger, Attach the crepping cloth to the wrist, The rope on each bracelet is held together using bracelet wire.
c. How to use: The patient wears a rubber band on the hand that will be trained in ROM movements; The patient's fingers are inserted into the rubber that has been attached to each finger (thumb, index finger, middle finger, ring finger and little finger); The ball is placed in the center of the palm; Encourage the patient to perform flexion, extension, abduction, and adduction movements of the fingers by pulling the string on each finger that has been provided, and the fingers touch the rubber ball. (This exercise can be done for each finger/each finger or can also be done for all fingers at once); Next, the trainer/patient/patient's family can identify the strength of the fingers to touch the rubber ball in the palm of the hand; The outcome indicator is when the patient is able to touch the rubber ball independently.
d. Design products



Tool Validation Instrument

The instrument used to validate the tool is to measure muscle strength using Manual Muscle Testing (MMT).

Table 1. Manual muscle testing (MMT) strength scale measurement

Evaluation	Assessment indicators
0 (zero)	No contraction on palpation, paralysis
1 (trace)	Feeling of muscle contractions, but no movement
2 (poor)	With the help or support of the joint, you can perform full joint movement (range of motion).
3 (fair)	Can perform full joint movement (ROM) against gravity, but cannot do it against resistance.
4 (good)	Can perform full ROM and can resist moderate resistance
5 (normal)	Can perform full ROM and can resist gravity and resistance

Source: Manual Muscle Testing (MMT)(Fransiska et al., 2024)

a. Expert Team Validation Stage, this expert validation test was conducted to assess the suitability of the device and assess its appearance. The expert validation test was conducted in collaboration with a physiotherapist working in the Medical Physiotherapy Room at Cut Nyak Dhien Regional General Hospital in Meulaboh.
b. Limited Group Testing Phase, this limited function test was conducted on the first 10 stroke patients and post-stroke patients according to the inclusion criteria in this study. The inclusion criteria are as follows: The inclusion criteria in this study are: Patients who are able to communicate well, Stroke patients who experience weakness of the upper limbs (hands and fingers), Post-stroke patients who experience weakness of the upper limbs (hands and fingers), Patients are willing to participate in this study,

After the device was declared ready for use, it was tested on the first 10 participants. The study was then conducted using an implementation observation sheet with the assessment indicators or measuring tool using the Manual Muscle Test (MMT) on a scale of 0-5. The test results began with a univariate analysis of the respondents' characteristic data. Next, a pre-assessment (before the action) was conducted to measure the respondents' muscle strength scale, then they were given exercises using ROM aids and the changes in the respondents' muscle strength scale were re-measured. The analysis results are as follows:

Univariate Results

Univariate analysis consists of the frequency distribution of Gender, Age, Occupation, Education, and duration of stroke, as shown in the following table:

a. Gender Distribution

Table 2. Frequency distribution of respondents' gender (n=10)

No	Age (years)	Amount	(%)
1	Man	6	60.0
2		4	40.0
	Total	10	100

Source: Primary Data 2025

Based on Table 2, it can be seen that the majority of respondents in this study were male, namely 6 respondents (60%), and the minority were female, namely 4 respondents (40%).

b. Age Distribution

Table 3. Frequency distribution of respondents' ages (n=10)

No	Age (years)	Amount	(%)
1	48 - 51 Years	4	40.0
2	52 - 55 Years	5	50.0
3	> 55 Years	1	10.0
	Total	10	100

Source: Primary Data 2025

Based on Table 3, it can be seen that the majority of respondents in this study were aged 52-55 years, namely 5 respondents (50%), and the minority were aged > 55 years, namely 1 respondent (10%).

c. Job Distribution

Table 4. Frequency distribution of respondents' occupations (n=10)

No	Age (years)	Amount	(%)
1	civil servant	1	10.0
2	Farmer	1	10.0
3	Housewife	2	20.0
4	Retired	2	20.0
5	Businessmaı	2	20.0

No	Age (years)	Amount	(%)
6	Fisherman	2	20.0
	Total	10	100

Source: Primary Data 2025

Based on Table 4, it can be seen that the majority of respondents in this study worked as fishermen, entrepreneurs, retirees, and housewives, with 2 respondents each (20%), and the minority worked as farmers and civil servants, with 1 respondent each (10%).

d. Distribution of Education

Table 5. Frequency distribution of respondents' occupations (n=10)

No	Age (years)	Amount	(%)
1	Bachelor	3	30.0
2	SENIOR HIGH SCHOOI	6	60.0
3	JUNIOR HIGH SCHOOI	1	10.0
	Total	10	100

Source: Primary Data 2025

e. Stroke Duration Distribution

Table 6. Frequency distribution of respondents' stroke duration (n=10)

No	Age (years)	Amount	(%)
1	2 years	3	30.0
2	3 years	1	10.0
3	4 years	4	40.0
4	5 years	2	20.0
	Total	10	100

Source: Primary Data 2025

Based on Table 6, it can be seen that the majority of respondents in this study experienced a stroke within 4 years, as many as 4 respondents (40%), and an educated minority, 1 respondent (10%). experienced a stroke within 3 years, as many as 1 respondent (10%). Tabulation results of respondents' pretest and posttest scores

a. Pre-test analysis results

Table 7. Tabulation results of respondents' pre-test scores (N=10)

No	Muscle Strength Value	Amount	(%)
1	3	4	40.0
2	2	6	60.0
	Total	10	100

Source: Primary Data 2025

Based on table 7, it can be seen that the muscle strength values of respondents before being given training showed a muscle strength value of 2 for 6 respondents (60%) and a muscle strength value of 3 for 4 respondents (40%).

b. Post test analysis results

Table 8. Tabulation results of respondents' post-test scores (N=10)

No	Muscle Strength Value	Amount	(%)
1	4	2	20.0
2	3	6	60.0
3	2	2	20.0
	Total	10	100

Source: Primary Data 2025

Based on table 8, it can be seen that the majority of muscle strength values in respondents after being given training showed a muscle strength value of 3 for 6 respondents (60%), muscle strength values of 2 and 4 for 2 respondents each (20%).

c. Normality Test, data normality test was conducted after obtaining pre-post results.

Table 9. Normality test values of pre and post ROM exercise values using ROM assistive devices (n=10)

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Pre-test score	.381	10	.000	.640	10	.000
post-test scores	.300	10	.011	.815	10	.022

a. Lilliefors Significance Correction

Table 9 shows that the normality test obtained from muscle strength values before and after ROM exercises using ROM aids showed a Shapiro-Wilk value for before exercise (p = 0.000) and after exercise (p = 0.022). Thus, it can be concluded that the distribution of these two exercises has non-normal data.

d. Bivariate Analysis, this analysis was conducted to test the difference in mean pre- and post-test scores. Data normality testing revealed non-normal distribution, so the bivariate analysis used was the Wilcoxon test.

Table 10. Statistical test results of pre and post ROM exercise values using the wilcoxon test (n=10)

	N	Median (minimum – maximum)	Mean±sd	*p*
Assess muscle strength before exercise	10	2 (2 - 3)	1.60±0.516	0.046
Muscle strength value after exercise	10	2 (3 – 4)	2.00±0.667	

Source: Primary Data 2025

Based on table 10, the average value of muscle strength before ROM exercises using ROM aids was 1.60 and the average muscle strength after ROM exercises using ROM aids was 2.00 with a significance value of 0.046 (p <0.05). Thus, it can be concluded that there is a significant difference in muscle strength before ROM exercises and after ROM exercises using ROM aids.

Limited group evaluation stage

After testing on a limited group, further evaluation was carried out on this ROM aid. The improvements made were as follows: (a) The strap used on the thumb can be added to perform rotation exercises on the thumb, not just flexion, extension, abduction and adduction (b) The strap installation can be colored so that the differences can be seen on each finger, (c) Use elastic materials, and more comfortable for respondents, such as soft leather materials such as Oscar leather as an alternative material, (d) It is better to use green materials

Large Group Trial Phase

The study continued by testing this ROM aid on a larger group of 20 respondents. Data analysis began with univariate data, namely respondent demographics, consisting of age, gender, education, occupation, and duration of stroke, followed by bivariate testing using the Wilcoxon test.

Univariate Results

a. Age Distribution

Table 11. Frequency Distribution of Respondents' Ages (N=20)

No	Age (years)	Amount	(%)
1	35 - 45 years old	4	20.0
2	46 - 55 years old	14	70.0
3	> 55 years	2	10.0

Total	20	100

Source: Primary Data 2025

Based on Table 11, it can be seen that the majority of respondents in this study were aged 46 - 55 years old as many as 14 respondents (70%) and a minority aged 35 - 35 years as many as 4 respondents (20%).

b. Gender Distribution

Table 12. Frequency distribution of respondents' gender (n=20)

No	Age (years)	Amount	(%)
1	Man	13	65.0
2	Woman	7	35.0
	Total	20	100

Source: Primary Data 2025

Based on Table 12, it can be seen that the majority of respondents in this study were male, 13 respondents (65%) and female, 7 respondents (35%).

c. Distribution of Last Education

Table 13. Frequency distribution of respondents' last education (n=20)

No	Age (years)	Amount	(%)
1	Bachelor	4	20.0
2	SENIOR HIGH SCHOO	13	65.0
3	JUNIOR HIGH SCHOOL	3	15.0
	Total	20	100

Source: Primary Data 2025

Based on Table 13, it can be seen that the majority of respondents in this study had a high school education of 13 respondents (65%) and the minority had a junior high school education of 3 respondents (15%).

d. Job Distribution

Table 14. Frequency distribution of respondents' occupations (n=20)

No	Age (years)	Amount	(%)
1	civil servant	2	10.0
2	Retired	3	15.0
3	Businessman	4	20.0
4	Farmer	3	15.0
5	Fisherman	3	15.0
6	Housewife	5	25.0
	Total	20	100.0

Source: Primary Data 2025

Based on Table 14, it can be seen that the majority of respondents in this study have housewife jobs, as many as 5 respondents (25%), and the minority have civil servant jobs, as many as 2 respondents (10%).

e. Distribution of Length of Stroke Experience

Table 15. Frequency distributionlong-term stroke experience respondents (n=20)

No	Age (years)	Amount	(%)
1	5 years	4	20.0
2		8	40.0

3	3 years	2	10.0
4	2 years	6	30.0
	Total	20	100.0

Source: Primary Data 2025

Based on Table 15, it can be seen that the majority of respondents in this study had experienced stroke for 4 years, namely 8 respondents (40%), and the minority had experienced stroke for 3 years, namely 2 respondents (10%). Tabulation results of respondents' pretest and posttest scores.

a. Pre-test analysis results

Table 16. Tabulation results of respondents' pre-test scores (n=20)

No	Muscle Strength Value	Amount	(%)
1	4	6	30.0
2	3	8	40.0
3	2	6	30.0
	Total	20	100.0

Source: Primary Data 2025

Based on table 16, it can be seen that the muscle strength values of respondents before being given training showed a muscle strength value of 3 for 8 respondents (40%) and a muscle strength value of 2 for 6 respondents (30%).

b. Post test analysis results

Table 17. Tabulation results of respondents' post-test scores (n=20)

No	Muscle Strength Value	Amount	(%)
1	5	2	10.0
2	4	9	45.0
3	3	9	45.0
	Total	20	100.0

Source: Primary Data 2025

Based on table 17, it can be seen that the muscle strength values of respondents after being given training showed muscle strength values of 3 and 4 for 9 respondents (45%) and muscle strength values of 5 for 2 respondents (10%).

Normality Test

Data normality test was conducted after obtaining pre-post results.

Table 18. Normality test values for pre and Post ROM exercise values with using ROM aids (n=20)

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
pre-exercise value	.200	20	.035	.813	20	.001
post-exercise scores	.284	20	.000	.773	20	.000

a. Lilliefors Significance Correction

Table 18 shows that the normality test obtained from the muscle strength values before and after ROM exercises using ROM aids showed the values Shapiro-Wilk for before exercise (p = 0.001) and after exercise (p = 0.000). Thus, it can be concluded that the distribution of these two exercises has non-normal data.

a. Bivariate Analysis, this analysis was conducted to test the difference in mean pre- and post-test scores. Data normality testing revealed non-normal distribution, so the bivariate analysis used was the Wilcoxon test.

Table 19. Statistical test resultspre and post rom exercise values using the wilcoxon test (n=20)

	N	Median (minimum – maximum)	Mean±sd	*p*
Assess muscle strength before exercise	20	2 (1 - 3)	2.00±0.795	0.008
Muscle strength value after exercise	20	2 (1 – 3)	2.35±0.671	

Source: Primary Data 2025

Based on table 19, it shows that the average value of muscle strength before ROM exercises using ROM aids was 2.00 and the average muscle strength after ROM exercises using ROM aids was 2.35 with a significance value of 0.008 ($p < 0.05$). Thus, it can be concluded that there is a significant difference in muscle strength before ROM exercises and after ROM exercises using ROM aids.

Discussion

Based on the research results above, the age of stroke patients in this study was around 46-55 years. Elderly patients experienced a worse quality of life than adult stroke patients. Elderly stroke patients were 144,000 times more susceptible to poor quality of life. Stroke patients were categorized into young adults, older adults, and the elderly. In stroke patients, young adults and older adults were still considered in the productive age group and therefore tended to have a better quality of life than elderly stroke patients.(Vivi et al., 2025)The gender of those experiencing stroke in this study was male. These results align with research showing that men are at greater risk of ischemic stroke, while women are more likely to suffer from hemorrhagic stroke, with a mortality rate twice that of men.(Rizkiana & Sukraeny, 2024)Women have hormonal factors that make them more protected against stroke. The estrogen and progesterone hormones women possess protect their organs, including blood vessels, before menopause.(Siamben et al., 2024)Many studies have reported that motor function in stroke survivors continues to improve for up to 2 to 3 years after stroke. Stroke survivors with regular exercise can maintain motor function and overall quality of life 4 years after the event. Several patient characteristics or clinical variables are associated with decreased outcomes several years after stroke rehabilitation, including older age, stroke severity, coexisting chronic disorders, cognitive problems, and depression.(Parellangi et al., 2025).

One treatment to improve mobility in stroke patients is Range of Motion (ROM) exercises. Range of Motion exercises include functional hand exercises. These exercises involve ROM movements such as flexion, extension, abduction, and adduction of the fingers. This is done to train the functional function of the fingers. These exercises can help maintain, build strength, and control the effects on muscles. They also help maintain ROM in the limbs, preventing muscle shortening (contractile) and disability.

The ROM aids used in this study showed that the average value of muscle strength before ROM exercises using ROM aids was 2.00 and the average muscle strength after ROM exercises using ROM aids was 2.35 with a significance value of 0.008 ($p < 0.05$), thus it can be concluded that there is a significant difference in muscle strength before ROM exercises and after ROM exercises using ROM aids. The results of this study are in line with research that found that ROM effectively increases muscle strength in stroke patients.(Suwaryo et al., 2022). Other research shows that rubber ball ROM Exercise therapy is effective in improving grip muscle strength in stroke patients and can be applied(Rismawati et al., 2022)Range of Motion exercises are a form of rehabilitation exercise that is considered quite effective in preventing disability in stroke patients.(Siamben et al., 2024).

Stroke patients should be mobilized as early as possible. One early mobilization method that can be implemented immediately is providing passive and active Range of Motion (ROM) exercises, aimed at improving post-stroke patient independence. Researchers assume that if implemented early and correctly, it will consistently have a positive impact on the patient's muscle strength.

CONCLUSION

Stroke or Cerebral Vascular Accident (CVA) is a condition of loss of function that results in hand drop characterized by the inability to lift the wrist, move the fingers or experience weakness in the hand area. This study aims to test the effectiveness of the ROM aid (Stroke hand Gripper) on the strength of the finger muscles in stroke sufferers or post-stroke in performing independent ROM. The results of the Wilcoxon test showed a difference in the average value of finger muscle strength before and after doing exercises with the ROM aid with a p value (0.008 (p <0.05). This study is expected to help stroke sufferers and post-stroke to perform independent ROM exercises both actively and passively.

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