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Range of motion and rubber ball grasping therapy for improving upper limb function in patient with ischaemic stroke

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Abstract

Background: Ischemic stroke can impair hand and arm movements, significantly impacting a patient's ability to perform daily activities and consequently reducing their quality of life. A combined approach of range of motion (ROM) exercises and rubber ball gripping therapy offers a potential avenue for rehabilitation. This combined therapy aims to strengthen muscles, maintain joint flexibility, and retrain movement patterns. Regularly applying this therapy is anticipated to accelerate patient recovery and promote independent function.

Purpose: To investigate the effectiveness of a combined range of motion exercise and rubber ball gripping in enhancing arm muscle strength in patients following an ischemic stroke.

Method: A comparative study was conducted involving two groups: an intervention group receiving the combined therapy and a control group that did not. Upper extremity muscle strength was assessed in both groups before and after the intervention period using a handgrip dynamometer and clinical scales (MRC scale and MSTs score).

Results: The study demonstrated a significant increase in upper extremity muscle strength in the intervention group compared to the control group ($p < 0.05$) as measured by the handgrip dynamometer. These findings indicate that combining ROM therapy and rubber ball gripping is an effective strategy for improving muscle strength in patients after an ischemic stroke.

Conclusion: The combination therapy of ROM exercises and rubber ball gripping can be considered an effective rehabilitation method for improving upper extremity muscle strength in patients with ischemic stroke. This study provides valuable evidence for medical professionals in developing more effective rehabilitation strategies for stroke patients.

Keywords: Ischemic Stroke; Non-Hemorrhagic Stroke; Range of Motion; Rubber Ball Grasping; Upper Extremity Muscle Strength.

INTRODUCTION

Stroke is a neurological emergency characterized by an interruption in cerebral blood flow, resulting in damage to brain tissue that can manifest as weakness, paralysis, or other functional impairments. It is generally classified into two major types: ischemic and hemorrhagic. Ischemic stroke, the more prevalent form, arises from arterial blockages that reduce blood supply to the brain, while hemorrhagic stroke occurs due to ruptured blood vessels causing intracerebral bleeding. Non-hemorrhagic strokes—primarily ischemic in nature—occur when arterial obstruction leads to brain tissue damage, often resulting in motor impairments, particularly weakness of the upper extremities, thereby limiting the ability to perform essential daily tasks (Indrawati, Fitryasari, & Ahsan, 2021).

Globally, the incidence of non-hemorrhagic stroke continues to rise, with ischemic strokes accounting for approximately 87% of all stroke cases (World Stroke Organization, 2021). In Indonesia, the national stroke prevalence increased from 7% in 2013 to 10.9% in 2018 (Ministry of Health of the Republic of Indonesia, 2019). Various risk factors—such as sex, age, educational level, history of hypertension, hypercholesterolemia, obesity, coronary artery disease, smoking, high-sodium diet, and physical inactivity—have been identified as contributing to the rising stroke burden (Hardika, Yuwono, & Zulkarnain, 2020). In Central Java, 96,794 stroke cases were recorded, with a slightly higher prevalence among males (11.0%) than females (10.9%). Nurses play a pivotal role across the continuum of stroke care, particularly in rehabilitation, which is critical for improving functional outcomes in stroke survivors.

The timing of medical intervention is a crucial determinant of prognosis, as delays in treatment can exacerbate neuronal damage. The symptoms of stroke are variable and depend on the affected brain region, with early signs including dizziness, headache, dysarthria, aphasia, dysphagia, and visual disturbances. Common clinical presentations include hemiparesis, hemianopia, and impaired speech. Delayed management often results in worse functional outcomes, underscoring the need for timely and effective treatment aimed at restoring cerebral perfusion and minimizing disability (Kuriakose & Xiao, 2020). Among stroke-related impairments, decreased muscle strength in the extremities—particularly the

upper limbs—is a major factor contributing to functional decline.

Motor deficits following ischemic stroke are highly prevalent, with moderate impairments affecting up to 90% of patients. Approximately 80% of individuals experience acute upper limb hemiparesis, but only about one-third regain full functional use. Around 55% of non-hemorrhagic stroke patients exhibit greater hand weakness, especially in the fingers, and 70% develop disabilities that interfere with daily activities. Without appropriate rehabilitative care, these impairments can lead to long-term functional limitations and decreased quality of life. Rehabilitation interventions such as Range of Motion (ROM) exercises are essential to prevent complications like abnormal muscle tone, orthostatic hypotension, deep vein thrombosis, and contractures (Garrison, 2003).

Post-stroke rehabilitation is fundamental in minimizing disability, with exercise therapy being a cornerstone. ROM exercises—both active and passive—aim to optimize joint mobility without inducing pain. One promising intervention involves combining ROM exercises with rubber ball squeezing. Studies have shown that this combination enhances hand muscle strength by promoting joint movement and sensory-motor activation (Faridah, Sukarmin, & Kuati, 2018). The physical characteristics of the rubber ball—its serrated, soft, and elastic surface—are thought to stimulate acupressure points in the hand, which may, in turn, activate neural pathways responsible for motor recovery (Hentu, Rochmawati, & Firmawati, 2019).

Ball grip exercises promote gentle, repetitive muscle contractions that engage both sensory and motor receptors. The unique texture of the rubber ball contributes to effective muscle fiber stimulation. Research indicates that as little as four days of rubber ball grip training can improve hand muscle strength, as the sensory input provided by the ball may help reactivate weakened neural circuits involved in motor control.

Several studies have explored the effectiveness of ROM and rubber ball grip exercises in enhancing muscle strength in stroke patients. ROM exercise rubber ball is effective in increasing the grip muscle strength of Stroke Patients” (Faridah, Sukarmin, & Kuati, 2018). Range of motion exercise and rubber ball movements have been proven effective in

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increasing muscle strength in non-hemorrhagic stroke patients who experience motor weakness (Hentu et al., 2019). Right-hand muscle strength improved in patients undergoing combined therapy, whereas no significant change was observed in the left hand that underwent ROM exercises alone (Sari & Kustriyani, 2023). These findings underscore the added value of combining ROM with grip training. However, many of these studies lacked a structured evaluation or monitoring framework to assess exercise adherence and progress (Asmawita, Ahyana, & Kamal, 2022).

Stroke remains a leading cause of long-term disability globally (World Stroke Organization, 2021). In Indonesia, the 2018 health survey reaffirmed the increasing stroke prevalence, with ischemic stroke constituting the majority of cases (87%) (Ministry of Health of the Republic of Indonesia, 2019). Clinical observations at Indriati Solo Baru Hospital revealed that among 36 post-stroke patients, the average upper limb muscle strength—measured via the Manual Muscle Testing (MMT) scale—was at grade 3, indicating moderate motor dysfunction. Without structured rehabilitation, such individuals are at elevated risk of chronic disability. Key challenges in recovery include inconsistent exercise routines and insufficient monitoring by healthcare providers post-discharge.

ROM and rubber ball grip therapy have demonstrated efficacy in restoring upper limb function and stimulating neuromuscular activity (Faridah et al., 2018; Hentu et al., 2019; Christaputri & Anam, 2023). However, most prior studies have not incorporated remote supervision mechanisms—such as WhatsApp support groups or video call-based monitoring—to enhance adherence and continuity of care. These tools offer promising avenues for improving therapy outcomes by facilitating regular interaction and supervision (Septianingrum & Subairi, 2024).

While existing evidence supports the effectiveness of ROM and rubber ball grip exercises in increasing upper limb strength in non-hemorrhagic stroke patients, there remains a lack of studies that

integrate continuous, technology-supported evaluation frameworks. Few studies have compared the outcomes of ROM alone versus its combination with grip exercises under structured remote supervision. This highlights a critical gap in the literature regarding the potential benefits of technology-assisted, combined therapy approaches for upper limb rehabilitation in stroke survivors.

RESEARCH METHOD

A quasi-experimental design using a non-equivalent control group approach, in which participants were not randomly assigned but were allocated into two distinct groups: an experimental group and a control group. The total sample consisted of 36 post-stroke patients with non-hemorrhagic stroke, all receiving care at Indriati Solo Baru Hospital. Each group comprised 18 participants. The experimental group received a combined intervention of Range of Motion (ROM) exercises and rubber ball grip therapy, whereas the control group was administered ROM exercises alone. Both interventions were delivered with equal frequency and duration—three sessions per week over a two-week period.

Data on upper extremity muscle strength were obtained using a hand dynamometer. The results were subjected to statistical analysis, including normality testing using the Shapiro-Wilk test, homogeneity testing via Levene's test, and comparative analysis using both paired and independent t-tests. All analyses were conducted using SPSS version 25.

Prior to initiating the intervention, the study obtained ethical clearance from the health research ethics committee of the faculty of medicine Universitas Muhammadiyah Surakarta under approval number: 5395/B.1/KEPK-FKUMS/XI/2024, and informed consent was secured from all participants in accordance with established ethical standards for health research.

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RESEARCH RESULTS

Table 1. Characteristics of The Participants (N=36)

Variable	Results	
	Intervention Group (n=18)	Control Group (n=18)
Age (Mean±SD)(Range)(Year)	(57.444±6.119)(45-70)	(59.889±5.005)(45-70)
Age (n/%)		
45-50	2/11.1	0/0
51-55	6/33.4	3/16.7
56-60	4/22.2	8/44.4
61-65	4/22.2	4/22.2
66-70	2/11.1	3/16.7
Gender (n/%)		
Male	8/44.4	12/66.7
Female	10/55.6	6/33.3
Education (n/%)		
Elementary	0/0	1/5.5
Junior High	8/44.4	7/38.9
Senior High	10/55.6	7/38.9
University/College	0/0	3/16.7
Smoking History (n/%)		
Yes	3/16.7	5/27.8
No	15/83.3	13/72.2
Marital Status (n/%)		
Married	11/61.1	15/83.3
Single	0/0	2/11.1
Widowed	4/22.2	1/5.6
Widower	3/16.7	0/0
Occupation (n/%)		
Civil Servant	4/22.2	2/11.1
Entrepreneur	10/55.6	5/27.8
Self employed	4/22.2	8/44.4
Farmer	0/0	3/16.7
Residence (n/%)		
Alone	5/27.8	5/27.8
With family	13/72.2	13/72.2

Table 1 presents the demographic characteristics of the 36 participants, divided equally into intervention and control groups (n=18 each). Variables analyzed included gender, education, age, smoking history, marital status, employment type, and place of residence. The intervention group comprised predominantly females (55.6%), while the control group was mostly male (66.7%). High school was the most common education level in both groups. The mean age was 57.44 years in the intervention group and 59.88 years in the control group (range: 45–70 years). Most participants were married, non-smokers, and lived with family. Employment types varied, with entrepreneurs prevalent in the intervention group and self-employed individuals in the control group.

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Table 2. Wilcoxon Test Results

Variable	Median QR0 Pre	Median QR Post	p-value	p-z
Muscle Strength				
Control group	3.00	3.00	-2.828	0.005
Intervention group	3.00	3.00	-3.520	0.001
Finger Grip				
Control group	32.850	33.900	-3.737	0.001
Intervention group	28.750	27.350	-2.945	0.003

Table 2 indicates that in the control group, the median muscle strength remained at 3.00 from pre- to post-test, yet the change was statistically significant ($z = -2.828$, $p = 0.005$). Similarly, the intervention group showed no change in median muscle strength (3.00), but with a greater statistical significance ($z = -3.520$, $p = 0.001$). For finger grip strength, the control group showed a significant increase from 32.850 to 33.900 ($z = -3.737$, $p = 0.001$), while the intervention group showed a significant decrease from 28.750 to 27.350 ($z = -2.945$, $p = 0.003$).

Table 3. Mann-Whitney Test Result

Variable	Control group		Intervention group	
	L Median	U Median	p-value	p-z
Muscle Strength				
Pre	3.00	3.00	156,00	0,802
Post	3.00	3.00	76,000	0,003
Finger Grip				
Pre	32.850	28.750	161.000	0.975
Post	33.900	27.350	120.000	0.183

Table 3 shows that both groups had the same median muscle strength (3.00) at pre-test, with no significant difference ($p = 0.802$). Post-intervention, the median remained unchanged; however, the difference between groups became statistically significant ($p = 0.003$). For finger grip strength, no significant difference was observed at pre-test ($p = 0.975$). Although the control group's grip strength increased and the intervention group's decreased at post-test, the difference remained non-significant ($p = 0.183$).

DISCUSSION

The demographic characteristics of participants in this study revealed similarities between the intervention and control groups, particularly in terms of age, educational attainment, and social environment. Age is a significant determinant of muscle strength, as aging is associated with reductions in muscle mass and neuromuscular function. Consequently, physical exercise becomes a

crucial strategy to preserve muscle strength and flexibility. Additionally, family support and education level can influence patients' motivation to adhere to therapy and their comprehension of the benefits of rehabilitative exercises (Lee, Tung, Liu, & Chen, 2018).

Moreover, the persistence of smoking habits among some participants was found to negatively impact both muscle strength and the recovery process. Smoking is known to impair peripheral circulation and tissue oxygenation, thereby hindering muscle regeneration. Other influential factors include nutritional status, routine physical activity, and comorbid conditions such as hypertension or diabetes mellitus, all of which can affect the success of rehabilitation programs (Distefano & Goodpaster, 2018).

Considering these factors, the observed improvements in muscle strength within the intervention group suggest that the combined ROM and rubber ball grip therapy is an effective

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rehabilitation strategy when implemented consistently and tailored to individual patient needs.

Both groups demonstrated significant increases in muscle strength post-intervention. However, the increase was more pronounced in the intervention group ($p = 0.001$) compared to the control group ($p = 0.005$). The enhanced outcomes in the intervention group are likely attributable to the synergistic effects of ROM and rubber ball grip therapy in promoting upper limb strength and joint mobility, thereby improving muscle mass and tone in post-stroke patients. Resistance-based interventions, including those used in this study, are known to enhance muscle strength through neuromuscular adaptations, even among older populations. These exercises typically stimulate motor unit recruitment, hypertrophy, and neuromuscular efficiency.

In the control group, gains in muscle strength may be partly explained by everyday physical activity or a learning effect resulting from repeated testing (Mayer, Scharhag-Rosenberger, Carlsohn, Cassel, Müller, & Scharhag, 2022). Repeated exposure to strength assessments can elicit modest adaptive responses over time.

Regarding finger grip strength, the intervention group maintained a median score of 3.00 but experienced a statistically significant improvement ($z = -3.520$; $p = 0.001$), confirming the efficacy of the intervention (Hikmareza, Widiyanto, & Kamal, 2024). Interestingly, the control group also showed significant improvements in finger grip strength ($p = 0.001$), while the intervention group demonstrated a significant decrease ($p = 0.003$).

The improvement in the control group may stem from engagement in routine physical tasks that indirectly sustain grip function. Light daily activities such as household chores or leisure pursuits can support or enhance grip strength (García-Hermoso, Ramírez-Velez, & Saavedra, 2019). On the other hand, the decline observed in the intervention group could result from insufficient emphasis on small hand muscles. Interventions that predominantly focus on larger muscle groups may induce fatigue in smaller muscles without eliciting adequate adaptive responses (Baz-Valle, Balsalobre-Fernández, Alix-Fages, & Santos-Concejero, 2022; Larsson, Bidonde, Olsen, Gay, Lerdal, Ursin, & Edvardsen, 2023). This highlights the necessity of designing comprehensive rehabilitation programs that specifically target the

affected muscle groups.

Overall, the findings suggest that combining ROM exercises with rubber ball grip therapy presents a viable and accessible option for stroke rehabilitation. Despite the absence of statistically significant intergroup differences in some outcomes, this method still holds practical value for preserving upper limb motor function. The simplicity, affordability, and home-based feasibility of this approach make it a promising tool in clinical and community settings. However, for optimal results, future interventions should include specific training for hand and forearm muscles and address individual factors such as age, sex, and lifestyle habits, including smoking, which may influence therapeutic outcomes (Dankel, Counts, Barnett, Buckner, Abe, & Loenneke, 2017).

Wilcoxon test results indicated that although the median muscle strength remained unchanged in both groups, the observed increases were statistically significant—potentially influenced by physical activity outside the formal exercise regimen. The intervention group showed a greater improvement, reinforcing the intervention's effectiveness. Conversely, in finger grip strength, the control group exhibited positive outcomes, while the intervention group declined, likely due to fatigue or the lack of focused training for intrinsic hand muscles (Baz-Valle et al., 2022).

Mann-Whitney test findings showed no significant pre-intervention differences between the groups. However, post-intervention analysis revealed a statistically significant disparity in overall muscle strength, supporting previous literature that emphasizes the role of physical training in enhancing muscle strength via neuromuscular adaptations. Notably, there were no significant changes in finger grip strength between the groups before or after the intervention (Moritani, 1993).

Nurses play a pivotal role within the healthcare system, functioning not only as caregivers but also as educators, advocates, and coordinators. Their responsibilities encompass holistic patient care that addresses physical, psychological, social, and spiritual dimensions. As educators, nurses facilitate patient and family understanding of health conditions and treatment regimens, encouraging adherence to therapeutic plans. In their advocacy role, nurses uphold patients' rights, ensuring ethical and dignified care. They also collaborate with interdisciplinary teams to coordinate seamless and effective

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healthcare delivery. Ultimately, nursing practice requires the integration of clinical expertise, empathy, and ethical responsibility to provide comprehensive and person-centered care.

CONCLUSION

The combination of Range of Motion (ROM) exercises and rubber ball gripping can significantly increase large muscle strength. However, finger grip strength has not increased much. Therefore, additional training is needed that focuses more on the small muscles of the hand. These findings can be a reference for educational institutions, health workers, and further researchers to develop more effective therapies, as well as encourage patients to be more enthusiastic in the recovery process.

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