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Original Article

Effect of rubber ball gripping range-of-motion exercise on hand muscle strength in patients with non-hemorrhagic stroke

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Abstract

Background: Stroke remains a major cause of disability worldwide, often resulting in impaired upper limb function and decreased hand muscle strength that limit independence in daily activities. Simple, structured rehabilitation strategies such as range-of-motion (ROM) exercises using a rubber ball may provide practical and cost-effective support for motor recovery, yet evidence regarding their specific impact on hand muscle strength in non-hemorrhagic stroke patients remains limited.
Objective: This study aimed to examine the effect of rubber ball gripping range-of-motion exercise on hand muscle strength in patients with non-hemorrhagic stroke.
Methods: This study employed a pre-experimental one-group pretest–posttest design conducted in the Stroke Center inpatient ward of RSUD Labuang Baji Makassar. A total of 21 patients with non-hemorrhagic stroke who experienced upper extremity weakness were recruited using consecutive sampling based on predefined inclusion criteria. Hand muscle strength was measured using the manual muscle testing scale before intervention and daily after implementation. The intervention consisted of rubber ball gripping ROM exercise performed twice daily for six consecutive days as part of evidence-based nursing practice. Data were analyzed using descriptive statistics and paired statistical testing with a significance level of $\alpha = 0.05$.
Results: The mean hand muscle strength score increased from 3.10 ± 0.301 before intervention to 4.10 ± 0.301 after six days of exercise. Progressive improvement was observed beginning on the third day of intervention, with statistically significant differences between pre- and post-intervention measurements ($p < 0.05$). These findings indicate that repetitive ROM rubber ball gripping exercise contributed to clinically meaningful improvement in upper limb muscle strength among non-hemorrhagic stroke patients.
Conclusion: Rubber ball gripping range-of-motion exercise demonstrated significant effectiveness in improving hand muscle strength in patients with non-hemorrhagic stroke.

Background

Stroke remains a leading cause of mortality and disability worldwide, with the global burden continuing to increase each year (Naghavi et al., 2017). Global Burden of Disease data show that stroke incidence and prevalence have risen significantly in recent decades across multiple regions (Feigin et al., 2021). Patients with non-hemorrhagic stroke experience neurological impairment due to cerebral vascular occlusion that reduces upper limb motor function (Chasanah et al., 2025). Hypertension as a major risk factor increases the vulnerability of older adults to ischemic stroke events (Annisa & Siahaan, 2025). Poor adherence to antihypertensive therapy increases the risk of complications including recurrent stroke attacks (Putri et al., 2025). Families with limited knowledge about stroke prevention contribute to increased risk of recurrent stroke among patients (Sari Wijayanti et al., 2025).

Patients with non-hemorrhagic stroke often experience hand muscle weakness that interferes with activities of daily living (Joyce Black, 2014). Motor dysfunction significantly reduces quality of life and increases patient dependence on caregivers (Anjos et al., 2022). Physical fitness training improves functional capacity in stroke patients through neuromuscular adaptation mechanisms (Saunders et al., 2020). High-intensity aerobic exercise increases neurotrophic factors that support neural plasticity after stroke (Hsu et al., 2021). Combined aerobic exercise and cognitive training improve cognitive outcomes in stroke rehabilitation (Amoros-Aguilar et al., 2021). Multimodal exercise interventions combining aerobic, resistance, and cognitive training demonstrate feasibility and safety in stroke recovery (Koch et al., 2020).

Optimal intensity walking rehabilitation improves motor recovery outcomes in chronic stroke patients (Boyne et al., 2022). High-intensity interval training enhances cardiovascular rehabilitation outcomes following ischemic cerebrovascular disease (Lapointe et al., 2023). Evidence indicates that high-intensity exercise remains safe for patients in acute and subacute stroke phases (Mah et al., 2023). Aerobic exercise interventions improve cognitive function through neuroplastic mechanisms in post-stroke populations (Li et al., 2022). Exercise interventions reduce depressive symptoms in older adults with cognitive impairment through neurobiological modulation (Liu et al., 2023). Exercise therapy also alleviates post-stroke pain through regulation of inflammatory pathways (Ma et al., 2022).

Home-based rehabilitation programs demonstrate effectiveness comparable to center-based exercise in improving walking speed and balance after stroke (Nascimento et al., 2022). Home exercise adherence requires structured strategies to ensure consistency and therapeutic benefit among stroke survivors (Mahmood et al., 2022). Randomized trials show that home-based exercise improves lower limb spasticity and functional recovery in post-stroke patients (Chen et al., 2021). Virtual reality–assisted rehabilitation provides effective motor recovery stimulation in stroke populations (Saposnik et al., 2016). Emerging studies indicate that Swiss-ball and virtual reality training improve balance and cortical activation in chronic stroke patients (Noreen et al., 2024). Myofascial release using ball-based techniques improves upper limb motor function and spasticity in chronic stroke rehabilitation (Parikh et al., 2022).

Specific rehabilitative exercises targeting upper limb function improve mobility and coordination in post-stroke hemiparesis patients (Suwaryo et al., 2023). Nursing interventions based on Roy's adaptation model improve physical mobility impairment in stroke patients (Saputra et al., 2025). Transcranial direct current stimulation demonstrates effectiveness in improving swallowing dysfunction after stroke rehabilitation (Zhao et al., 2022). Aerobic exercise combined with cognitive training improves functional rehabilitation outcomes in stroke patients (Yeh et al., 2022). Exercise interventions contribute to global cognitive improvement after minor stroke or transient ischemic attack (Deijle et al., 2022). Combined exercise interventions significantly improve physical and psychological outcomes in stroke rehabilitation settings (Frank et al., 2022).

Rubber ball gripping range-of-motion exercise represents a simple, low-cost intervention that potentially improves hand muscle strength in patients with non-hemorrhagic stroke. However, evidence regarding its specific effectiveness on hand muscle strength remains limited compared with broader exercise interventions. Therefore, this study aims to examine the effect of rubber ball gripping range-of-motion exercise on hand muscle strength in patients with non-hemorrhagic stroke using a pre-experimental study design.

Methods

Study Design

This study employed a pre-experimental one-group pretest–posttest design to evaluate the effect of rubber ball gripping range-of-motion (ROM) exercise on hand muscle strength in patients with non-hemorrhagic stroke. The design was selected because the intervention was implemented as an evidence-based nursing practice (EBNP) application in a clinical setting without randomization or control group allocation. The one-group pretest–posttest structure enabled direct comparison of hand muscle strength before and after the intervention within the same participants. This design was considered appropriate to examine preliminary effectiveness and feasibility of a low-cost rehabilitative intervention in a real-world hospital context. The study reporting followed the TREND Statement guideline to ensure transparency in describing intervention delivery, participant flow, eligibility criteria, statistical procedures, and outcome measurement.

The study was conducted at RSUD Labuang Baji Makassar, a type B public hospital under the South Sulawesi Provincial Government. The hospital has a dedicated stroke inpatient ward that has been operational for approximately four months prior to the study. Preliminary observation of medical records indicated that no

standardized non-pharmacological instrument or structured protocol for rubber ball gripping ROM exercise had been implemented in routine stroke care. Therefore, this study aimed to introduce and systematically evaluate this intervention within clinical nursing practice.

Samping

The target population consisted of patients diagnosed with non-hemorrhagic stroke who were hospitalized in RSUD Labuang Baji. Hospital records in 2023 documented 130 non-hemorrhagic stroke patients treated during that year. The accessible population included patients admitted during the data collection period who met eligibility criteria.

Sample size was calculated using G*Power statistical software. The calculation incorporated an effect size of 0.79, alpha error probability (α) of 0.05, and statistical power (1–β) of 0.80 for a paired mean comparison test. The analysis indicated a minimum required sample size of 19 participants. To anticipate a potential dropout rate of 10%, the adjusted required sample size was increased to 21 participants. Participants were recruited using consecutive sampling, whereby all eligible patients during the study period were invited to participate until the required sample size was reached.

Inclusion criteria consisted of patients diagnosed with non-hemorrhagic stroke who were undergoing treatment at RSUD Labuang Baji, patients experiencing upper extremity weakness, patients who were able to communicate clearly, patients with full consciousness indicated by a Glasgow Coma Scale (GCS) score of 15, patients with muscle strength grading between 3 and 4, and patients accompanied by a caregiver willing to cooperate during the intervention process. Exclusion criteria included patients who discontinued participation due to failure to perform the ROM exercise continuously for six consecutive days and patients who withdrew consent during the study period.

Instruments

Hand muscle strength was measured using a standardized manual muscle testing (MMT) scale graded from 0 to 5, where grade 0 indicates no muscle contraction and grade 5 indicates normal muscle strength against full resistance. The MMT assessment was performed by trained nursing personnel to ensure consistency in scoring. The instrument was selected because it is widely used in neurological rehabilitation settings and provides practical clinical evaluation of upper limb muscle performance.

Demographic characteristics including age, sex, duration of stroke, affected side, and comorbid conditions were recorded using a structured data collection sheet developed by the researchers. The sheet was designed to capture baseline characteristics relevant to stroke recovery. Before implementation, assessors received standardized briefing to minimize inter-rater variability in muscle strength evaluation.

Intervention

The intervention consisted of rubber ball gripping range-of-motion exercise implemented as an evidence-based nursing practice. The exercise protocol involved instructing patients to grip and release a medium-resistance rubber ball using the affected hand. Each session included repeated cycles of gripping and relaxation movements designed to stimulate muscle contraction and promote neuromuscular activation.

The intervention was administered twice daily, in the morning and afternoon, for six consecutive days. Each session lasted approximately 10–15 minutes and was supervised by nursing staff to ensure correct technique and safety. Caregivers were also instructed on how to assist patients during exercise sessions to enhance adherence. The frequency and duration of the intervention were determined based on feasibility within the inpatient care schedule and principles of repetitive motor stimulation in stroke rehabilitation.

Participants underwent baseline muscle strength assessment prior to the first intervention session. Post-intervention assessment was conducted after completion of the six-day program. The structured implementation ensured consistency in exercise delivery across participants

Data Collection

Data collection was conducted during the inpatient hospitalization period. Baseline demographic data were collected upon enrollment. Pretest hand muscle strength was assessed prior to initiation of the rubber ball gripping ROM exercise. The intervention was then implemented for six days under supervision. Posttest muscle strength assessment was conducted on the seventh day following completion of the intervention protocol.

All measurements were documented in structured recording forms. Researchers ensured that assessments were performed at approximately the same time of day to reduce variability due to fatigue or circadian fluctuation. Participant adherence to the intervention was monitored daily through attendance logs and caregiver confirmation.

Data Analysis

Data were analyzed using statistical software. Descriptive (univariate) analysis was performed to summarize participant characteristics and study variables. Numerical data were presented as mean ± standard deviation, while categorical variables were presented as frequency and percentage.

Normality testing was conducted using the Shapiro–Wilk test to determine data distribution. If the distribution of pretest and posttest muscle strength scores was normal, the dependent (paired) t-test was used to compare mean differences before and after the intervention. If the data were not normally distributed, the nonparametric Wilcoxon signed-rank test was applied as an alternative. Statistical significance was set at $\alpha = 0.05$ with a 95% confidence interval.

Effect size was also calculated to determine the magnitude of the intervention effect on hand muscle strength. This approach provided not only statistical significance but also clinical relevance of the findings.

Ethical Considerations

Ethical approval for this study was obtained from the appropriate Institutional Ethics Committee prior to data collection. The study adhered to ethical principles including respect for autonomy, beneficence, non-maleficence, and justice.

Participants and caregivers received detailed explanation regarding study objectives, procedures, potential benefits, and risks. Written informed consent was obtained before participation. Participants were informed that their involvement was voluntary and that they could withdraw at any time without affecting their medical care. Confidentiality of personal data was maintained by assigning coded identifiers to each participant.

The intervention posed minimal risk because it consisted of low-intensity hand gripping exercises routinely applied in rehabilitation settings. Continuous monitoring was conducted to prevent fatigue or discomfort during exercise sessions.

Results

The implementation of evidence-based nursing practice (EBNP) involving rubber ball gripping range-of-motion (ROM) exercise was conducted to improve hand muscle strength among patients with non-hemorrhagic stroke treated in the Stroke Center inpatient ward of RSUD Labuang Baji Makassar. A total of 21 patients participated in this EBNP implementation. The intervention was carried out in three stages, namely baseline measurement of hand muscle strength using the muscle strength scale (pre-intervention), administration of ROM rubber ball gripping exercise twice daily for six consecutive days, and repeated daily measurement of hand muscle strength following the intervention period.

Table 1. Characteristics of Respondents Receiving Rubber Ball Gripping ROM Exercise Intervention

Variables	Frequency (n)	Percentage (%)
Level of Education		
Primary High School	3	14.3
Senior High School	9	42,9
Collage	9	42,9
Occupation		
Housewife	10	47,6
Enterpreneur	6	28,6
Civil Servant	5	23,8
	Mean	**SD**
Age (years)	58.76	12.39

Table 1 shows that most respondents had a senior high school or college educational background, each accounting for 42.9% of the total sample, while only 14.3% had primary school education. This distribution indicates that the majority of participants had moderate to relatively higher educational attainment, which may influence understanding of rehabilitation instructions.

Based on occupation, nearly half of the respondents were housewives (47.6%), followed by entrepreneurs (28.6%) and civil servants (23.8%). This finding suggests that most participants were not formally employed in structured occupational settings, which could affect physical activity levels and rehabilitation engagement.

The mean age of respondents was 58.76 years with a standard deviation of 12.39 years, indicating that most participants were middle-aged to older adults. This age profile aligns with the epidemiological trend of stroke occurrence, where increasing age is associated with higher stroke risk and functional impairment.

Overall, the respondent characteristics demonstrate that the intervention was applied predominantly to middle-aged and older adult stroke patients with varied educational and occupational backgrounds, providing contextual understanding for interpreting the outcomes of the ROM rubber ball gripping exercise intervention.

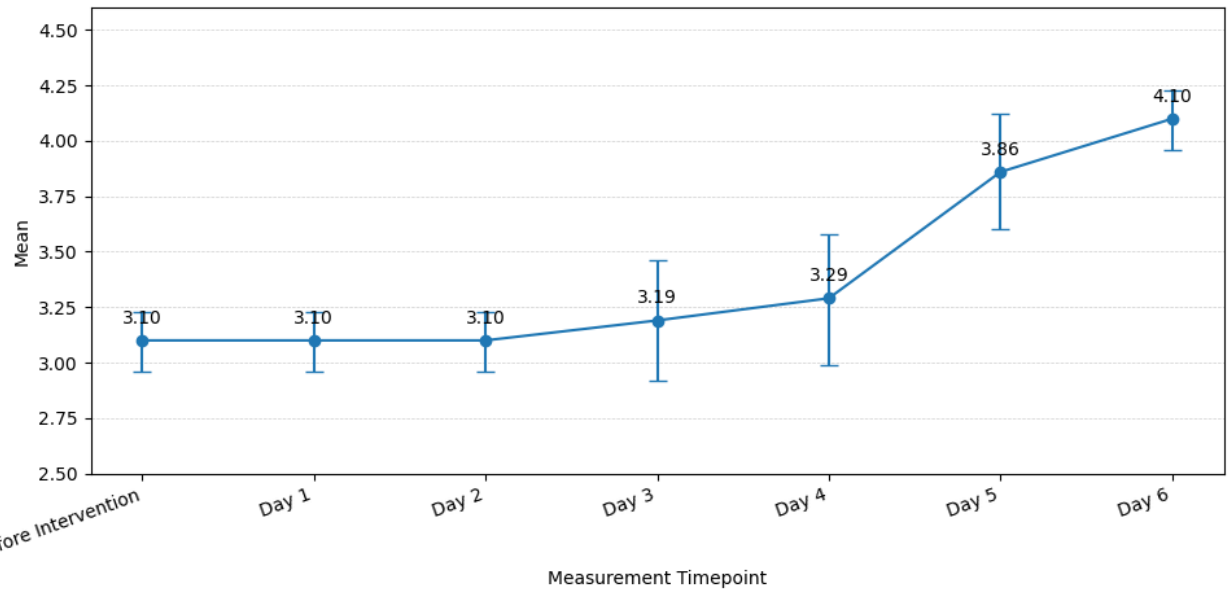

Figure 1. Distribution of Hand Muscle Strength Before and After Rubber Ball Gripping ROM Exercise in Patients with Non-Hemorrhagic Stroke

Figure 1 presents the distribution of hand muscle strength scores before and after the implementation of the rubber ball gripping ROM exercise over six days.

The mean baseline muscle strength score before intervention was 3.10 ± 0.301 with a range of 3–4, indicating that most participants had moderate muscle weakness classified within grade 3 to 4. The 95% confidence interval ranged from 2.96 to 3.23, reflecting relatively homogeneous baseline muscle strength among participants.

On Day 1 and Day 2 after intervention, the mean muscle strength remained at 3.10 ± 0.301, which indicates that immediate improvement was not observed within the first two days of exercise. However, beginning on Day 3, the mean score increased to 3.19 ± 0.602 with a wider range (3–5), suggesting early neuromuscular adaptation in some participants.

A progressive increase was observed on Day 4 with a mean score of 3.29 ± 0.644, followed by a substantial increase on Day 5 to 3.86 ± 0.573. By Day 6, the mean muscle strength reached 4.10 ± 0.301 with a minimum score of 4 and maximum of 5, indicating that most participants achieved near-normal muscle strength.

The consistent upward trend from Day 3 to Day 6 demonstrates a gradual improvement pattern in hand muscle strength following repetitive ROM rubber ball gripping exercise. The narrowing standard deviation on Day 6 suggests more uniform improvement among participants. Overall, these findings indicate that six consecutive days of structured ROM rubber ball gripping exercise contributed to clinically meaningful improvement in hand muscle strength among patients with non-hemorrhagic stroke.

Table 2. Difference in Mean Hand Muscle Strength Before and After Rubber Ball Gripping ROM Exercise in Patients with Non-Hemorrhagic Stroke

Variable	Mean	SD	Mean Difference	95% CI of Difference	p-value
Before ROM Exercise	3.10	±0.301	1.00	0.86 – 1.14	0.000
After ROM Exercise (Day 6)	4.10	±0.301			

Table 2 presents the comparison of mean hand muscle strength scores before and after six days of rubber ball gripping ROM exercise.

The mean baseline muscle strength score before intervention was 3.10 ± 0.301. After completion of the six-day intervention program, the mean muscle strength score increased to 4.10 ± 0.301. The mean difference between pre- and post-intervention scores was 1.00 point on the muscle strength scale.

The 95% confidence interval of the mean difference ranged from 0.86 to 1.14, indicating that the true population mean improvement is likely to fall within this interval. The paired statistical test showed a p-value of 0.000 ($p < 0.05$), demonstrating a statistically significant improvement in hand muscle strength following the ROM rubber ball gripping exercise.

These findings indicate that structured and repetitive ROM exercise using a rubber ball significantly improved hand muscle strength in patients with non-hemorrhagic stroke within a short intervention period of six days.

Discussion

The findings of this study demonstrate that rubber ball gripping range-of-motion (ROM) exercise significantly improved hand muscle strength in patients with non-hemorrhagic stroke after six consecutive days of intervention. The mean muscle strength increased from 3.10 at baseline to 4.10 on the sixth day of intervention. The improvement showed a progressive pattern beginning on the third day of implementation. Statistical analysis indicated a significant difference between pre- and post-intervention scores with $p < 0.05$. The magnitude of change suggested not only statistical significance but also clinical relevance in functional recovery. These results indicate that repetitive, structured hand exercise may

accelerate neuromuscular recovery in post-stroke patients.

Stroke pathophysiology causes ischemic damage that disrupts motor neuron signaling in the affected hemisphere (Feigin et al., 2021). Neuronal injury reduces voluntary motor control and produces muscle weakness in the upper extremities (Joyce Black, 2014). Exercise intervention stimulates neuroplastic adaptation through repetitive motor activation in damaged neural circuits (Saunders et al., 2020). Aerobic and task-oriented exercise increases brain-derived neurotrophic factor levels that support synaptic remodeling (Hsu et al., 2021). Structured rehabilitation promotes cortical reorganization through repeated motor task engagement (Koch et al., 2020). Therefore, repetitive gripping movements likely contributed to neuromuscular activation and gradual strength improvement observed in this study (Li et al., 2022).

The progressive improvement beginning on Day 3 suggests that neuromuscular adaptation requires repeated exposure to motor stimulation (Mah et al., 2023). Exercise intensity and repetition influence functional recovery outcomes in chronic stroke rehabilitation (Boyne et al., 2022). High-frequency interval-based training enhances motor learning and functional performance in ischemic stroke patients (Lapointe et al., 2023). Early changes in motor strength often occur after consistent repetitive stimulation across several days (Chen et al., 2021). Repetition-based home programs improve balance and motor performance through cumulative neuromuscular adaptation (Nascimento et al., 2022). Thus, the six-day ROM gripping protocol likely provided sufficient stimulus for measurable motor recovery (Mahmood et al., 2022).

The substantial increase observed on Days 5 and 6 reflects enhanced muscle recruitment and coordination (Ma et al., 2022). Exercise therapy reduces post-stroke pain and facilitates improved motor output via inflammatory modulation (Ma et al., 2022). Improvement in motor function often parallels improvement in psychological adaptation after stroke (Frank et al., 2022). Combined motor and cognitive engagement strengthens rehabilitation outcomes in stroke populations (Amoros-Aguilar et al., 2021). Multicenter randomized trials confirm that structured exercise programs improve functional recovery safely (Yeh et al., 2022). Therefore, even simple task-specific hand exercises may generate clinically meaningful motor gains when applied consistently (Suwaryo et al., 2023).

Upper limb rehabilitation benefits from object-based interaction that stimulates sensory-motor integration (Saposnik et al., 2016). Ball-based interventions improve spasticity and upper limb motor function in chronic stroke patients (Parikh et al., 2022). Swiss-ball and task-oriented balance training enhance cortical activation and mobility performance (Noreen et al., 2024). Targeted stimulation of affected limbs accelerates motor relearning through repeated activation pathways (Saputra et al., 2025). Non-invasive stimulation combined with rehabilitation enhances swallowing and motor recovery post-stroke (Zhao et al., 2022). Thus, rubber ball gripping exercise likely facilitated both mechanical strengthening and neural reactivation mechanisms.

The demographic profile of participants indicates that most respondents were middle-aged to older adults, which aligns with stroke epidemiology (Naghavi et al., 2017). Hypertension as a primary risk factor increases stroke incidence among older populations (Annisa & Siahaan, 2025). Poor medication adherence contributes to recurrent cerebrovascular events in hypertensive patients (Putri et al., 2025). Family knowledge influences prevention of recurrent stroke episodes (Sari Wijayanti et al., 2025). Educational level may affect comprehension of rehabilitation instructions and engagement in exercise protocols (Resnayati et al., 2025). Therefore, structured and supervised exercise programs remain essential to ensure adherence and effectiveness in this population (Mahmood et al., 2022).

Although this study demonstrated significant improvement, the pre-experimental design limits causal inference compared to randomized controlled trials (Koch et al., 2020). Future

studies should incorporate control groups and longer follow-up to evaluate sustained functional outcomes (Boyne et al., 2022). Multimodal rehabilitation integrating aerobic, cognitive, and resistance components may enhance upper limb recovery further (Amoros-Aguilar et al., 2021). High-intensity protocols should be evaluated carefully to ensure safety in subacute stroke patients (Mah et al., 2023). Nevertheless, simple and low-cost interventions such as rubber ball gripping exercise provide practical benefits in clinical nursing settings (Saunders et al., 2020). These findings support the integration of structured ROM gripping exercises into routine stroke rehabilitation programs to improve hand muscle strength effectively.

Conclusion and Recommendation

The results of this study indicate that the implementation of rubber ball gripping range-of-motion (ROM) exercise significantly improved hand muscle strength in patients with non-hemorrhagic stroke after six consecutive days of intervention. The progressive increase in muscle strength suggests that repetitive and structured hand exercises can effectively support motor recovery and functional improvement in stroke rehabilitation. Therefore, this intervention can be considered a simple, low-cost, and practical non-pharmacological therapy that can be integrated into routine nursing care for stroke patients. It is recommended that healthcare providers consistently implement structured ROM exercises as part of rehabilitation programs, while future studies should involve larger samples, control groups, and longer observation periods to further strengthen evidence regarding effectiveness and sustainability of outcomes.

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Declaration of conflict of interest

The authors declare no competing interests.

Declaration on the Use of AI

No AI tools were used in the preparation of this manuscript.

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