RELATIONSHIP BETWEEN PINCH STRENGTH AND RADIOULNAR JOINT POSITIONS IN PATIENTS WITH STROKE

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Abstract

Background: Post-stroke hand impairments can cause functional limitations, especially in pinching and object manipulation, which negatively impact patients' quality of life. A major concern for stroke patients is the recovery of upper extremity motor function. **Objective:** To trace the relationship between pinch strength and radioulnar joint positions in stroke patients. **Methods:** Forty-Five patients with chronic stroke with age ranged from 45 to 65 years participated in this study. Sociodemographic Data on demographic aspects were gathered carefully. The subjects were assessed while seated, the head was in mid-position with the shoulder was adducted, and medially rotated and the elbow was flexed at 90 °. The radioulnar joint was in the neutral position. The strength of the key, palmar, and tip-to-tip pinches were measured using a pinch gauge. Three trials average values were computed. Repeated measurements were taken with the radioulnar joint in supinated and pronated positions. **Results:** Regarding the key and the palmar strengths, the radioulnar joint neutral position showed a statistically significant difference compared to the pronation position in favor of the neutral position ($p<0.001$) while there was no statistically significant difference between neutral and supination positions ($p<0.735$ for the key strength and $p<0.842$ for the palmar strength). Concerning the tip-to-tip strength, the radioulnar joint neutral position showed a statistically significant difference compared to the supination position in favor of the supination position ($p<0.014$), and a significant difference was detected in the neutral compared to the pronation position in favor of the neutral position ($p<0.001$). There were significant positive correlations between the key pinch and palmar pinch, key pinch and tip-to-tip pinch, and Palmar pinch and tip-to-tip pinch with radioulnar joint positions (neutral, supination, and Pronation). **Conclusion:** Pinch strength after stroke is influenced by radio ulnar joint positions, with higher key strength and palmar strength when the radioulnar joint is neutral than when it is pronated. And higher tip-to-tip strength in supination than in neutral and pronation positions.

Keywords: stroke, radioulnar joint positions, hand, pinch strength.

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INTRODUCTION:

Following a stroke, abnormal muscle tone is the main deficit, which results in loss of selected motor control, decrease force generation then decrease ability to pinch and holding of objects. [1]. Hand motor dysfunction is typical. About one-third of patients experience wrist and hand contractures six months following a severe stroke, and more than half of those with hand impairments never regain function. Losing the ability to move hands normally is disabling and can last for years [2].

The thumb and index finger are used in a variety of dynamic ways throughout the day. The inability to exert force with adequate magnitude and control using the thumb and index finger, resulting in the unexpected dropping of objects, is known as "pinch impairment." A number of studies have demonstrated that pinch grip recovery is slower than handgrip recovery [3]. As a result, pinch strength is frequently examined in stroke patients. Pinch grip recovery after stroke requires long-term therapy. When the thumb meets the lateral aspect of the index finger, it is referred to clinically as lateral prehension, or "key pinch." For many functional actions, such as turning, lateral pinch strength is required [4].

The pinch range is defined as the distance that exists between the thumb and the lateral aspect of the index finger, and the amount of force required to execute a task, measured in kilograms (kg), is known as the lateral pinch strength [5]. The palmar pinch or 3-jaw chunk refers to the action in which the tip of the distal phalanx of the thumb is opposite the tip of the distal phalanx of both the index and middle fingers [6]. Tip-to-tip pinch, which involves using the index finger and an active thumb during flexion and extension to precisely manage a small object, is crucial to hand function. The kinematics of the digits have an impact on the tip pinch [7].

The thumb-to-index finger key and tip pinch are two essential uses of the intrinsic hand muscles. Various activities of daily living (ADL) depend on this function, including using keys, handling utensils, dressing, holding a toothbrush, and tearing open packaging. The adductor pollicis (AP), first dorsal interosseous (DI), flexor pollicis brevis (FPB), as well as opponent pollicis muscles, are the intrinsic muscles predominantly involved in these motions [8].

Although the effect of wrist and elbow positions were studied on grip and pinch strength [9], the effect of radioulnar joint positions were not studied on these variables except for a study that explored the effect of neutral and pronation positions on key and palmar pinch strength in normal female participants [10]. This clarifies that there is a scarcity of research up till now on the relationship between pinch strength and radioulnar joint positions in stroke patients that necessitates exploring this issue to reach a standardized protocol that would help in reducing the negative impact of the functional limitations that affect stroke patients' quality of treatment and shorten the time of rehabilitation.

So, the purpose of the current study was to detect the relationship between pinch strength and radioulnar joint positions in stroke patients.

METHODS:

Study design

A prospective, cross-sectional, observational study was carried out at The Out-Patient Clinic of Neurology and the Out-Patient Clinic, Faculty of Physical Therapy, Cairo University between October 2022 and March 2023. Before beginning the study, ethical approval was fulfilled from the institutional review board at the Physical Therapy, Cairo University **(approval number: NO P.T.REC/012/004487).**

Subjects:

A sample of convenience, non-probability type, of forty-five stroke patients, was signed up via a flyer handed out at the outpatient clinic, Faculty of Physical Therapy, Cairo University, and the Stroke unit in The Out-Patient Clinic of Neurology, Kasr Al- Aini Hospitals, Cairo University. Informed consents were obtained from participants after the scope and objectives of the study were clarified, assuring them that they had the right to quit at any time and that their data were concealed. All data was coded to ensure privacy.

Participants were of both genders who experienced their first stroke and their age ranged from 45 to 65 years old. According to the Modified Ashworth Scale (MAS), the affected upper limb muscle spasticity was graded as grades 1 and 1+ for a period of 6 to 12 months [11, 12, 13]. Cases with visual or auditory impairments, any musculoskeletal conditions affecting the upper extremity, convulsions, and polyneuropathy were all excluded from participating. Patients with scores below 22 on the Mini-Mental State Examination (MMSE) were disqualified as having cognitive impairment [14, 15, 16, 17].

Clinical assessment:

Clinical characteristics, social and demographic data were gathered from all patients. Clinical factors included duration of illness, presentation (right or left hemiparesis), and type of stroke (ischemic or hemorrhagic).

All participants also provided the MMSE [18]. After that, patients underwent thorough neurological testing. With the head in a neutral alignment and no towel beneath the head, a comfortable supine position was used to measure the muscle tone of the affected upper limb using MAS. Before being evaluated, the patient was told to empty his bladder and remove any tight clothing to avoid nociceptive or exteroceptive stimuli. The affected upper limb was grasped by firm, continuous physical contact from a bony prominence, and was passively moved at a steady, rhythmic rate. Examining the affected upper extremity muscle strength utilizing manual muscle testing, sensory testing, and checking the shoulder joint for possible shoulder pain [19].

Measurement of pinch strength:

Pinch gauge:

In the current academic work, the baseline LITE Hydraulic Pinch Gauge **12-0226** with **SN 62207030** was employed. Patients squeezed the silver tab to instantly read the gauge needle's pound per square inch (PSI) value. For simpler reading, the pinch gauge freezes at its greatest force. On a dual scale with a maximum reading of 50 lbs. or 22.5 kg., pinch force was measured. The pinch gauge's weight was not intended to be carried by the patient; hence the device was made to be held by the examiner. This enables more precise measurements [20].

Positioning of the subject:

The subject was sitting in front of the table. Foam cushioning was added to the back. The patient was instructed and advised not to lean forward, stand up, or shift sideways numerous times. The head was held neutrally and erect. Throughout testing, the participant's legs were in front of the chair, with their feet firmly planted on the ground.

***Procedures of measuring pinch strength*:**

The shoulder was 30 degrees flexed. The radioulnar joint was in the neutral position and the elbow was 90 degrees flexed and the wrist should be in a neutral position. The pinch gauge was held by the examiner. Three trials were calculated, and the mean was used for analysis. To prevent fatigue, the participant took a minute off between each trial. Repeated measurements were taken with the radioulnar joint in the pronated and supinated positions [21, 22].

i. Key (lateral) pinch strength:

The pinch gauge was positioned between the pad of the thumb and the radial surface of the middle phalanx of the index [23].

ii. Palmar (three-jaw chuck) pinch:

The pinch gauge was positioned between the thumb and pads of the index and middle fingers [24].

iii. Tip (two-point) pinch strength:

The pinch gauge was positioned between the tips of the thumb and index finger [25].

STATISTICAL ANALYSIS:

The data were entered and coded using IBM's Social Science Statistical Package for Windows, Version 28 (*IBM Corp., Armonk, NY, USA).* Mean and standard deviation were employed for summarizing the quantitative data, while frequencies (the number of cases), as well as relative frequencies (percentages), were employed for summarizing the categorical data. The groups were compared using an analysis of variance (ANOVA) using multiple comparisons as well as two groups using an unpaired t-test. Multiple-group comparisons were performed using a post hoc test [26]. When comparing categorical data, the Chi-square test was utilized. The exact test was used instead [27] when the anticipated frequency was lower than five. Correlations among quantitative variables were calculated using the Pearson correlation coefficient [28]. P-values less than 0.05 were considered statistically significant.

RESULTS:

Subject demographics and clinical features:

The current study covered 29 men (64.44%) and 16 women (35.55%) diagnosed with a stroke, with a mean age of 57.32 years (SD: 5.65; range: 45–65). The mean disease duration was 8.61 months (SD: 2.51; range: 2-12). Twenty-four (54.33%) of the cases presented with right-sided hemiparesis and 21 (46.66%) with left-sided hemiparesis. Thirty-eight (84.44%) of them had a stroke due to infarction, and seven (15.55%) of them were due to hemorrhage. ***Table 1*** shows a summary of the Subject's demographics and clinical features.

Table 1. Demographic characteristics of the study's participants

	Patients (n = 45)
Age (years), mean ± SD	57.32 ± 5.65
Gender, %	
Males	64.44
Females	35.55
Height (cm), mean ± SD	163.39 ± 8.90
Weight (kg), mean ± SD	85.75 ± 15.87
BMI, mean ± SD	33.19 ± 9.22
Disease duration (months), mean ± SD	8.61 ± 2.51
Presentation, %	
Right hemiparesis	54.33
Left hemiparesis	46.66
Type of lesion, %	
Infarction	84.44
Hemorrhage	15.55

Assessment of pinch strength in different radio ulnar joint positions:

The repeated measures one-way ANOVA revealed that there was a clear disparity between the mean scores of key strengths (Wilks' Lambda = 0.611, F(df) = 20.98 (2), p<0.001), palmar strength (Wilks' Lambda = 0.694, F(df) = 14.565(2), p<0.001), and tip-to-tip strength (Wilks' Lambda = 0.475, F(df) = 36.424(2), p<0.001) in different radio ulnar joint positions. Their relationship to each of the radioulnar joint positions was analyzed. ***(Table 2).***

Multiple pairwise comparison using the Bonferroni post-hoc test revealed that key strength, palmar strength, and tip-to-tip strength are higher in the radioulnar neutral position compared with the pronation position, and in the radioulnar supination position compared with the pronation position. The tip-to-tip strength in the radioulnar supination position was also higher than in the neutral position. No significant difference was found between both the key strength and palmar strength in neutral and supination positions. ***(Table 3).***

Table 2. *Mean values of key strength in different radio ulnar joint positions:*

Radioulnar joint's position	Pre-treatment	Wilks' Lambda	F-value	*Df*	p-value
	Key strength				
Neutral	10.13 ± 3.11	0.611	20.981	2.0	<0.001*
Supination	9.77 ± 2.25				
Pronation	8.43 ± 2.60				
	Palmar strength				
Neutral	6.96 ± 1.81	0.694	14.565	2.0	<0.001*
Supination	7.18 ± 1.60				
Pronation	6.08 ± 1.51				
	Tip-to-tip strength				
Neutral	4.80 ± 0.53	0.475	36.424	2.0	<0.001*
Supination	5.29 ± 1.94				
Pronation	3.91 ± 0.43				

P-Value: Probability value; **F-Value:** one-way repeated measures ANOVA test; **df:** degree of freedom; *Significant at p<0.05

Table 3. *Multiple pairwise comparisons between all radio ulnar joint positions as regards the key strength:*

Multiple pairwise comparisons between all radio ulnar joint's positions			
Pairs	**MD**	**P-value**	**95% C.I**
	Key strength		
Neutral vs. Supination	0.365	0.735	-0.399 – 1.128
Neutral vs. Pronation	1.702	<0.001*	1.017 – 2.387
Supination vs. Pronation	1.337	<0.001*	0.623 – 2.052
	Palmar strength		
Neutral vs. Supination	-0.216	0.842	-0.703 – 0.271
Neutral vs. Pronation	0.879	<0.001*	0.325 – 1.433
Supination vs. Pronation	1.095	<0.001*	0.592 – 1.598
	Tip-to-tip strength		
Neutral vs. Supination	-0.490	0.014*	-0.901 – -0.079
Neutral vs. Pronation	0.888	<0.001*	0.555 – 1.221
Supination vs. Pronation	1.378	<0.001*	0.949 – 1.807

MD: mean difference; **P-Value:** Probability value *Significant at p<0.05; **C.I:** confidence interval for difference

CORRELATIONS

In the radioulnar joint neutral position, key strength showed a crystal-clear positive correlation with palmar and tip-to-tip strengths (r=0.663,0.619 & p<0.001). A strong positive correlation was also detected between palmar and tip-to-tip strength (r=0.777, p<0.001). Key strength was directly related to both palmar (r=0.847, p<0.001) and tip-to-tip (r=0.766, p<0.001) strengths in the supinated position; and palmar strength showed a positive correlation with tip-to-tip strength (r=0.816, p<0.001). A similar correlation was detected in the radioulnar joint pronation position between key strength and palmar (r=0.847, p<0.001) and tip-to-tip (r=00.766, p<0.001) strengths and between palmar and tip-to-tip strength (r=0.816, p<0.001).

DISCUSSION:

The current study showed that the key pinch strength in the radioulnar joint position is better in neutral than in the pronation position. Key pinch scores were found to be significantly greater with the radioulnar joint in a neutral position compared to when it was pronated, agreeing with the findings of a study by **Ng & Saptari [29].** This agrees with the guidelines of the American Society for Hand Therapists, which recommends a neutral radio ulnar joint position when assessing the key pinch **[10].**

On the same line, **Jain et al., [30]** also reported the maximum key pinch was higher when recording the radio ulnar joint in a neutral position rather than supination or pronation. Furthermore, the findings of the current study are supported by the results of **Fujiwara & Suzuki**, **[31]** who reported that the radioulnar joint position was found to influence key pinch, where less force was produced in pronation than in both neutral and supination positions.

The present study revealed that the palmar strength in the radioulnar joint neutral position is higher than in the pronation position, while there was no significant difference between the palmar strength in neutral and supination positions. The results of the current study also agreed with a more clinically-oriented model offered by **Fan et al., [32],** who suggested that palmar strength was significantly different between radio ulnar joint positions. The strongest palmar grip was achieved in the neutral position, then accompanied by supination and pronation. One possible explanation for these variations is the lengthening of the extrinsic finger flexors that occurs with forearm rotation. Differences in pinch strength during radioulnar joint rotation can be explained by the length-tension relationship of muscle fibers **[33].**

The results of this study were in contrast with **Ng & Saptari,[29]** who reported that palmar pinch was slightly higher in pronation. The tenodesis function of multi-joint muscles, particularly the flexor digitorum superficialis (FDS) as well as flexor digitorum profundus (FDP), has been hypothesized to contribute to the partially greater scores in pronation. These muscles don't have adequate flexibility to allow a complete range of motion in the finger as well as wrist joints simultaneously. Finger flexion strength increases as the FDS and FDP are lengthened in response to voluntary wrist extension. When the palmar pinch was tested in the neutral radio ulnar joint position, no such additional extension of the wrist joint was allowed. Assessing palmar pinch strength from a neutral position is suggested because the wrist is more controllable in that position. The pronated palmar pinch testing position was also reported to be uncomfortable by some subjects **[10].**

Based on the findings of this study, radioulnar joint supination is preferable to a neutral position for optimal tip-to-tip strength. But the tip-to-tip strength in the neutral position was significantly greater than in the pronation position.

The current study's findings are consistent with those of **Bardo et al. [33]**, who also discovered changes in lateral as well as tip pinch measurements across the various radio ulnar joint sites. measures of lateral pinch were discovered to be at least in the supinated position, whereas measures of tip pinch were at least in the pronated position of the radioulnar joint.

Similarly, pronation decreased the pinch force used across all three pinches (combined and separately). Despite there being no significant differences between neutral and supinated radio ulnar joint positions, a greater force may be generated in both compared to pronation.

Concerning to the length-tension relationship **Fujiwara and Suzuki [31]** observed that the radioulnar joint position has an effect on pinch strength. The main reason why pinch strength is reduced during pronation is that the radius bone is crossing over the ulna, which causes the long flexor muscles to shorten relatively. The same process explains the creation of force by all skeletal muscles.

On the same line, **Pederzini et al. [34]** found that torque during supination was greater than torque during pronation. This is consistent with biomechanical research on the primary muscles responsible for the rotation of the radioulnar joint. The radio ulnar supinator has a Physiological Cross-Section Area (PCSA) of 12.7 cm^2 and the pronators have a PCSA of 7.47 cm^2, with a difference of over 40%. Although no average value for supination/pronation torques was reported, data on the two primary rotation muscles, the biceps brachii (BB), and pronator teres (PT) were provided. Mean meta-analysis results for the BB serving as a supinator for the neutral radioulnar joint with the elbow flexed at 90° were 1.31 cm higher than those for the PT serving as a pronator, at 0.41 cm. This provides support that supination is the stronger position. The mean maximum torque in supination was 16.2 Nm, whereas the maximum torque in pronation was 13.5 Nm.

Yacyshyn et al. [35] also noted, according to neurological data, that spinal as well as cortical excitability to the BB is affected by the radioulnar joint position. Using the cervicomedullary motor evoked potential (CMEP), he discovered that motoneuronal excitability was lesser in pronation in comparison with neutral. Spinal motoneuronal

excitation was also greater in neutral and supination when compared to pronation, supporting the hypothesis that radio ulnar joint position has a comparable effect on force constancy and motoneuronal excitation.
To the best of the author's knowledge, no previous study has investigated the correlation between pinch strength and radioulnar joint positions.
The study's limitations include the fact that cases who demonstrate high spasticity found it challenging to grasp the pinch gauge during the evaluation of palmar pinch from the supination position.

CONCLUSION:

According to current academic work outcomes, radioulnar joint position influences pinch strength after a stroke, key pinch, and palmar pinch were greater in the neutral position of the radioulnar joint than in the completely pronated position. However, there was a significant difference between the tip-to-tip strength in the neutral and pronation positions, favoring the neutral position. The tip-to-tip strength in the radioulnar joint supination and pronation positions also differed significantly, favoring the supination position. In the radio ulnar joint neutral position, key strength showed a positive correlation with palmar and tip-to-tip strengths. A strong positive correlation was also detected between palmar and tip-to-tip strength. Key strength was directly related to both palmar and tip-to-tip strengths in the supinated position; and palmar strength showed a positive correlation with tip-to-tip strength. A similar correlation was detected in the radio ulnar joint pronation position between key strength and palmar and tip-to-tip strengths and between palmar and tip-to-tip strengths.

Conflict of interest:

The study's authors affirm that no financial or commercial ties might be viewed as having a potential conflict of interest.

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