



## Effect of forearm rotation on grip strength in normal healthy individuals

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### Abstract

**Background & Purpose:** Many daily function and sporting events require high activity levels of the flexor musculature of forearm and hands. The hand is irreplaceable when it comes to performing any kind of movement, be it gross or skilled. The prime function of hand is grip. The importance of a normally functioning hand need no emphasis in performing activity of daily living, weather in earning in living, practicing a hobby or allowing independence in daily activities. Hand and wrist are the most active and intricate parts of upper extremity. There mobility is enhanced by a wide range of movements at the shoulder and complementary movements at the elbow and forearm. The 28 bones, numerous articulations and 19 intrinsic and 20 extrinsic muscles of the wrist and hand provide the tremendous variability of the movement. Grip is an action or activity of the hand in moving, grasping or taking hold of an object between any two surfaces of the hand, the thumb may or may not be involved. Measurement of grip strength is an important component of hand rehabilitation as it helps to establish the baseline for treatment and it is a measure of the effectiveness of therapy. Testing grip strength is a popular assessment used by physical therapist in clinical settings. It is generally agreed that a standardized testing protocol and position is important for reliability and compare the data. This study focused to determine the effect of forearm rotation on grip strength in normal healthy individuals.

**Method:** This cross-sectional study involved 150 healthy individuals. Following ethical approval and consent, participants performed grip strength tests with their dominant hand using a Jammer dynamometer. Tests were conducted in three forearm positions—full pronation (elbow at 90°), mid-prone, and supination—with three trials per position. Rest intervals of 2-3 seconds between trials and 2 minutes between position changes were observed.

**Results:** Data analysis used unpaired t-tests for comparisons within the same forearm positions but different elbow positions, and ANOVA with post-hoc tests for comparisons across different forearm positions. Significance was set at  $p \leq 0.05$ .

**Conclusion:** Maximum grip strength was observed in the mid-prone position for both elbow angles (0° and 90°), followed by supination and pronation. This finding highlights the importance of forearm position in optimizing grip strength.

**Keywords:** Hand grip, forearm positions, hand function, jammer hand grip

### Introduction

Many daily function and sporting events require high activity levels of the flexor musculature of forearm and hands. The hand is irreplaceable when it comes to performing any kind of movement, be it gross or skilled. The prime function of hand is grip. The importance of a normally functioning hand need no emphasis in performing activity of daily living, weather in earning in living, practicing a hobby or allowing independence in daily activities<sup>[1]</sup>. Hand and wrist are the most active and intricate parts of upper extremity. There mobility is enhanced by a wide range of movements at the shoulder and complementary movements at the elbow and forearm. The 28 bones, numerous articulations and 19 intrinsic and 20 extrinsic muscles of the wrist and hand provide the tremendous variability of the movement<sup>[2]</sup>. Grip is an action or activity of the hand in moving, grasping or taking hold of an object between any two surfaces of the hand, the thumb may or may not be involved. Grip can be categorized as either power grip or precision handling. Power grip is forceful act resulting in flexion of all the finger joints. When thumb is used, it acts as a stabilizer to the object held between the finger and the palm. Precision handling in contrast is the skillful placement of an object between the fingers and the thumb. Various types of power grip are cylindrical grip, spherical grip and hook grip.<sup>3</sup> all articulation and musculature around wrist play their own role in all the types of grip. The flexor digitorum profundus

(FDP) performs the dynamic closing action whereas the flexor digitorum superficialis (FDS) assists when intensity of grip requires greater force. Metacarpo Phalangeal (MCP) flexors, abductors, adductors help in strong grip as same as extrinsic flexor. Extensor digitorum (ED) increases the joint compression and enhances the joint stability. Muscles of hypothenar eminence are active in cylindrical grip. The extrinsic finger and the thumb flexor of the thenar muscle follow the pattern of variability and activity in a spherical grip. The major activity is done by the flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP). It is widely accepted that the grip strength provides an objective index of the functional integrity of the upper extremity<sup>[4]</sup>. Grip strength is correlated with the upper extremity function, overall strength. Because of this correlation, grip strength has been measured as an objective clinical measure in a variety of situations<sup>[5]</sup>. Grip strength has been used to assess general strength in order to determine work capacity, to determine extend of injury and diseases process and the potential for the progress of rehabilitation<sup>[6]</sup>. Grip strength is one of the many components to be considered in the examination of hand function. Grip strength commonly used to evaluate the integrated performance of muscle by determining maximal grip force that can be produce in one muscle contraction<sup>[7]</sup>. Measurement of grip strength is an important component of hand rehabilitation as it helps to establish the baseline for treatment and it is a measure of the effectiveness of therapy

[8]. Testing grip strength is a popular assessment used by physical therapist in clinical settings [9]. It is generally agreed that a standardized testing protocol and position is important for reliability and compare the data. Variations from testing position have been observed to affect the grip strength in a number of ways. It has been observed by several researchers that change in elbow position alters the strength of mass and power grip. Balogun J.A; Akomolafe, C.T., and Amusal O. studied effects of testing posture and elbow position in 1991 found that the male had higher grip strength than females at all the testing posture and elbow joint angle, and there was significant difference between the grip strength measured in subjects sitting with elbow in 90° flexion and standing with elbow in full extension. And also, it has also been observed by research that change in forearm position alters the strength mass of grip strength Richards, Banniolsan, Pamela, Thomas in 1996 [10] studied how forearm affects grip strength and they concluded that, grip is strongest when forearm in supination, followed by grip in neutral position and weakest in pronation. Hazelton F.T in 1975 studied the influence of wrist position on the force produced by the finger flexor found that the percentage distribution of the total force produced by the finger flexor to each individual finger bear a constant relationship regardless of wrist position. The magnitude of the total force produced varies with wrist position. Ruchika Gupta, Nishant Quddus, Anish Raj studied effect of shoulder flexion on grip strength and they concluded that shoulder has an maximum grip strength and maximum grip strength can be obtained in 180° of shoulder flexion and elbow in extension. This study focused to determine the effect of forearm rotation on grip strength in normal healthy individuals.

**Objectives:** To determine grip strength in different combination of elbow and forearm position using jammer’s hand-held dynamometer and to compare the grip strength with different combination of elbow and forearm position using jammer’s hand-held dynamometer.

**Methodology**

The study employed a cross-sectional observational design to investigate the chosen variables. A total of 150 healthy subjects, comprising both male and female participants, were selected for the study. This sample size was calculated based on data derived from prevalence studies. Purposive sampling was utilized to select the participants, ensuring that they met the criteria for inclusion. The inclusion criteria required participants to be untrained non-athletes, aged between 25 and 40 years, and in good general health. Participants with any orthopedic or neurological conditions affecting the dominant upper extremity were excluded from the study. The study was conducted in multiple settings, including the outpatient department (OPD) of R.V. College of Physiotherapy, various community setups, and a clubhouse in selected locations in Bengaluru.

**Procedure**

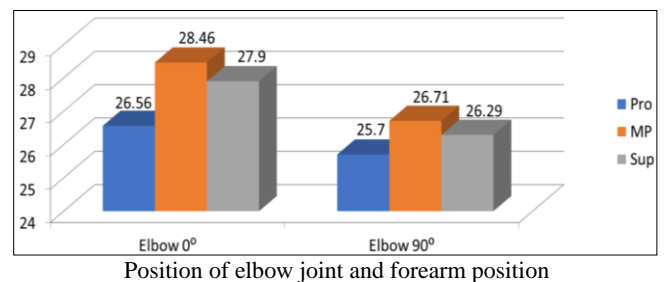
The investigator personally contacted the above-mentioned study set up and obtained permission from the concerned authorities to conduct the study. Subsequently after

obtaining the permission the investigator explained the details and purpose of the study to the subjects who were recruited as per the inclusion and exclusion criteria after obtaining informed consent from the subjects. Demographic data was collected and recorded.

**Materials Required:** Hand held Dynamometer, stopwatch, cussion pillow, armrest chair, screening form. The procedure explained and demonstrated to the subjects in details and consent was taken. A subject fulfilling the inclusion as well as exclusion criteria was recruited from the study setup. Each subject was asked to sit comfortably in chair and the testing was done on the dominant hand. In first testing position, the elbow was kept at 90° of flexion with the forearm supported with a soft pad on armrest in full pronation and wrist out of the armrest. The subjects were instructed to hold the dynamometer and squeeze it hard for 3sec. Subjects were asked to relax and the final reading was noted. The dynamometer was reset to zero, after 3 seconds of relaxation period the procedure is repeated in same position. Three trials for each position were recorded. The best value of each test was taken as the final reading.

**Data analysis**

Collected data was analysed using Comparison between same forearm positions with different position of elbow was done using unpaired t-test. Comparison between different forearm positions with same position of elbow was done with anova, when anova was found significant post-hoc test was applied to find out the significant difference. Level of significant was  $p \leq 0.05$ .



**Graph 1:** Mean grip strength in different combination of elbow joint and forearm position

**Result**

The comparison of grip strength in midpronation and supination with elbow flexed at 0° and 90° show no significant difference

**Table 1:** Comparison of grip strength with forearm in midprone, pronation and supination

Forearm	Elbow	Mean (Kg)	SD (+)	t value	p value
Midprone	0°	28.16	9.51	1.303	0.1935
	90°	26.17	8.77		
Pronation	0°	26.56	9.09	0.998	0.9206
	90°	25.70	7.58		
Supination	0°	27.90	9.09	1.956	0.0514
	90°	26.29	8.54		

**Table 2:** Comparison of grip strength with elbow at 0°

ANOVA table	SS	DF	MS	F (DFn, DFd)	P value
Treatment (between columns)	223.1	2	111.6	F (1.983, 295.4) = 22.92	P < 0.0001
Individual (between rows)	36670	149	246.1	F (149, 298) = 50.57	P < 0.0001

Residual (random)	1450	298	4.866		
Total	38344	449			

**Table 3:** Comparison of grip strength with elbow at 90°

ANOVA table	SS	DF	MS	F (DFn, DFd)	P value
Treatment (between columns)	76.70	2	38.35	F (1.617, 240.9) = 8.529	P = 0.0007
Individual (between rows)	29571	149	198.5	F (149, 298) = 44.14	P < 0.0001
Residual (random)	1340	298	4.497		
Total	30988	449			

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
PRO vs. MP	-1.007	-1.677 to -0.3365	Yes	**
PRO vs. SUP	-0.5867	-1.205 to 0.03119	No	Ns
MP vs. SUP	0.4200	-0.0009161 to 0.8409	No	Ns

Tukey's multiple comparisons test	Mean Diff.	95% CI of diff.	Significant?	Summary
PRO vs. MP	-1.607	-2.188 to -1.026	Yes	****
PRO vs. SUP	-1.347	-1.945 to -0.7483	Yes	****
MP vs. SUP	0.2600	-0.3688 to 0.8888	No	Ns

**Discussion**

In the present study effort was made to study the effect of various combinations of elbow joint and forearm position on grip strength in subjects falling in the age group of 25 to 40 years. Measurement of grip strength was done using Jammer's hand held dynamometer for all the subjects. Statistical analysis was done as per forearm and elbow joint in 0° and 90°. Studies on the effect of elbow position on grip strength had conflicting findings. Balogun et.al (1991 c) [11] and Kuzala and Vargo (1992) found greatest grip strength with elbow in full extension [10] Mathiowetz (1985b) found grip strength higher in 90 degree flexion [16]. Ferraz et.al found no relationship between elbow position and grip strength. Richards's et.al (1996) [10] found forearm positioned in supination has greatest grip strength in neutral position with pronation producing lowest grip strength [11]. Results of the present study shows maximum grip strength when forearm is in midpronation and elbow at 0° of flexion. Starling's law states length is directly proportional to the Tension developed in a muscle. Maximum tension can only be developed at on optimal length of the muscle as maximum member of cross bridges between the actin and myosin fibers occur. Muscles are able to generate moderate tension in the lengthened range, Maximal tension in the middle ranges and Minimal tension in Shortened range during a concentric/active shortening of a muscle. This muscle length tension relationship also proves as the base for active and passive insufficiency of a muscle. One might consider length tension relationship of the muscles involved. FDS is the only primary finger flexor that crosses the elbow joint; therefore elbow position may affect the strength performance of this muscle. As a muscle is placed in a shortened position it may become incapable of generating the tension necessary to achieve a functional contraction. As the elbow is placed in more degree of flexion, placing it at a mechanical disadvantage progressively places FDS in a more shortened position, there. This may serve to explain the decrease in grip strength that resulted as degree of elbow flexion increased. All muscles have an optimal length at which they produce maximal contraction. Any external shortening or lengthening of a muscle changes the length tension relationship of its fibers and impairs that muscles

ability to contract maximally. Supination and pronation takes place around the superior and inferior radioulnar joints. As the hand moves from supination to pronation, the direction

of pull of the muscles is in the anterior or flexor compartment is changed. Potential changes in the length tension relationship one would predict a weaker grip in the pronated position than in supinated position. The change in the length of long flexor muscles from supination to pronation also potentially changes the synergistic relationship among the long flexors of the fingers and the flexor and extensors muscles that stabilize the wrist joint. The results of this study showed both significant and non-significant differences in grip strength in various combinations of elbow joint and fore arm position. Grip strength recordings in midprone and supinated forearm in various elbows in 0° and 90° were highest but there was no significant difference between them. Grip strength recordings in pronated forearm and elbow in all the positions were lowest in the study and were significant when compared between them. This demonstrates that elbow and forearm position should be an important consideration when one takes grip strength measurements. Mainly while measuring the grip strength forearm can be kept in supinated or midprone position. And elbow position would either be in 90° flexion or 0° extension these positions would give relevant grip strength measurement. The results of our study can be incorporated into treatment techniques and functional activities as per the patient's needs.

**Conclusion**

When elbow is placed at 0°, maximum grip strength is found in midprone position, followed by supination and pronation. When elbow is placed at 90°, maximum grip strength is found in midprone position, followed by supination and pronation.

**Clinical implication-**

Mid prone position of the forearm with elbow at 0 degrees can be used as an assessment position for the evaluation of grip strength.

**Limitation of study**

Only young adults of 25 to 40 years of subjects were taken into consideration. Study done on normal healthy and asymptomatic population only.

**Scope for future studies**

Research can be done in older population to check and compare the result in younger population. Evaluation can be done with different elbow and shoulder position. Study can be conducted in patients with hand involvement. Male and female comparison can be done

**Conflict of interest**

There was no personal or institutional conflict of interest for this study

**Source of funding**

Self.

**Ethical clearance**

Institutional ethical clearance obtained

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