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Effect Of Elbow And Wrist Joint Position On Grip Strength

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Abstract
Background and Objective: *Grip and pinch strength measurements provide an objective index of the functional integrity of the upper extremity. Hand strength evaluation is importance in determining the effectiveness of different treatment strategies or effects of different procedures. As studies on the effect of elbow and wrist positions on grip strength remain controversial, the present study aimed to find out the effect of elbow and wrist joint positions on grip strength and the favorable and advantageous position to improve grasp function.* ***Method:*** *This study included 144 healthy normal subjects with 13 males and 131 females. A standard adjustable hydraulic hand dynamometer was used for measuring grip strength of various positions of elbow and wrist.* ***Result:*** *The result of the study showed that the elbow and wrist positions had impact on the grip strength when considered individually (p<.01). But the interaction effect of these two different positions could not able to show any significant difference.* ***Conclusion:*** *Grip strength was maximum with elbow in full extension and wrist in neutral. The changes in wrist position on grip strength were observed with variations in elbow and wrist positions.*
Keywords: *Grip strength, Hand Dynamometer, Elbow and wrist positions*

I. Introduction

Grip strength has been widely used in evaluating the integrated performances of muscles in orthopedics, rehabilitation and ergonomics[1]. It is widely accepted that, grip and pinch strength measurements provide an objective index of the functional integrity of the upper extremity[2] and in clinical settings as an indicator of disease activity[3]. Reliable and valid evaluation of hand strength is of importance in determining the effectiveness of different treatment strategies or effects of different procedures. Body positioning appears to be a key factor that affects hand function because the fine motor control of the fingers and hand could be augmented by an optimal position of the upper limb[4]. American society of hand therapist suggested a standardized testing protocol for handgrip strength in which subject is seated with the shoulder adducted and neutrally rotated, the elbow flexed at 90^0 and forearm in neutral and the wrist between 0^0 and 30^0 degrees extension and between 0^0 and 15^0 ulnar deviation [2].Standardized grip strength testing procedures have been recommended to provide even greater objectivity of measurement. In a clinical setting, however, there are a number of reasons why it may be impossible to follow standardized testing procedures, such as patient's inability to tolerate an upright position or the presence of contractures in upper extremity joints[3].

However, study findings of the optimal wrist position to facilitate grip strength are equivocal. Hazelton, Smidy, Flatt, and Stephens (1975) found that ulnar deviation (UD) and extension of the wrist resulted in greater strength in the middle and distal phalanges[4].Recent studies have attempted to provide a definitive picture of the difference between dominant and nondominant hand strengths. Crosby et al investigated normative values of hand grip, pulp and key pinch and claimed that the population as a whole demonstrated significant differences between the dominant and nondominant hands. In their study, hand grip and pulp pinch strengths were 6% and 5% higher for the dominant hand respectively [2].

Standing has been found to result in higher grip strengths than when sitting when using the same instrument.Studies on the effect of elbow position on grip strength remain controversial. *Mathiowetz*tested the grip strength of 29 female college students with the elbow joint flexed at 90^0 in one test and fully extended in another. Significantly higher grip strength was obtained in the 90^0 elbow flexed position than in the fully extended position. *Balogun*tested the grip strength of 61 college students in four positions: (i) sitting with elbow in 90^0 flexion; (ii) sitting with elbow in full extension; (iii) standing with elbow in 90 flexion; and (iv) standing with elbow in full extension. Lowest scores were recorded when the measurement was taken while the subject was sitting with the elbow joint in 90^0 flexion [3].Wrist position is another variable that affects grip strength performance. Pryce found no significant difference in grip strength with test angles of (a) 0^0 and 15^0 ulnar deviation, (b) 0^0 and 15^0 wrist extension and (c) any combinations of these positions. *Kraft and Detels*found significant differences with wrist positioned at 0^0, 15^0 and 30^0 extensions. Both studies found grip strength to be significantly less than 15^0 of palmar flexion. Recently *O'Driscoll*investigated the relationship between the

optimum wrist position and maximal grip strength in 20 healthy subjects. An electro-goniometer recorded the wrist position naturally assumed by the subjects during their maximal unconstrained grip.
So the aim of study was to find out the effect of elbow and wrist joint positions on grip strength and to find the favorable and advantageous position for powerful grip to improve grasp function.

II. Materials And Methods

This study included 144 subjects were taken with 13 males and 131 females with age between 18-23years, and excluded those who have any previous history of Upper Extremity abnormalities, inflammatory Joint Diseases, Neurological Disorder, and Injury to Upper Limb, other health conditions, pain or tenderness in upper extremity.

Fig. 1 Dynamometer

A standard adjustable hydraulic hand dynamometer, SH-5001 with Serial number 11041040, made in Korea (Saehan) was used for measuring grip strength.Height was measured and recorded with the help of markings on the wall, made by measure tape. The subject was assessed for ROM (Range of motion) of shoulder, elbow and wrist Joint, and MMT (manual muscle testing) for muscles surrounding shoulder, elbow and wrist. After that the subject was asked to be seated on a high stool. Before testing grip strength, the examiner demonstrated how to use the dynamometer. The positions of measurements were as below:
1 Elbow fully extended, with wrist in neutral.
2. Elbow fully extended, with wrist in extension.
3. Elbow flexed at 90^0,with wrist in neutral.
4. Elbow flexed at 90^0,with wrist in extension.

Three readings were taken in each position, and average of the three was recorded.

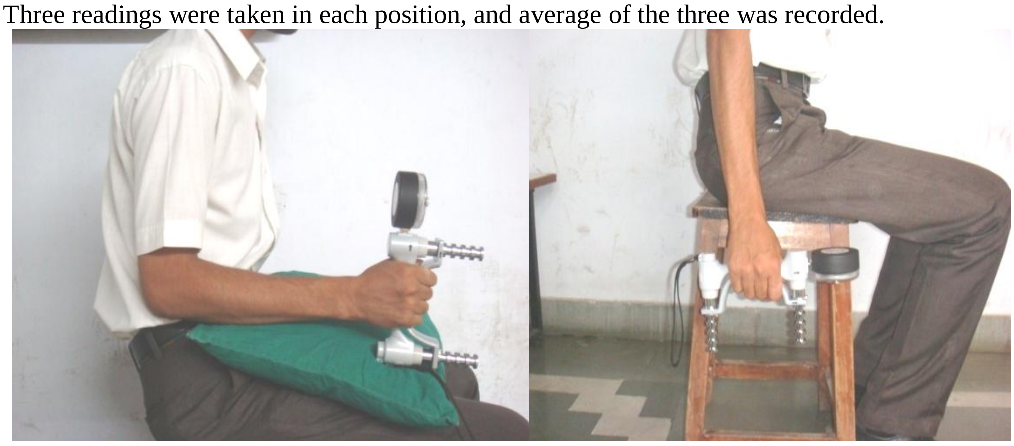

Fig. 2 Elbow in flexion and fully extended, with wrist in neutral.

III. Statistical Analysis

Data were computed with Factorial analysis of variance procedure (ANOVA) to determine the effects of various positions of elbow and wrist on grip strength.Oneway ANOVA with post hoc analysis was done to find out the homogenous subsets among the four different measurements. Data were analyzed using IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp. Statistical significance was set at $p<0.05$ (Two tailed).

IV. Results

The present study included 144 subjects with age between 18-23years. Table 1, 2 &3show the meanof grip strength scores for the various elbow and wrist positions. The result of the study showed that the elbow and wrist positions had impact on the grip strength when considered individually(p<.01). But the interaction effect of these two different positions could not able to show any significant difference (p>.05) (Table 4 &Figure 1).The table 5&6 show the mean difference between the combinations of elbow and wrist positions and homogenous subsets as well. The grip strength was high for neutral elbow and wrist combination than other combination.When the wrist is in extension the position of elbow does not impact grip strength but when it is neutral the elbow neutral position has more grip strength than elbow flexion position significantly.

Table:1Grip strength(Kg) during different elbow positions

Elbow position	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Elbow neutral	17.933	.388	17.170	18.695
Elbow flexion	16.080	.388	15.317	16.843

Table: 2 Grip strength(Kg) during different wrist positions

Wrist position	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Wrist neutral	19.043	.388	18.280	19.805
Wristextension	14.970	.388	14.207	15.733

Table:3 Grip strength(Kg) during different elbow and wrist positions

Elbow position	Wrist position	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Elbow neutral	wrist neutral	20.435	.549	19.356	21.514
	Wristextension	15.430	.549	14.351	16.509
Elbow flexion	wrist neutral	17.650	.549	16.571	18.729
	Wristextension	14.510	.549	13.431	15.589

Table 4 : Factorial ANOVA model

Position of elbow and wrist	Degrees of freedom	F value	Significance
Corrected Model	3	23.127	.000
Intercept	1	3842.880	.000
Elbowposition	1	11.400	.001
Wristposition	1	55.094	.000
Elbowposition * Wristposition	1	2.889	.090
Error	396		
Total	400		
Corrected Total	399		

Table : 5 Post hoc analysis for different positions of elbow and wrist

Group	Group	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
EWneutral	ENWE	5.0050*	.78851	.000	2.9611	7.0489
	EFWN	2.7850*	.85526	.007	.5690	5.0010
	EFWE	5.9250*	.78153	.000	3.8990	7.9510
ENWE	EWneutral	-5.0050*	.78851	.000	-7.0489	-2.9611
	EFWN	-2.2200*	.77030	.023	-4.2164	-.2236
	EFWE	.9200	.68751	.540	-.8613	2.7013
EFWN	EWneutral	-2.7850*	.85526	.007	-5.0010	-.5690
	ENWE	2.2200*	.77030	.023	.2236	4.2164
	EFWE	3.1400*	.76315	.000	1.1620	5.1180
EFWE	EWneutral	-5.9250*	.78153	.000	-7.9510	-3.8990
	ENWE	-.9200	.68751	.540	-2.7013	.8613
	EFWN	-3.1400*	.76315	.000	-5.1180	-1.1620

(EW neutral –elbow/wrist neutral , ENWE- elbow neutral wrist extension, EFWN-elbow flexion wrist neutral, EFWE-elbow flexion wrist extension)

Table: 6 Homogenous subsets

Group	N	Subset		
		1	2	3
EFWE	100	14.5100		
ENWE	100	15.4300		
EFWN	100		17.6500	
EWneutral	100			20.4350
Sig.		.417	1.000	1.000

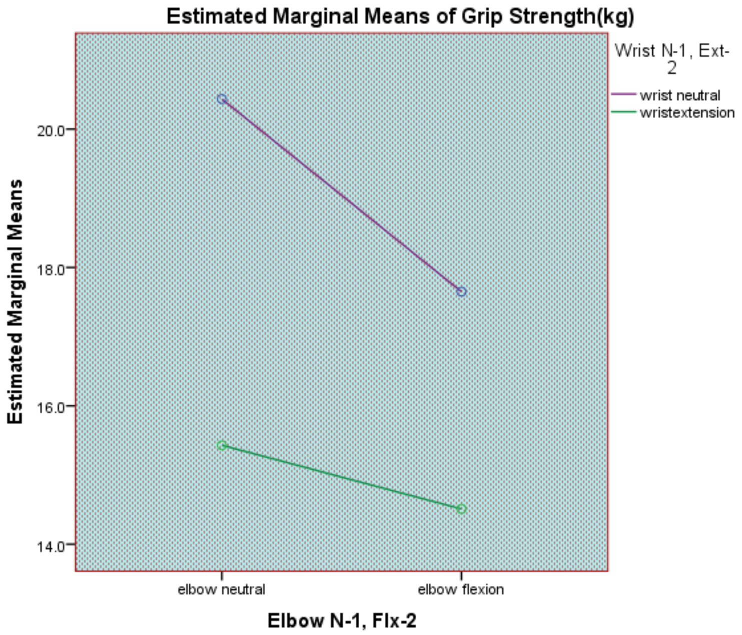

Fig.3 Means of grip strength on various positions of elbow and wrist

V. Discussion

The result of the present study showed that the highest mean grip strength was recorded when the elbow was in full extension with wrist in neutral. Grip strength with the elbow extension regardless of shoulder position was significantly higher than the elbow flexion position. It may be attributed to the fact that the length-tension relationship of the forearm muscles involved in producing grip strength is most favorable when the elbow is in an extension position. These results are in accordance with the study performed by *Su et al (1994)*[5]. But on contrary a study by A. J. Shyam Kumar, *et al* (2008) showed that there was no difference of grip strength values between the elbow in full extension or in 90° flexion.

The simplest explanation for this observation is that oppositely directed simultaneous movements will tend to lengthen one end while shortening the other end of two joint muscles, resulting in reduction of grip strength, and in some situations a reversal may occur when only one joint ismoved. The same is confirmed when the adjacent elbow is moved in the same direction as the wrist, greater reciprocal lengthening and shortening of the wrist flexor and extensor muscles would result in movements being detected at smaller thresholds than when only the wrist was moved [6].

Grip strength measurements were found to be significantly lower when subjects were supine, compared with grip strength scores recorded with subjects in a standing or seated position [7, 8]. Shoulder joint angle can affect the grip strength performance and should be between 45º and 135º for optimal grip strength which may be due to synergist action and length-tension relationship[9,10,11].

Among the four positions the mean grip strength scores were higher when wrist was positioned in neutral than in extension position. This may be explained on the basis of the length–tension relationship of active contractile elements within a muscle. It may be that when the wrist is positioned at neutral with slight ulnar deviation the muscular compartments for individual fingers attain optimal length for production of maximum active force. As the wrist moves in full extension the associated muscle compartment length for each finger exceeds the optimal range leading to decrease in grip force. This can occur can occur when musculo-tendinous units such as the extrinsic finger flexors (digitorumsuperficialis, flexor digitorumprofundus) that are primarily responsible for powerful finger force production cross more than one joint. According to *Li (2002)* when we apply an external force at a distal phalanx during gripping, the profundus is the only flexor that balances the extension torque but at the proximal inter-phalangeal and meta-carpophalangeal joints is progressively assisted by the flexor digitoriumsuperficialis and intrinsic muscles. The flexor digitorumprofundus crosses many joints like the wrist, the metacarpophalangeal, proximal inter-phalangeal and distal inter-phalangeal joints leading to increase in the length of its elements beyond optimum levels. Therefore, decreased grip force at a deviated wrist position may be primarily caused by the decreased force production capability of the flexor digitorum profunds [3].

In this study, there was least significance given to forearm rotation on grip strength because as dynamic testing demonstrated no difference in grip strength when the forearm rotated between 70^0 supination and 70^0 pronation [12]. Wrist deviation can also affects the grip strength, according to a study, grip strength found to be less with radial deviation as compared to ulnar deviation [13]. The maximum grip strength is achieved when the grip span is in the range of 7.5-8.0 cm [14]. Another study says the maximum grip force is also strongly dependent on the population i.e. industrial workers, students, or ethnic group [14,15].

In essence, our study showed that the various joint positions,commonly the elbow and shoulder joints can affect grip strength, with respect to wrist positions (neutral and extension). If positioning is standardized, the measurements appear to be highly repeatable because only healthy participants were tested; our results may not be directly extrapolated to persons who may have pain or discomfort with gripping. Nevertheless, this study provides useful guidelines for therapists in assessing grip strength in clinical settings as well as implications of the wrist positions that may facilitate power grip strength [4].

VI. Conclusion

The results of the study had supported the hypothesis that the grip strength is maximum with elbow in full extension and wrist in neutral. The changes in wrist position on grip strength are observed with variations in elbow and wrist positions. It is vital that when measuring grip strength, one understands how small changes in body position can result in altered grip strengths. Further studies are needed to find out the effect of wrist deviations (i.e. ulnar deviation and radial deviation) on grip strength.In this study, the angles of each subject were not measured, which make it difficult to analyze the relationship between the joint angles and the reduction of grip strength. In the future, it would be necessary to measure the joint angles and to try to evaluate the muscular activities together.

Authors'contribution

RDL designed ,coordinated and Drafted the manuscript of the study, *ATR* performed the statistical analysis and interpretation of the data and reviewed the draft; *DS, JA,NP and NT* acquisition and collection of data .

Conflict of interest

The authors declare that they have no competing interests.

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