ISSN 2454-6089(E)
ISSN 0973-2020

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*Journal of Exercise Science & Physiotherapy*
*JESP Vol. 12, No. 1, 2016: 76-80* *Published by Exercise Fitness & Health Alliance*
*Article no. 254; DOI: 10.18376//2016/v12i1/86816*

# Effects of Hand Position with Relation to Elbow and Shoulder Position on Maximum Grip Strength

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**Communication Date: Nov. 20, 2015**

**Acceptance Date: Nov.. 30, 2015**

**DOI: 10.18376//2016/V12I1/86816**
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**Key Words: Grip, VAS, MSD**

**To cite this article:**
**Kaushik, Aakriti; Prakash, Niti; Jagga, Vinay**
Effects of Hand Position with Relation to Elbow and Shoulder Position on Maximum Grip Strength. [online]. *Journal of Exercise Science and Physiotherapy*, Vol. 12, No. 1, June 2016: 76-80.

**Abstract**

This study aimed at determining the grip strength at various angles of shoulder and elbow positions and associate them with discomfort at each point. Method: 60 right handed male subjects aged 20-35 years were taken to measure grip strength at shoulder forward flexion at 0º,45º,90º,135º,180º with elbow at 0º and 90º flexion; discomfort was measured with a VAS scale. Result: scores of grip strength: minimum at 90º elbow and 180º shoulder and maximum at 0º elbow and 180º shoulder. VAS score: the maximum at 0 º elbow and 135 º shoulder and minimum at 0º elbow and 0º shoulder. Conclusion: there exists a relation between grip strength and discomfort.

## Introduction

The hand is an integral part of normal human functioning. Quality of performance in daily living skills, recreational, and vocational pursuits is influenced by adequate hand function. Power grip is the result of a sequence of (a) opening the hand, (b) positioning the fingers, (c) bringing the fingers to the object and (d) maintaining a static phase that actually constitutes the grip *(Landsmeer et al, 1960).* Fingers in power grip usually function in concert to clamp on and hold an object into the palm. The fingers assume a position of sustained flexion that varies in degree with the size, shape, and weight of the object. *De et al (2011)* reported variations in grip strength with the changes of posture and body joint angles and established an optimal body posture and joint angle for the maximum grip strength for adult Bengalee population. *Parvatikar & Mukkannavar (2009)* demonstrated that various joint positions can affect grip strength, especially elbow and shoulder joints with respect to wrist positions. Handgrip strength is a physiological variable that is affected by a number of factors including age, gender and body size. Since the force exerted on the hand or wrist while performing a task may be a contributing factor in the development of MSD disorders in the upper-arm, it has become imperative to design hand tools

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and workstation so as to reduce the effects. If an individual has to exert more than his/her maximum voluntary strength, there is a potential risk involved in the work which may ultimately lead to MSD *(Kattel, 1996).* The anatomical point (i.e. a point with a distance from the worker in the direction of the line between the shoulder and the gripping hand) can be defined as the 'relative position' to the worker. Although a standardized arm position for hand-strength tests has been provided by ASHT *(Fess & Moran, 1981).* It is thought that the grip strength data measured at postures defined by the joint angles are not ultimately applicable to practical work conditions *(Kong et al, 2011).* Measurement of grip strength is an important component for hand rehabilitation. Previously grip strength was measured in various upper-extremity postures, which were defined by the joint angles of the wrist, elbow and shoulder. In practical working conditions, workers generally hold a hand tool, control a machine or handle work materials at a given point and carry out a task by performing physical exertions. These positions are not ultimately applicable to the actual working conditions, exposing the working population to risk of MSD's.

## Methods and Materials

Sixty healthy Right handed males aged 20-35 years were asked to perform the ranges in term of hand direction with reference to the shoulder forward flexion at 0º, 45º, 90º, 135º, 180º, with elbow in 0º and 90º flexion.VAS was recorded at each of these positions. An adjustable hydraulic hand dynamometer set at second handle position (of the five positions available) and same dynamometer was used throughout the study. A VAS scale was used to measure the discomfort perceived at that position. Each subject was asked to to perform their maximum grip with the hand dynamometer several times in a training session, before the experiment began. In the main experiment, subjects in the standing position were instructed to assume the given position and hold the grip of the dynamometer. The subject held the grip tightly on the verbal signal of the examiner and kept performing maximum strength for five seconds until the stop signal. Grip strength was measured in kilogram force (kg). Three trials were allowed in each position. Mean of 3 trials were recorded for calculation purpose. After finishing each task, the subject rated his feeling of discomfort by showing the subject the 10 cm VAS line and asked to mark on the line the level of discomfort experienced at that position. The subject was given at least three minutes for rest between each task.

## Results and Discussion

**Table 1: Mean & SD values of Grip strength at various elbow & shoulder positions**

| Elbow and shoulder position | N | Mean (Kg) | SD |
|---|---|---|---|
| $0^0$ Elbow $0^0$ Shoulder | 60 | 40.90 | 6.249 |
| $0^0$ Elbow $45^0$ Shoulder | 60 | 42.55 | 6.236 |
| $0^0$ Elbow $90^0$ Shoulder | 60 | 42.74 | 5.899 |
| $0^0$ Elbow $135^0$ Shoulder | 60 | 41.74 | 5.968 |
| $0^0$ Elbow $180^0$ Shoulder | 60 | 43.997 | 6.966 |
| $90^0$ Elbow $0^0$ Shoulder | 60 | 40.36 | 5.393 |
| $90^0$ Elbow $45^0$ Shoulder | 60 | 38.96 | 6.391 |
| $90^0$ Elbow $90^0$ Shoulder | 60 | 39.31 | 5.208 |
| $90^0$ Elbow $135^0$ Shoulder | 60 | 39.37 | 5.920 |

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| | | | |
|---|---|---|---|
| $90^0$ Elbow $180^0$ Shoulder | 60 | 37.77 | 5.783 |

Table 1 depicts the mean and standard deviation values of grip strength in all the ten positions with respect to shoulder and elbow positions. The results of ANOVA findings indicated significant overall difference ($p<0.05$) in grip strength across ten positions for the total sample with respect to shoulder and elbow positions. Table 2 depicts mean & SD values of VAS at various elbow & shoulder posiions. the level of significance of the VAS score obtained at each of the positions. Data shows significant difference in the value of VAS all the positions at which grip strength was measured.

**Table 2: Mean & SD values of VAS at various elbow & shoulder posiions**

| Elbow and shoulder position | | N | Mean | SD |
|---|---|---|---|---|
| $0^0$ Elbow $0^0$ Shoulder | VAS | 60 | 1.38 | 0.490 |
| $0^0$ Elbow $45^0$ Shoulder | VAS | 60 | 3.07 | 1.247 |
| $0^0$ Elbow $90^0$ Shoulder | VAS | 60 | 4.18 | 1.455 |
| $0^0$ Elbow $135^0$ Shoulder | VAS | 60 | 5.82 | 0.792 |
| $0^0$ Elbow $180^0$ Shoulder | VAS | 60 | 6.27 | 1.191 |
| $90^0$ Elbow $0^0$ Shoulder | VAS | 60 | 1.93 | .733 |
| $90^0$ Elbow $45^0$ Shoulder | VAS | 60 | 3.60 | .887 |
| $90^0$ Elbow $90^0$ Shoulder | VAS | 60 | 6.42 | 1.293 |
| $90^0$ Elbow $135^0$ Shoulder | VAS | 60 | 7.78 | 1.209 |
| $90^0$ Elbow $180^0$ Shoulder | VAS | 60 | 7.75 | 1.159 |

**Table 3: ANOVA determining grip strength differences in all the ten positions with respect to shoulder and elbow positions**

| | Sum of squares | df | P | Signicance |
|---|---|---|---|---|
| Between Groups | 2102.47 | 9 | <0.001 | Significant |

**Table 4: Depicting differences in the value of VAS in all the positions at which grip strength was measured**

| | VAS | Sig |
|---|---|---|
| Chi-square | 481.642 | |
| df | 9 | |
| Asymp. Sig. | <.001 | Significant |

Table 3 depicts the repeated measures of ANOVA determining grip strength differences in all the ten positions with respect to shoulder and elbow positions. The results of ANOVA findings indicated significant overall difference ($p<0.05$) in grip strength across ten positions for the total sample with respect to shoulder and elbow positions. Table 4 depicts the level of significance of the VAS score obtained at each of the positions. Data shows significant difference in the value of VAS all the positions at which grip strength was measured.

The results of our study shows grip strength score at various positions of elbow and shoulder. When elbow and shoulder were in neutral position the grip strength was observed to be least (Mean= 40.90) when compared with increasing angle of shoulder forward flexion. When angle of shoulder flexion with elbow maintained in full extension was increased an increase in the grip strength values was observed i.e. at 0º elbow 45º shoulder (Mean= 42.55); at

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0º elbow 90º shoulder (Mean= 42.74); at 0º elbow 135º shoulder (Mean =41.74) and the maximum grip strength with elbow extended was obtained at 0º elbow 180º shoulder (Mean = 43.99). However with elbow in 90º of flexion and shoulder in forward flexion the grip strength variation was on a different line as compared to that when elbow was extended i.e. at 90º elbow and 0º shoulder (Mean =40.36); at 90º elbow and 45º shoulder (Mean=38.96) at 90º elbow and 90º shoulder (Mean =39.31); at 90º elbow and 135º shoulder (Mean=39.365); at 90º elbow and 180º shoulder (Mean =37.765) the least mean score for grip strength was obtained. A study conducted by *Su et al (1994)* reported that the greatest mean value of grip strength was found when shoulder was positioned in 180º of flexion with elbow in full extension where as the position of 90º elbows flexion with shoulder in 0º flexion exhibited the lowest grip strength scores. Though the results of our study was found to be similar, but the lowest mean grip strength was recorded when the shoulder was positioned in 180º of flexion with elbow 90º flexion. It is postulated that at an elbow posture of 90º flexion, the Triceps Brachii is physiologically strongest; however, the contribution of other muscles in the limb may not be at their maximal. *(Kattel et al, 1996).* Previous studies have established that there is a relationship between handgrip strength with position of elbow *(Balogun et al, 1991; Kuzala & Vargo, 1992).*

Discomfort was rated at these positions using a VAS score. The VAS score also showed significant difference on each of the positions. From various ranges and discomfort associated at each of the position; minimum scores were obtained at 0º elbow 0º shoulder (Mean±S.D=1.38± .490) indicating the least discomfort was experienced at this position; the scores increased at 0º elbow 45º shoulder (Mean±S.D=3.07±1.247) , 0º elbow 90º shoulder (Mean±S.D=4.18± 1.455) and 0º elbow 135º shoulder (Mean±S.D=5.82±0.792) and at 0º elbow 180º shoulder (Mean±S.D=6.27± 1.191); when elbow was flexed at 90º VAS scores were obtained at 90º elbow and 0º shoulder (Mean±S.D=1.93 ±.733); 90º elbow and 45º shoulder (Mean±S.D=3.60± .887) and 90º elbow and 90º shoulder (Mean±S.D=6.42 ±1.293) the maximum scores for discomfort was obtained at 90º elbow and 135º shoulder (Mean±S.D=7.78 ±1.209) the score slightly reduced with the next position i.e. 90º elbow and 180º shoulder (Mean±S.D=7.75±1.159). Use of VAS as a scale to measure the level of discomfort compliments the study by *Kong at al (2011)* who also used the same scale as score for discomfort. The results that showed that there is a significant relation in position of upper extremity and discomfort associated with those positions ($p \leq .001$). These results showed that subjective ratings of VAS can be a reliable measure for the evaluation of physical exertions *(Kong at al, 2011).* Although the grip strength was maximum with the direction of shoulder angle being 180º and that of elbow was 90º; this range appeared to make the subject feel uncomfortable due to the position of the upper extremity. Our rating and results of discomfort measurement compliments the study conducted by Kong et al that included the relative distance and direction of the hand to the shoulder. Discomfort ratings showed

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relatively low values in 0~90º of shoulder forward flexion as compared to those of over 135º of hand direction.

The results of our study give us an indication that there is a definite relation between shoulder and elbow positions and grip strength and discomfort as perceived by the subjects. With our study it could be concluded that it is vital that when measuring grip strength, one understands how changes in body position can result in altered grip strengths and that some of these postures could not be comfortable for the subjects to work in. These changes in the posture while gripping may in turn lead to long term problem for the subjects and exhibit as MSD. Hence the findings are valuable in evaluation and rehabilitation training of hand injured athletes or patient and in designing work equipments that would minimise the discomfort and maximise the efficiency of the worker.

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**Conflict of Interest: None Declared**