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EFFECT OF DIFFERENT ELBOW ANGLES POSITIONS ON HAND GRIP STRENGTH AND MYOELECTRICAL ACTIVITY OF WRIST FLEXORS IN HEALTHY SUBJECTS

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ABSTRACT

Background and purpose: *Handgrip strength is an objective measure of muscular function in the upper extremity and has been used as a marker of frailty in adults. Muscle electromyography (EMG) is an indirect and non-invasive method to evaluate muscle function and activity and predict hand grip force.*

Subjects*: Fifty normal male university students volunteered to participate in this study. They were selected from the students of Faculty of Physical Therapy, Cairo University. Those subjects were collected in one group.*

Procedures*: Hand grip strength was assessed using Hand held dynamometer and Root mean square of wrist flexors was assessed by using Noraxon MyoSystem 1400A Instrument. Three dependent variables; Root mean square (RMS) of flexor carpi radials (FCR), RMS of flexor carpi ulnaris (FCU), and handgrip strength were measured and one independent variable which was the (elbow positions); within subject factor which had three levels (0° elbow flexion, 90° elbow flexion, and full elbow flexion).*

Results*:*

For hand grip strength, RMS of FCR and RMS of FCU, the results showed that there was significant increase in the value of three values index in favor to 90° elbow flexion position than all other elbow flexion position.

Conclusion*: it was concluded that there were significant effects of the tested elbow positions (the independent variable) on the three tested dependent variables; RMS of flexor carpi radials,RMS of flexor carpi ulnaris, and handgrip strength (F=143.4, P=0.0001*).*

KEY WORDS: grip strength, Root mean square and Noraxon

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INTRODUCTION

Handgrip strength is an objective measure of muscular function in the upper extremity and has been used as a marker of frailty in older adults[1].

Grip strength is one of the components that have been tested while evaluating hand function. It also provides an objective index of the functional integrity of the upper extremity. Measurement of grip strength is also an important component of hand rehabilitation as it is a measure of the effectiveness of therapy[2].

Many daily functions and sporting events require high activity levels of the flexor musculature of the forearms and hands. These are the muscles involved in gripping strength. From sports like wrestling, tennis, football, basketball, and baseball to daily activities such as carrying laundry, turning a doorknob, and vacuuming, some degree of grip strength is necessary to be successful[3].

According to Shea (2007)[4] many daily functions and sporting events require high activity levels of the flexor musculature of the forearms and hands. These are the muscles that involved in gripping. He also stated that there are 35 muscles involved in the movement of the hand and the forehand. Many of these muscles involved in gripping activities. The flexor muscles in the hand and the forearm will create the grip strength while the extensor muscles in the forearm will stabilize the wrist during gripping activities. Most sports activities also require adequate grip strength to enhance performance and prevent injuries. Overuse injuries like Lateral epicondylosis are closely associated with inadequate grip strength[5].

Hand and finger force data are used in many settings, as industrial design and physical rehabilitation to indicate the progress of the case. The application of appropriate work design principles, during the design of tools and workstations may minimize upper extremity injuries within the workplace. In addition, it is necessary to understand the capabilities of the hand and fingers in order to evaluate the level of disability caused by existing injuries and also to assess the progress made during recovery. Understanding the physical capabilities and limitations of individuals is therefore necessary to optimize performance and minimize injury[6].

Hand held dynamometer has been one of the most common methods of assessment of grip strength. Hand held dynamometer is considered on the most important biomechanical measurement that used to assess hand grip strength and measure the muscular force generated by the hand and forearm's flexor mechanism[7].

Muscle electromyography (EMG) is an indirect and non-invasive method to evaluate muscle function, predict hand grip force and for developing hands-free control systems for assistive devices[8].

METHODS

Method Design

Three factorial one shot design study was used. A single trained investigator evaluated all subjects and collected all data to eliminate inter-investigator errors. This was an observational, quantitative and descriptive study. It was conducted at the Laboratory of Noraxon, Faculty of Physical Therapy, Cairo University from January to June 2016. The aim of the study was to examine the effects of different elbow joint positions on the hand grip strength and electromyographic (EMG) activities of wrist flexor muscles in normal subjects. Data collection phase lasted for about 6 months (from February 2016 – July 2016). All subjects or their legal representatives signed two copies of an informed consent form before the beginning of data collection. The present study was approved by the ethical and research committees of the involved institutions.

Participants

Fifty normal male university students volunteered to participate in this study. They were selected from the students of Faculty of Physical Therapy.

General Characteristics

Fifty participants participated in the study. Their mean ± standard deviation for age, body mass, height, and BMI were 21.92±1.78 years, 77.08±6.45 kg, 171.88±5.05cm, and 26.47±3.21 respectively.

Inclusion criteria:

1. Subjects with age ranged from 18-25 years, height ranged from 161-180, and weight ranged from 65-92 kg.
2. Subjects were males.
3. Subjects with good cognition that enables them to understand the requirements of the study.
4. Subjects with free and full range of motion of shoulder, elbow and wrist joints of tested limb.
5. The assessment was done for the dominant limb either right or left.
6. Subjects were not performing any strenuous activities to strength hand grip muscles one month ago.

Exclusion criteria:

1. Subjects with any orthopedic disorders or neurological disorders that affect upper limb strength or movement.
2. Subjects whose cannot follow instructions as blindness and deafness.
3. Subjects with any cognitive and psychiatric disorders.
4. Subjects who participated in sports using hand like handball, tennis, basketball etc.

Equipment:

1- Hand held dynamometer was used to assess hand grip strength

2- Noraxon MyoSystem 1400A Instrument was used to calculate Root mean square of wrist flexors.

Procedure:

Hand grip strength was measured according to a standard protocol based on the recommendations of the ASHT (Fess, 1992), using the second handle of the Jamar dynamometer **(fig.1).** The second handle position has been assumed to be the most reliable and consistent position and produce maximal grip strength (Roberts et al., 2011). HGS was assessed from three different positions of the elbow joint (full elbow flexion, 900 elbow flexion and 0 elbow flexion)

For RMS, it measured using Noraxon MyoSystem 1400A Instrument **(fig.2)**. Each subject was informed about the nature of the study. The skin over the site of wrist flexors muscles at the forearm was cleaned with alcohol 70% to reduce skin resistance. Detection of the proper site of EMG recording electrodes was performed by palpating the muscle belly while the subject was performing maximum isometric contraction of wrist flexors against resistance and the surface EMG electrodes were applied over the muscles belly of wrist flexors (Flexor carpi radialis and flexor carpi ulnaris) but The reference self-adhesive (ground) electrode was applied over olecranon process of radius bone. The Root Means Square (RMS) calculation will used to quantify the muscle activity in the EMG signals in 3 the three different positions of elbow joint. Normalization of RMS EMG signals was performed using a model or an estimator and the values actually observed. RMS value was used because it is a parameter that better reflects the levels of muscle activity at rest and during contraction, and for this reason, one of the most widely used in scientific studies. The greatest score of the three trials of MVC was taken for statistical analysis. The greatest score of the three trials of hand grip strength was taken for statistical analysis. Regarding RMS EMG, the mean of the three trials was taken for statistical analysis.

Data analysis

All statistical measures were performed using the Statistical Package for Social Sciences (SPSS) version 20 for windows. Before statistical analysis, data exploration was performed as a prerequisite for parametric calculations of the analysis of difference.

The study included one independent variable (tested elbow positions) with three levels (three positions) and three dependent variables which were: hand grip strength and RMS EMG activities of FCR and FCU. Statistical analysis using one-way repeated measure within subject MANOVA (Multivariate Analysis of Variance) was conducted to compare RMS EMG of FCR and FCU between different three elbow positions within the same subject. In addition, it was used to compare the magnitude of grip strength between different three elbow positions. The alpha level was set at 0.05.

RESULTS

The main purpose of this study was to investigate the effect of three different positions of the elbow joint on the hand grip strength and the myoelectrical activity of the wrist flexors in normal individuals .

Statistical analysis was conducted using SPSS for windows, version 18 (SPSS, Inc., Chicago, IL). The current test involved one independent variable was the (elbow positions); within subject factor which had three levels (0° elbow flexion, 90° elbow flexion, and full elbow flexion). In addition, this test involved three tested dependent variables (RMS of flexor carpi radials, RMS of flexor carpi ulnaris, and hand grip strength). Accordingly, repeated measure MANOVA was used to compare the tested variables of interest at different tested elbow positions. Within subject MANOVA was performed on the examined sample with the alpha level 0.05.

The participants' demographic data:

Fifty participants participated in the study. Their mean ± standard deviation for age, body mass, height, and BMI were 21.92±1.78 years, 77.08±6.45 kg, 171.88±5.05cm, and 26.47±3.21 respectively. Repeated measure MANOVA for dependent variables in different positions. Statistical analysis using repeated measure MANOVA indicated that there were significant effects of the tested elbow positions (the independent variable) on the three tested dependent variables; RMS of flexor carpi radials, RMS of flexor carpi ulnaris, and handgrip strength (F=143.4, P=0.0001*).

Dependent Variables:

1. RMS of flexor carpi radialis:

As presented in **table (1)** and illustrated in **fig. (1)**, the mean ± SD values of RMS of flexor carpi radialis in the "0° elbow flexion position", "90° elbow flexion position", and "full elbow flexion position" were 0.51 ±0.14, 0.66± 0.16 and 0.34 ±0.11 respectively. The univariate tests of repeated measure MANOVA revealed that there were significant differences in the mean values of RMS of flexor carpi radialis among different elbow flexion positions (F=134.148, P=0.0001*). So, multiple pairwise comparison tests (Post hoc tests) revealed that there was significant differences between (0° elbow flexion position versus 90° elbow flexion position), (0° elbow flexion position versus full elbow flexion position), and(90° elbow flexion position versus full elbow flexion position with (p=0.0001, 0.0001*, and 0.0001*) respectively and this significant increase in the value of RMS of flexor carpi radialis index in favor to 90° elbow flexion position than all other elbow flexion position.

Table (1): Descriptive statistics and repeated measure MANOVA for RMS of flexor carpi radialis at different elbow flexion positions.

Descriptive statistics for the RMS of flexor carpi radialis at different elbow flexion positions			
	0° elbow flexion position Mean ±SD	90° elbow flexion position Mean ±SD	Full elbow flexion position Mean ±SD
RMS of flexor carpi radialis	0.51 ±0.14	0.66 ±0.16	0.34 ±0.11
The univariate tests for the mean of RMS of flexor carpi radialis among at different elbow flexion positions.			
	F-value		P-value
RMS of flexor carpi radialis	134.148		0.0001*
Multiple pairwise comparison tests (Post hoc tests) for the RMS of flexor carpi radialis among different			

elbow flexion positions.			
	0° elbow flexion position Vs. 90° elbow flexion position	0° elbow flexion position Vs. full elbow flexion position	90° elbow flexion position Vs. full elbow flexion position
RMS of flexor carpi radialis	0.0001*	0.0001*	0.0001*

Significant at alpha level <0.05

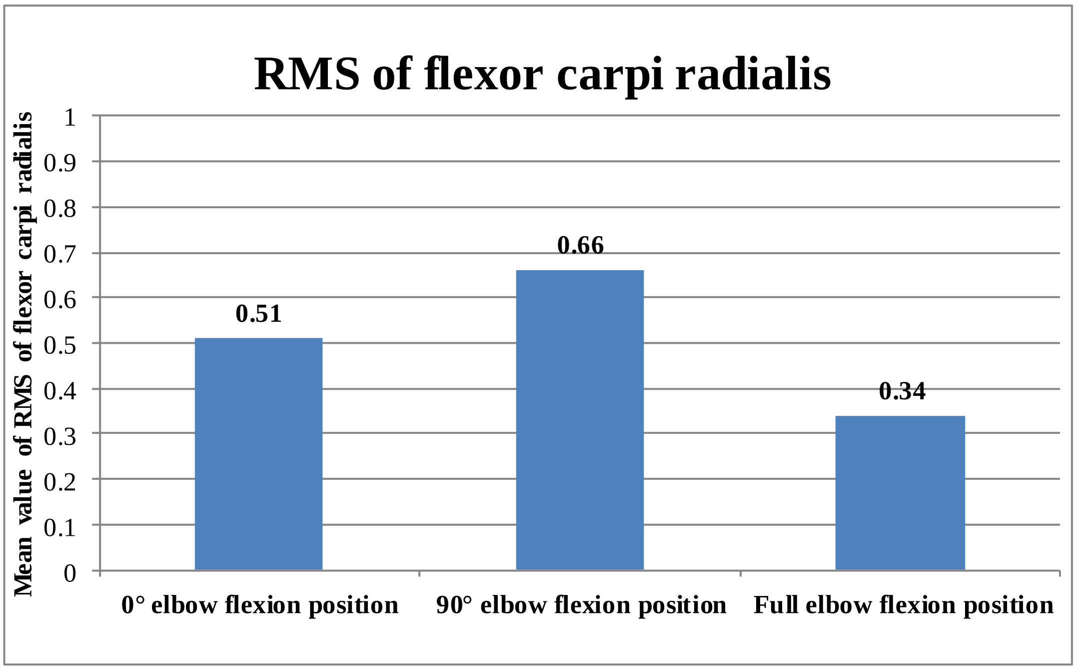

Figure (1): Mean values of the RMS of flexor carpi radialis among different elbow flexion positions.

2. RMS of flexor carpi ulnaris:

As presented in **table (2)** and illustrated in **fig. (2)**, the mean ± SD values of RMS of flexor carpi ulnaris in the "0° elbow flexion position", "90° elbow flexion position", and "full elbow flexion position " were 0.53 ±0.14, 0.680.16±, and 0.37 ±0.13respectively. The univariate tests of repeated measure MANOVA revealed that there were significant differences in the mean values of RMS of flexor carpi ulnaris among different elbow flexion positions (F=88.161, P=0.0001*). So, multiple pairwise comparison tests (Post hoc tests) revealed that there was significant differences between (0° elbow flexion position versus 90° elbow flexion position), (0° elbow flexion position versus full elbow flexion position), and (90° elbow flexion position versus full elbow flexion position with (p=0.0001, 0.0001*, and 0.0001*) respectively and this significant increase in the value of RMS of flexor carpi ulnaris index in favor to 90° elbow flexion position than all other elbow flexion position.

Table (2): Descriptive statistics and repeated measure MANOVA for RMS of flexor carpi ulnaris at different elbow flexion positions.

Descriptive statistics for the RMS of flexor carpi ulnaris at different elbow flexion positions			
	0° elbow flexion position Mean ±SD	90° elbow flexion position Mean ±SD	Full elbow flexion position Mean ±SD
RMS of flexor carpi ulnaris	0.53 ±0.14	0.68 ±0.16	0.37 ±0.13

The univariate tests for the mean of RMS of flexor carpi ulnaris among at different elbow flexion positions.		
	F-value	P-value
RMS of flexor carpi ulnaris	88.161	0.0001*

Multiple pairwise comparison tests (Post hoc tests) for the RMS of flexor carpi ulnaris among different elbow flexion positions.			
	0° elbow flexion position Vs. 90° elbow flexion position	0° elbow flexion position Vs. full elbow flexion position	90° elbow flexion position Vs. full elbow flexion position
RMS of flexor carpi ulnaris	0.0001*	0.0001*	0.0001*

significant at alpha level <0.05

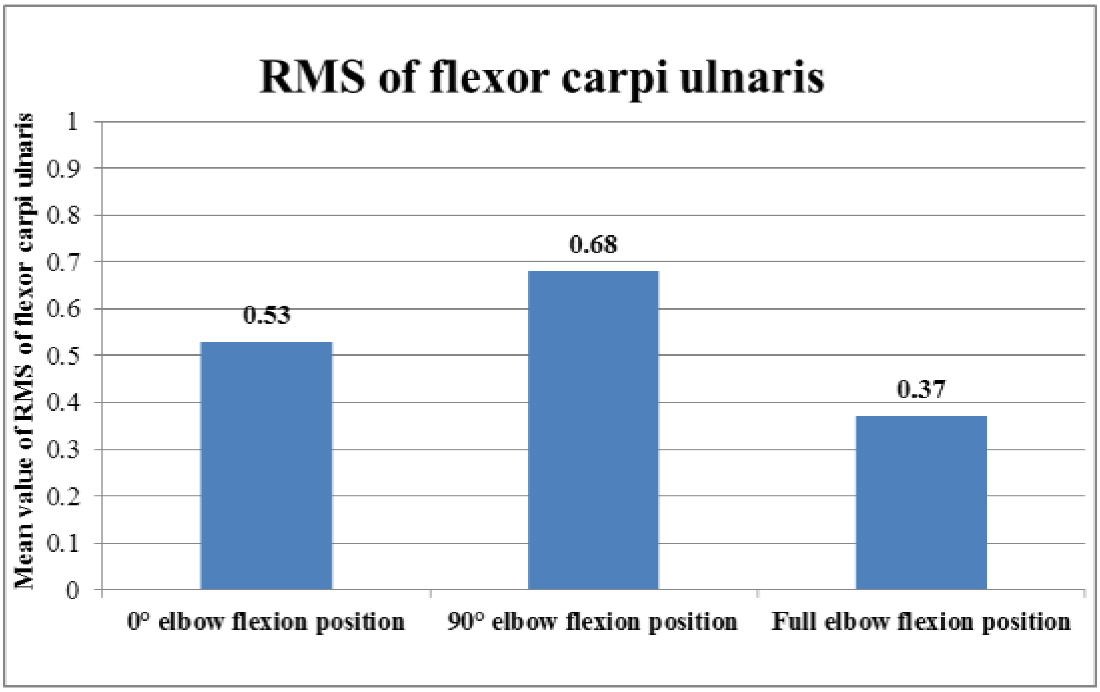

Figure (2): Mean values of the RMS of flexor carpi ulnaris among different elbow flexion positions.

3. Handgrip strength:

As presented in **table (3)** and illustrated in **fig. (3)**, the mean ± SD values of handgrip strength in the "0° elbow flexion position", "90° elbow flexion position", and "full elbow flexion position " were 32.48 ±3.39, 37.1 ±4.16, and 27.66±3.68respectively. The univariate tests of repeated measure MANOVA revealed that there were significant differences in the mean values of handgrip strength among different elbow flexion positions (F=305.966, P=0.0001*). So, multiple pairwise comparison tests (Post hoc tests) revealed that there was significant differences between (0° elbow flexion position versus 90° elbow flexion position), (0° elbow flexion position versus full elbow flexion position), and (90° elbow flexion position versus full elbow flexion position with (p=0.0001, 0.0001*, and 0.0001*) respectively and this significant increase in the value of handgrip strength index in favor to 90° elbow flexion position than all other elbow flexion position.

Table (3): Descriptive statistics and repeated measure MANOVA for handgrip strength at different elbow flexion positions.

Descriptive statistics for the handgrip strength at different elbow flexion positions			
	0° elbow flexion position Mean ±SD	90° elbow flexion position Mean ±SD	Full elbow flexion position Mean ±SD
Handgrip strength	32.48 ±3.39	37.1 ±4.16	27.66±3.68
The univariate tests for the mean of handgrip strength among at different elbow flexion positions.			
	F-value	P-value	
Handgrip strength	305.966	0.0001*	
Multiple pairwise comparison tests (Post hoc tests) for the handgrip strength among different elbow flexion positions.			
	0° elbow flexion position Vs. 90° elbow flexion position	0° elbow flexion position Vs. full elbow flexion position	90° elbow flexion position Vs. full elbow flexion position
Handgrip strength	0.0001*	0.0001*	0.0001*

Significant at alpha level <0.05

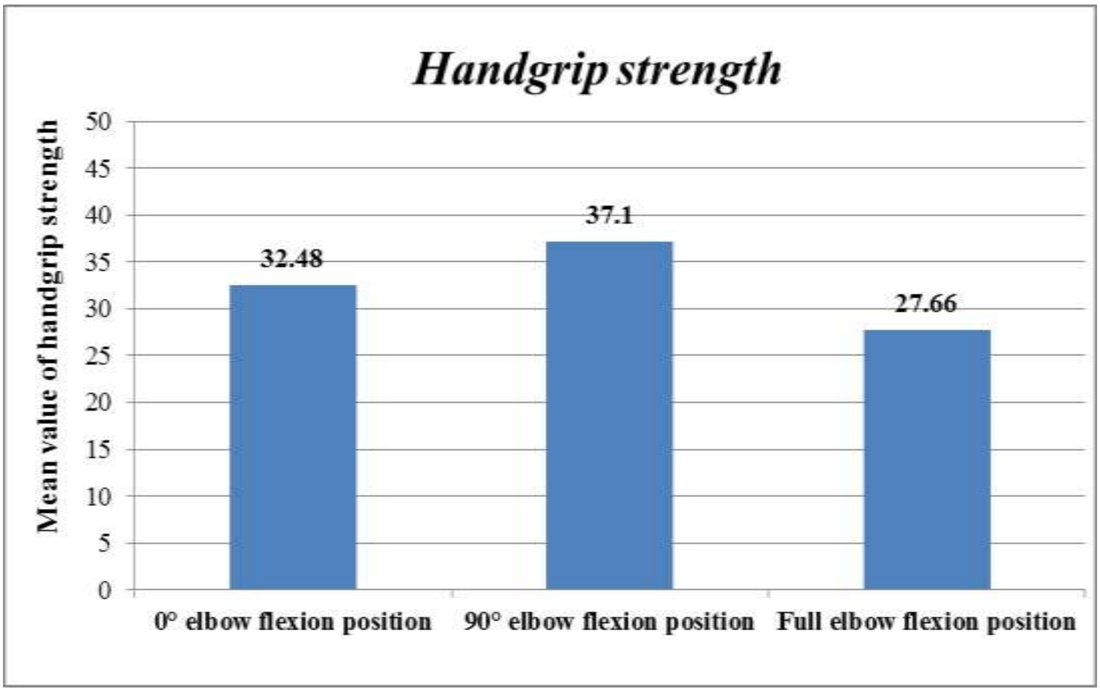

Figure (3): Mean values of the handgrip strength among different elbow flexion positions.

DISCUSSION

The main purpose of this study was to investigate the effect of different the elbow joint position on the hand grip strength and the myoelectrical activity of the wrist flexors in normal individuals. Understanding the impact of hand activity or gripping on elbow loading and pain is necessary in order to establish appropriate assessments and clinical evaluations. However, little attention has been given to the effect of elbow joint positions on the forearm EMG activity (wrist flexors). This study investigated the effect of different positions of elbow joint on the hand grip strength and the myoelectric activity of the wrist flexors. The results of this study could guide clinicians and researchers to choose appropriate testing position for grip strength measure for those who are 17-27 years old. The results indicated that hand grip strength was significantly higher in the position where the shoulder was neutral and the elbow was 90° flexed. There was a significant difference was observed in hand grip strength between three positions where elbow either full flexed (position 1) or 90o flexion (position 2) or full extension (position 3) with shoulder in neutral position. Highest RMS of EMG activities of wrist flexors was significantly recorded in position (2). By taking this position as a reference task, statistical analysis revealed that the percentage of RMS EMG of wrist flexors showed a significant difference between the remaining two positions (1 and 3). Also this study indicates that there was significant differences between (0° elbow flexion position versus 90° elbow flexion position), (0° elbow flexion position versus full elbow flexion position), and (90° elbow flexion position versus full elbow flexion position with (p=0.0001, 0.0001*, and 0.0001*) respectively and this significant increase in the value of RMS of flexor carpi radials index in favor to 90° elbow flexion position than all other elbow flexion position. These results indicated that changing the position of the elbow from neutral to flexion 90 stimulated greater activities from wrist flexor which in turns led to greater hand grip strength. In addition, flexed elbow position resulted in highest hand grip strength compared to extended position (all with shoulder in neutral position). The previous finding is in disagreement with **(Dorf et al., 2007)**[9] who concluded that the grip strength decreases as one moves from a position of flexion to a position of extension of the elbow. The authors attributed this to the fact that the motor units of the wrist cross the elbow, so their length and muscle tension are affected by elbow position. The result of this study disagrees with (**Balogun et al., 1991)**[10] who revealed that isometric strength of the hand grip with the elbow fully extended was greater compared with the elbow at 90° of flexion. Also the result of this study was in disagreement with (**Su et al 1994)**[11] who reported that the highest mean grip strength was found when elbow in full extension where the position of 90 degree elbow flexion. In the current study, there was a significant increase in the hand grip strength index in elbow flexion 90 degree than full flexion in sitting position and all subjects were males. A recently published study explained by (**Barut & Demirel, 2012**)[12] who assessed the grip strength of both sexes in two positions; standing with elbow in full extension, and sitting with elbow in 90° flexion found that grip strength with elbow flexed was higher in males, but females had higher grip strength values with elbow extended which assure the result of this study that hand grip strength was more significant higher with elbow flexion 90o than other positions. The result of this study was explained by (**Kendall & McCreary, 1983**)[13] who reported that from a biomechanical perspective, one might consider length-tension relationships of the muscles involved. Flexor digitorum superficialis 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 degrees of flexion, flexor digitorum superficialis is progressively placed in a more shortened position, thereby placing it at a mechanical disadvantage. This may serve or explain the decrease in grip strength that resulted from increased elbow flexion which means that hand grip strength is significant higher in elbow flexion 90^0 than 0^0 elbow flexion (elbow extension). Several studies have been performed to evaluate the difference in grip strength between positions of elbow flexion and extension in healthy adults. Although results vary, these studies generally show higher values for grip strength measurements with the elbow in full extension than for grip strength measurements recorded with the elbow in 90° of flexion **(Dorf et al., 2007**)[14]. In this study there was a significant increase in the value of handgrip strength index in favor to 0° elbow flexion position than full elbow flexion position, which agree with Vanesa et al., 2010 who indicate that handgrip strength levels are significantly higher when the test is performed with the elbow extended compared with those obtained with the elbow full flexed. It has been reported earlier by (**Nordin and Frankel, 2001)**[15] that by increasing muscle length, the output force or tension produced by the muscle increases the force or tension that a muscle exerts varies with the length at which it is held in a relation called length-tension relationship. In this relationship maximal active tension is produced when the muscle fiber is approximately at its resting length and if the fiber is held at shorter lengths, the active tension falls. This clarify the result of this study that showed more RMS of wrist flexors muscles in elbow flexion 90^0 and 0^0 elbow flexion (full extension) than full elbow flexion

Declaration of interest: The authors report no conflict of interest.

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