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Selective activation of Forearm muscles for improving Wrist Joint Stability

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Abstract: The wrist movements has important role in the daily life activities .Flexion, Extension and Abduction and Adduction are acceptable movements in the wrist. The Strength training of extension is necessary for prevention of wrist sprains due to flexion movements because flexion force is more than extension. Aim of this study was to improve the muscle strength by human resistive training and inspecting selective activation of forearm muscles in the above movements. 10 subjects were recruited for performing maximum Isometric contraction at human resistive training and Flexor carpi ulnaris, Flexor carpi radialis, Extensor carpi radialis longus, Extensor carpi ulnaris and abductor pollicis longus were selected for investigation. Surface electromyography was used to get the contraction level. Our result showed co activation of investigated muscles were less in synergistic than antagonist function (FCU: during Abduction 45%, ECU: during Abduction 37%, FCR: during adduction 43%, ECRL: during adduction 29%, APL: during flexion 23%) ($P < 0.0001$). In the APL investigation, there was significant difference observed in the interaction effect ($P = 0.054$, $F_{(3, 9)} = 140.29$, $\eta_p^2 = 0.205$). In the isometric training, biomechanical stability of radio carpal and midcarpal was improved due to strengthening of forearm muscles.

Keywords: Selective Activation, wrist joint, human resistive training, Agonist and Synergist function.

1. INTRODUCTION

The wrist movements have key role in the task of daily living and sports in many ways [1-2]. Flexion, Extension, Abduction and Adduction are acceptable movements in wrist joint [3]. The flexion and extension of the forearm plays key indicators in radio carpal and midcarpal joint instability of wrist complex [4-6]. The maximum acceptable wrist flexion force is higher than extension and ulnar deviation [7]. But extensor muscles have more resistive for task dependent changes and stabilization of wrist joint. So the specific extension strength training is useful to counteract forearm muscle weakness for prevention of wrist sprains [8].

To improve the extension – flexion strength ratio and stabilize inappropriate hand positioning for practical usage [9]. In contrast, the strengthening of extension increases the anti- flexion capacity of muscle (Extensor carpi radialis longus, Extensor carpi ulnaris), which is potentially beneficial in the prevention of sports [10], related overuse injuries (Boxing) to excessive forearm extension. In every forearm muscle that passes the wrist joint act as flexion, extension, and Abduction or adduction movements which is based on orientation axis of the radio carpal joint and midcarpal [11-12].

Flexor carpi ulnaris, Flexor carpi radialis, Extensor carpi radialis longus, Extensor carpi ulnaris and Abductor pollicis longus are the main muscles that involved in the movement of flexion, Extension, Adduction and



Abduction of wrist movement[13]. While doing exercise program, it is necessary to know in which movements plane the target muscles have to be stimulated to increase muscle strength. Anatomical study in wrist joint, Flexor carpi ulnaris has flexion and adduction movement, Flexor carpi radialis has flexion with abduction, Extensor carpi radialis longus has extension with abduction and extensor carpi radialis brevis has extension with abduction are noticed.

From our knowledge, there is no study that has explained the activation patterns of forearm muscles during resisted isometric flexion, extension, Abduction and adduction. Meta-organization principle [14] states that, each of the isolated movements need complex intramuscular coordination due to anatomy of wrist joint. This gives the guidelines about, the interaction of the motor unit and proprioception is coordinated with central nerve system, which coordinates the activation of the target muscles from the demands of motor units action. Separate sensory direction has fixed in the each forearm muscles[15] the CNS gets the information from individual's sensory nerve of the forearm muscles. Thus it may be speculated that anatomical differences, e.g. variable lever arm lengths of FCU and ECU are transferred into different activation levels when these muscles are activated during resisted flexion and abduction movements. Past Studies states that [16] activation of the Biceps, Triceps and brachioradialis muscles during isometric contraction depends on the anatomical elbow angle for elbow flexion and extension.

From above discussion, the main aim of our study was to determine the level of activation for each forearm limb muscle when functioning as a synergist and agonist. In addition, we compared the activation patterns of the prime movers (Flexor carpi ulnaris, Flexor carpi radialis, Extensor carpi radialis longus, Extensor carpi ulnaris and Abductor pollicis longus) during maximum voluntary isometric contractions (MVIC) as we know hand posture influences muscle activity in many movements in sports and daily life.

2. Material and Methods

2.1 Subjects demography

In this study, we selected 10 subjects (6 Male, 4 Female) for the data collection. The Subjects were no history upper limb injury and no more musculoskeletal disorder.

Table 1 Mean and SD of Subjects.

Variables	Males (n=6)	Female (n=4)
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Age $20 \pm 1.220 \pm 1.03$

Height(m) $1.70 \pm 0.31.60 \pm 0.2$

Weight (kg) $65 \pm 2.463.2 \pm 2.2$

Body Mass Index $\text{Kg}/(\text{m})^2 22.3 \pm 0.6 \quad 22.6 \pm 0.8$

Experimental procedures were explained to the subjects before the data collection and their signatures were collected on the consent form. This Study was approved by the local institutional ethics Board.

2.2. Experimental method

Resisted movement Experiment. In the resisted experiments (Fig.1.a, b, c, d) the subject's elbow is positioned in extension so that activation structure of the wrist is more pressured and simple to find even a small loss of functionality of muscle and tendon misalignment.

2.2.1. Resisted flexion. The neutral position is maintained by the subject's hand and the subject's elbows is kept in the extension by run over the analyzer's opposite side arm then keep the forearm with the hand. The resistance in the palmar is created by other hand of examiner's hand kept under the subject's hand. This test determines the flexors of the wrist and fingers – the flexor carpi radialis, flexor carpi ulnaris.

2.2.2. Resisted extension. Fixation of the patient's forearm is as in the previous test. The Analyzer creates resistance in posterior point of the subjects' hand. This test examines the extensors of the wrist and fingers – the extensor carpi radialis longus, extensor carpi ulnaris.



Figure 1. a) Resisted Flexion. Figure 1. b) Resisted Extension.



Figure 1. c) Resisted Radial Deviation. Figure 1. d) Resisted Ulnar Deviation.

2.2.3. Resisted radial deviation. Opposing force by the tester is applied at the radial aspect of the subject's hand and the thumb is in constant position. The test was conducted the radial deviators of the wrist, the extensor carpi radialis longus and flexor carpi radialis.

2.2.4. Resisted ulnar deviation. The opposing force by the analyzer is applied at the ulnar aspect of the hand and tests the ulnar deviators of the wrist, the extensor carpi ulnaris and flexor carpi ulnaris.

2.3 Electrode placement

Surface electrode was used to record muscle activity in the dominate muscles of wrist motion .In our experiments we considered five muscles like, flexor carpi radialis (FCR), flexor carpi ulnaris (FCU), extensor carpi radialis (ECR), extensor carpi ulnaris (ECU) and Abductor pollicis longus for placement of Electrode. Electrodes were placed over in the fiber direction and movement direction of muscle followed by SENIAM norms [17]. A Bipolar Ag/AgCl was used to collect the data with inter electrodes distance of 2cm was placed over belly above mentioned muscles. To reduce skin impedance ground electrode was placed over on the lateral epicondyle of the dominant arm and all the recording places were shaved the hair with cleaning of alcohol before to place the electrodes.

2.4 EMG recording

The raw EMG signal is stored in Biopac MP36 Bio amplifier at the sampling rate of 10 KHz and are preprocessed using a band pass filter (10-500Hz) and a notch filter of 50Hz issued to remove motion artifacts, high frequency noise and power line interference. Further preprocessing and interpretation is carried out using in MATLAB 2014a, with system of I3 processor core 3.4GHz, 4GB RAM, Windows 10, 64 bit operating system.

2.5 EMG Processing

The resultant raw EMG signal was full wave rectified, for each muscle the greatest incentive from MVIC was resolved from a 512ms [18] moving window over the filtered and rectified signal. The root means square value of EMG was determined from the sifted sign and standardized to get MVC for each muscle information. The overall Standardization is accomplished by fixing an estimation of 100 to the greatest action of each subject's movement direction. In the event that we take a reference, consider the greatest MVIC of ECR was 100, at that point staying three MVIC (for example opposed flexion, abduction and adduction) were expressed as a level of 100 (extension). A two way ANOVA approach was utilized for measurements of co activation examination by utilizing Microsoft excel.

3. Result

Significant differences in EMG action were demonstrated for all the muscles which were analyzed in these examinations when looking at the MVICs of the Subjects. Each muscle shows its greatest action when it was enacted in its agonist work

Table 2 Two way ANOVA (MVIC Type $\times$ Subjects) with Replication Measures significant analysis of each muscle ($\alpha=0.05$).

Muscle Name	F-Statistics	p-value	η_p^2
Flexor Carpi Radialis	$F_{(3, 9)}=251.68$	0.0011	0.825
Flexor Carpi Ulnaris	$F_{(3, 9)}=221.15$	0.0011	0.806
Extensor Carpi RadialisLongus	$F_{(3, 9)}=356.47$	0.0013	0.869
Extensor Carpi Ulnaris	$F_{(3, 9)}=151.57$	0.0015	0.739
Abductor PollicisLongus	$F_{(3, 9)}=140.29$	0.054	0.205

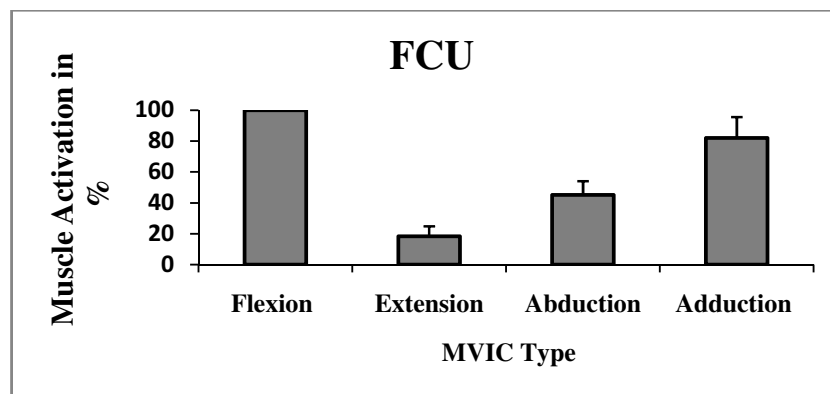


Fig.2 Agonist activity of FCU for investigated muscles. All the values are normalized based on FCU and MVIC type is statistically different ($p<.0011$).

Compared to flexion movements, (fig.2).FCU was co activated during Adduction (82%) and Abduction (45%) and very less co activation in extension (18%) and FCR co activation (fig.3) was more in Abduction movements (76%) compared to other movements, during adduction (45%) and during extension was very less (15%). In the same activation of ECRL, (fig.5) co activation was more in abduction (84 %) and other movements activation was 29% and 14% during adduction and flexion respectively. ECU and ECRL are the agonist activation of extension movements which was slightly differ in magnitude where we observed. For APL activation, (fig.6) co activation during extension (44%) and remaining co activation during flexion and adduction was very less.

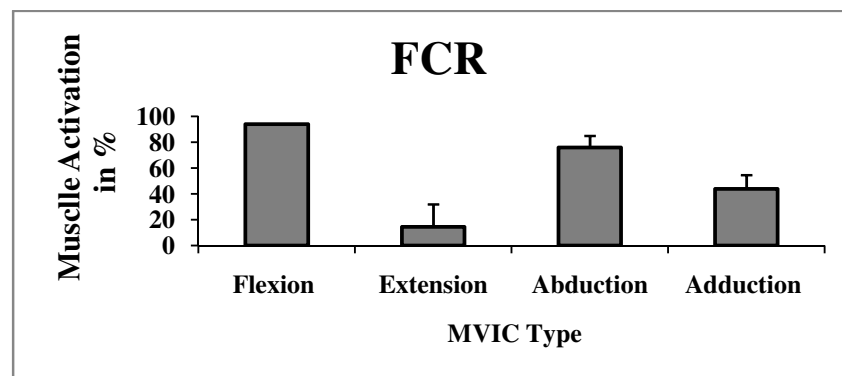
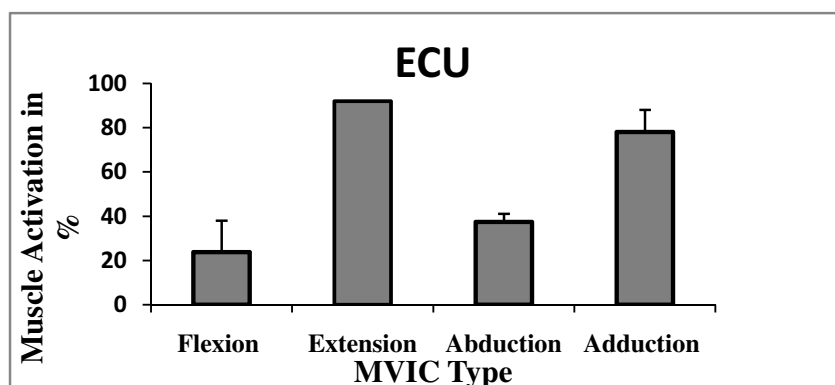


Fig.3. Agonist activity of FCR for investigated muscles. All the values are normalized based on flexion movements (FCU) and MVIC type is statistically different ($p < .0011$).



4 Agonist activity of ECU for investigated muscles. All the values are normalized based on extension movements and MVIC type is statistically different ($p < 0.0013$).

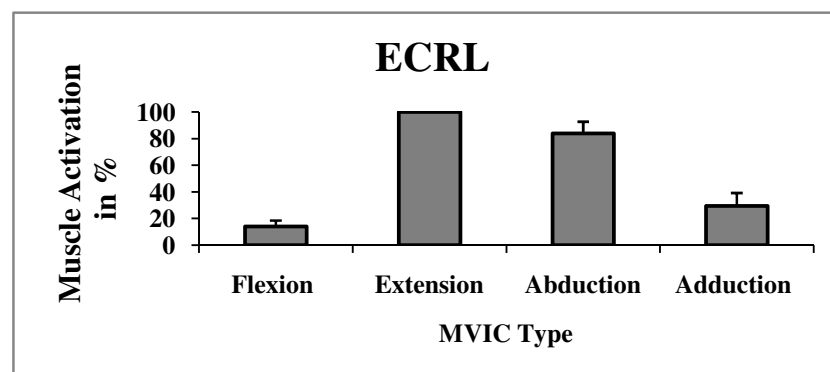


Fig.5 Agonist activity of ECRL for investigated muscles. All the values are normalized based on Extension movements and MVIC type is statistically different ($p < 0.0015$).

In the APL investigation, significant difference observed in the interaction effect ($P = 0.054$, $F_{(3,9)} = 140.29$, $\eta_p^2 = 0.205$). No more main significant difference in FCU, FCR, ECU, ECRL and APL of agonist activity and interaction activity. This result showed that, agonist activation of each muscle group was more than synergist activation.

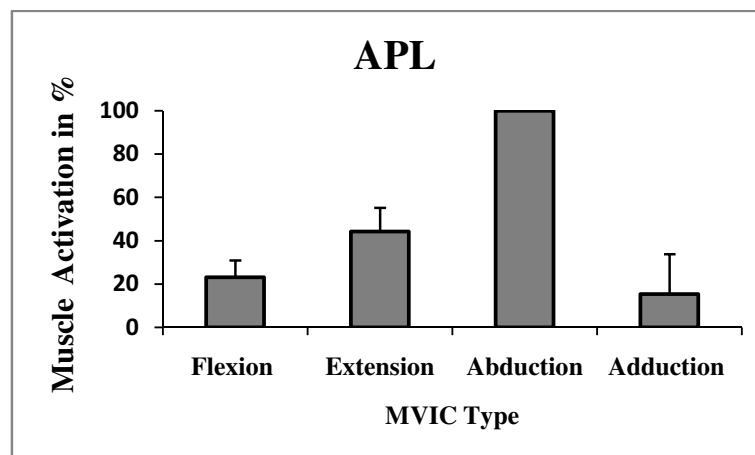


Fig.6 Agonist activity of APL for investigated muscles. All the values are normalized based on abduction movements and MVIC type is statistically different ($p < 0.054$).

4. Discussion

The principle discoveries of this study were to investigate the activation pattern of muscles that are inspected the prime movers of the wrist when disengaged flexion, extension, Abduction and adduction MVIC were performed against manual obstruction. Our explored muscle demonstrates our hypothesize that the movement direction chooses the degree of activation. FCR, FCU, ECR, ECU and APL present their greatest movement when they proceeding as agonists work.

In conventional life systems reading material, depiction of the capacity of the forearm muscles depends on examinations that have utilized cadaveric biomechanical testing. In such investigations, diverse burden is applied to forearm muscle and relating movement is observed. For instance FCR power was higher when hand is moved from extension to flexion and FCU power was higher when hand is moved from flexion to extension [19]. But the FCR and FCU also attribute the abduction and adduction correspondingly but the both are agonist function of flexion. The flexion muscles produced 3.5 fold greater activities than extension muscles during palmerforce (20). In addition to this, our finding shows that the innervations pattern of flexion and extension have most advantages to lever arm lengths.

In the previous studies showed, the principle of neuromechanical matching [21] was proof of our investigation. FCU and ECU were the proof of this principle during flexion and extension of our study. Flexion movement generates more force because of the anatomical course of its tendon has more than 10mm, results in mechanical advantages for flexion[22]. From our observation FCU activation was less in abduction (37%) due to less lever arm compared to flexion arm length and during adduction was (82%) because of agonist activity of FCU. Extension movement effect of ECU was the anatomical course of tendon associated with that wrist joint [23]. The ECU tendon has less lever arm in abduction movements compared to extension. In our result showed an average co-activation of ECU for 32% during abduction and 78% during adduction. In the anatomical course reading [24] guided, ECU isn't credited for Abduction, it is co enacted as adduction MVIC incites an overall extension of the midcarpal joint.

Our exploration is concurred with those of [25], who examined that the particularity of a movement pattern produces specific activation of the motor units. In this exploration a somatotopic model was portrayed by the author to the different synaptic contributions to the distinctive motor unit. Our result demonstrated complying with this model, shifting in the area of the motor neuron of the agonist and synergists' capacity of muscle diverse innervations pattern noticed. In the previous observation showed that FCR was controlled by median nerve through the roots C5 and T1 [26] for the movement of Flexion and abduction and FCU was controlled by ulnar nerve through the roots of C8 and T1 for the movements of flexion and adduction.

The lower arm muscle on work – particularity, which depends on their biomechanical capacities, has crucial function in reasonable applications for lower arm strength preparing and wrist dependability. For enhancing biomechanical task efficiency, the increase of muscle strength and size is necessary (hypertrophy). This is achieved by forcing the muscles over its myofibril – specific threshold [27]. When the muscles are activated in agonist function the highest mechanical myofibriller stimulation of the pic out muscles will be fulfilled.

Based on size principle of muscles [28], due to lower-threshold motor unit activation of synergist activation FCU was abduction (45%) and ECU during abduction (37%).

Our research has some limitation; we considered only five muscles in the forearm like FCR, FCU, ECR, ECU and APL. For better comprehension of innervations example of wrist muscles on strength preparing exercise, EMG recording of confined and dynamic movements is important.

5. Conclusion

From our result each forearm muscle produces significantly high level activation when it is actuated in its agonist work contrasted with its synergistic capacity. Therefore selective movements direction decides the highest activity of forearm muscles for strength training. To acquire desired raise of strength and joint stability of forearm muscle and wrist joints the physician want to know the innervations pattern of each forearm muscles follows its neuro mechanical response. The training in extension movements enhance the extensor muscles to balance the flexion force hence wrist joint stability improvement.

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