Surface EMG Analysis of Forearm Muscle Activation at Various Grip Positions

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ABSTRACT

Grip is used daily in almost every activity of daily life, from opening a door to moving furniture. Conditions such as synovitis, arthritis, volar plate fractures, and tendon rupture can all have a negative effect on the ability of an individual to grasp objects. The purpose of this experiment was to statistically analyze the myoelectric activation of the muscles responsible for flexing and extending the fingers, as well as the pulling capability of the upper extremity during an overcoming isometric contraction. The half crimp and open crimp grips are two common grip positions used to grasp edges. In this study, the Avanti EMG electrodes by Delsys Inc. were used to collect EMG signals from the right arm of a 21 year old healthy male with no relevant past medical history of the upper extremity. A statistical analysis was performed to observe the differences in activation between the muscles used during different grip positions. Future studies will include more subjects, bilateral observation, as well as a greater variety of grip positions. This data may be used by physicians as well as those seeking prehospital instruction as to what grip positions they may need to avoid in order to reduce stress on their musculoskeletal system during injury rehabilitation.

INTRODUCTION

Throughout an individual's daily life, they may use a variety of grip positions to perform basic tasks. Some examples of these would be carrying bags, opening a door, and moving objects such as furniture. The completion of these Activities of Daily Life (ADL's) requires a certain amount of force production potential from various muscles of the forearm.

This paper seeks to quantify the difference of major muscle activation between the forearm flexors and extensors during the performance of various grip positions under a variety of loads [2]. In addition, it will determine the average amount of force necessary to complete basic tasks [3]. Applying these findings will allow physical therapists, physicians, and coaches to assess the level of activation that is necessary for an individual to successfully perform tasks without injury [1].

METHODS

EMG signals reflect electrical activity in the muscle over time. During a muscle contraction, minute chemical changes occur and cause small currents to flow through the muscle. These currents are measured in microvolts (μV). An increase in μV positively correlates with the contraction strength of the muscle

Grip Positions:

The two grip positions chosen for this experiment were the half crimp (HC) and the open crimp (OC). The HC grip is characterized by full extension of the wrist, hyperextension of the Distal Interphalangeal joint (DIP), and full flexion of the Proximal Interphalangeal joint (PIP). This may be used when grasping small edges of minimal depth. The OC grip is characterized by minimal extension of the wrist, as well as mild flexion of all phalangeal joints. This grip may be used when grasping larger edges that have a moderate to high coefficient of friction, meaning slipping would not be an issue.

EMG Placement:

Data was collected using a Trigno wireless EMG system. Muscles were selected for measurement based on their involvement in the grip positions and action of the upper extremity. The sensors were placed on the muscle belly of the subject's Flexor Digitorum Superficialis (FDS), Brachioradialis (B), and Extensor Digitorum (ED), as shown in Figure 2.

EMG Data Collection:

The test was performed over a 10 second interval in which seconds 6-9 were taken for data collection. The RMS value of the EMG amplitude was taken to represent the myoelectric activity of the muscle.

Force Data Collection:

Force data was collected using a Bluetooth strain gauge produced by Tindeq. The gauge had a sampling frequency of 80Hz with a precision of 0.15 Kg. Upon exertion of force, the data was sent from the device to a smartphone via Bluetooth, where it was saved and uploaded. The subject was tested at Maximum Voluntary Contraction (MVC), 30% MVC, 20% MVC, and 10% MVC for their force production.

As shown in Figure 1, the subject instructed to take a seated position and grasp the testing edge with their feet anchored on the bar. The subject then received a 10 second count after they had indicated that they were prepared. They would gradually increase force until they reached the target level of force at the 6 second mark; this level of force would be sustained until they were past the 9 second mark.

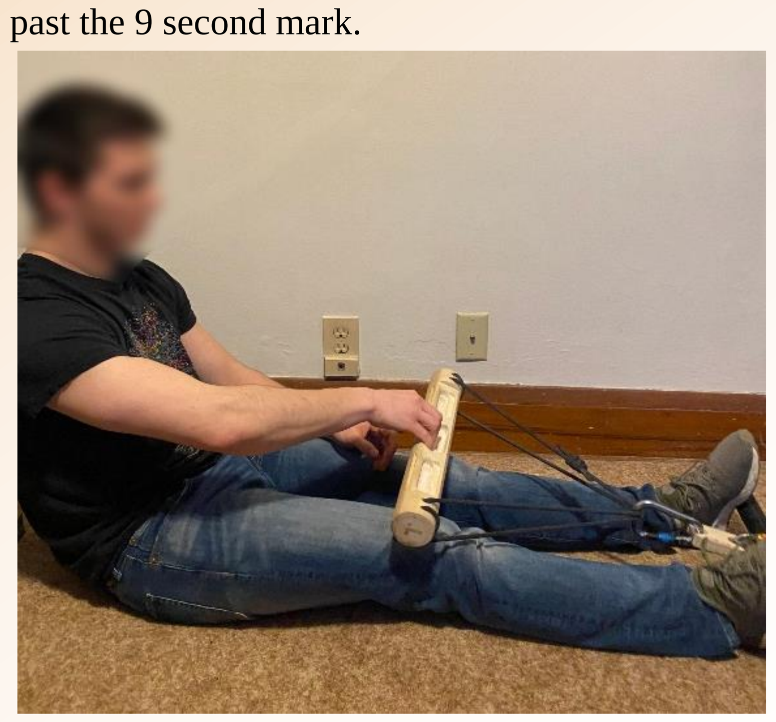

Figure 1: Subject in the testing position

Figure 2: Flexor Digitorum Superficialis on left, Brachioradialis in middle, Extensor Digitorum on right

RESULTS

Figure 3, 4, and 5 demonstrate the data obtained from the EMG recording, as well as its analysis

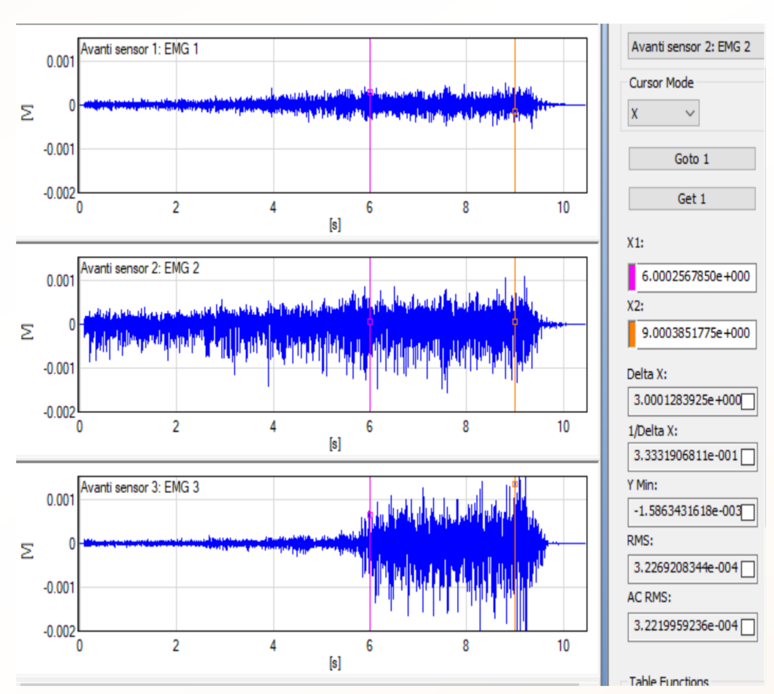

Figure 3: Example of EMG signals obtained from the subject. Cursors indicate the interval over which data was collected

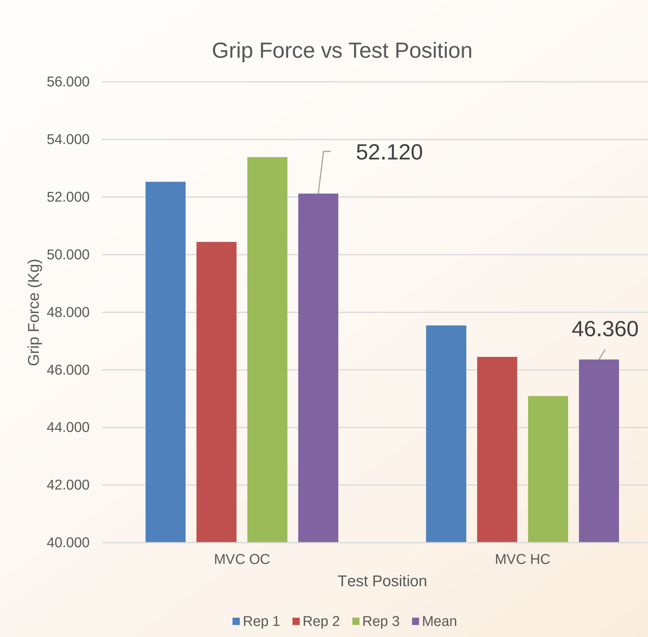

Figure 4: Bar graph of the mean grip force exerted vs the testing position of the fingers

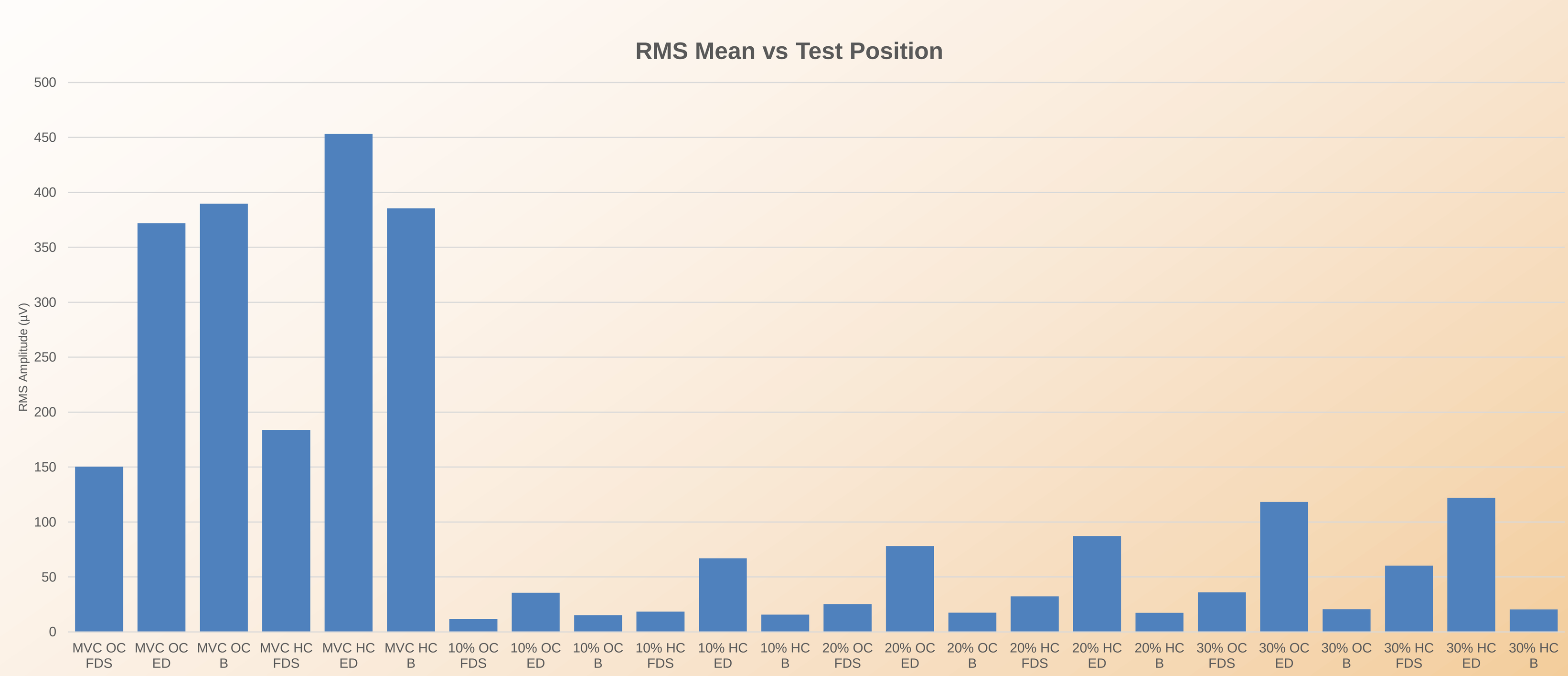

Figure 5: Bar Graph of the Mean RMS amplitude collected from the EMG sensors attached to the subject in each of the tests

Following the procedures outlined in the methods section, the RMS data was analyzed and compared. It can be observed that for both the ED and FDS muscles, there is significantly greater activation in the HC position than in the OC position. In contrast, for the B muscle, the ratio is nearly 1 for all tests and remains consistent across all tests.

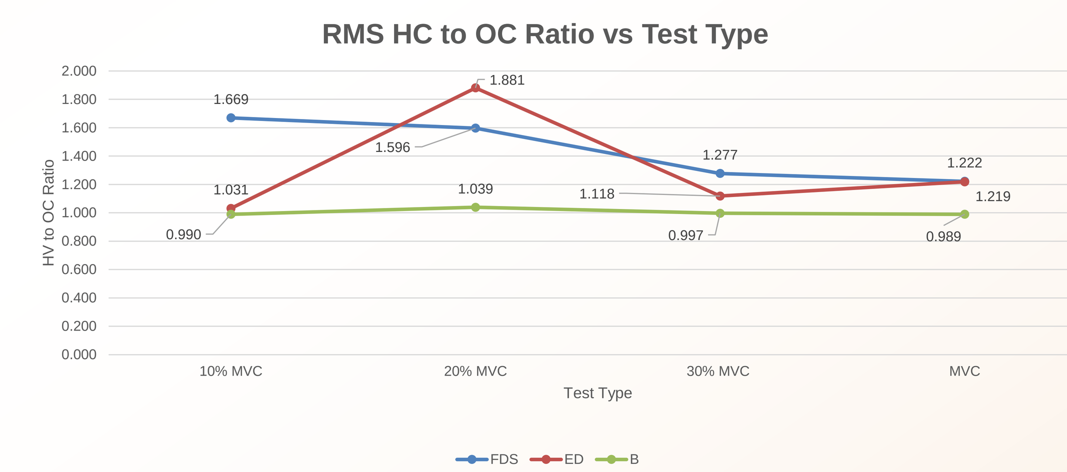

Figure 6: Line graph of the measured RMS signal ratio between the HC and OC finger positions vs the test type

DISCUSSION

The HC grip position was not as capable of producing as much force in the MVC test, as shown by Figure 4. An interesting phenomenon of this position is that although there is 11.05% lower force production, there is a higher amount of myoelectric activation of both the ED and the FDS, as evidenced by Figure 6. The MVC test showed that both the FDS and the ED exhibited 22% and 21.9% greater activation during the HC position than the OC position, respectively. Some reasons as to why there is lower force production may be related to the fact that there is greater counteractive force production via activation of the antagonist or that there is suboptimal myosin head attachment in the sarcomeres of the muscle; this would be a product of deviation from the longer resting length of the muscle when the HC grip position is brought into full contraction.

There was 11% less activation of the Brachioradialis during the MVC test in the HC than in the OC position. This may be explained by the fact that the lesser amount of force exerted on the testing edge in the HC resulted in autoregulation of the elbow flexor. If the Brachioradialis was to exert more pulling force, thus greater activation, the muscle tension would surpass the isometric force production potential capacity of the FDS. This would result in eccentric movement or the muscles and compromise the grip position.

A patient who has undergone surgery of their phalangeal joints, finger flexors, or extensors must be mindful of how they use their fingers. The evidence of this experiment suggests that the patient should avoid using the HC grip, and instead use the OC grip. This is due to the fact that the OC grip is capable of producing more force with less muscle activation, therefore, reducing joint reaction force and tension within the connective tissues, as well as the FDS and ED muscles.

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SOURCES

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