Electromyography (EMG) and Hand Gripping Force During Standing and Sitting

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Abstract. Musculoskeletal disorders reduced the motion and strength of upper limb muscle, especially when doing a task repeatedly. Evaluation of upper limb muscle strength has been commonly conducted using hand grip strength measurement. Previous studies had explored Electromyography (EMG) and hand grip strength but when studies related body postures, only hand grip strength method was considered. However, previous studies involved the effect of body postures on upper limb muscle strength only focused on hand grip strength method, not EMG. The aim of this study is to investigate the effect of EMG time domain during standing and sitting while gripping in order to identify the postures that are riskier for musculoskeletal injuries. Three feature extraction namely root mean square (RMS), mean absolute variance (MAV), and variance (VAR) were used to represent the EMG. Based on the result, the responses of 0.118 μV, 0.0613 μV, and 0.0139 μV were recorded at sitting position while 0.1455 μV, 0.0843 μV, and 0.0148 μV were recorded at standing position, for respective feature extractions. It shows that the response value of EMG changed for different body postures. To conclude, the body posture is crucial when conducting the upper limb studies for both hand grip strength measurement and EMG.

1. Introduction
Musculoskeletal injuries contribute to the weakness and fatigue of the upper limb motion and muscle strength [1]. This condition happens when a task was done repetitively. Any activity that was performed for a long time in the same body posture could also cause back and neck pain. Musculoskeletal disorders among student have become one of the high-risk sufferers from musculoskeletal injuries. Handgrip strength measurement is very common for upper limb muscle strength evaluation [2], which is a very useful method for rehabilitation [3] and in the clinical setting [4]. Managing the hand grip strength from different posture helps the patient recover back their maximum strength to perform activity daily live (ADL), work skills, skills that you want to develop. Static posture does not require active movements such as standing and sitting while dynamic posture is for active movement activities such as jogging and walking [5]. Usually, the hand grip dynamometer was very popular among the researcher and unfortunately this type of hand grip strength does not available in rehabilitation because of costly. The digital hand grip was the alternative for the measurements, not to mention these types are low cost and convenient at the rehabilitation and laboratory [6]. Generally, the alternative hand grip has some
disadvantages with lack in some function compared to the high cost one. So, this study was performed with EMG with the hand grip strength to produce better performance in data collection and hopefully it covers the lack of function in digital hand grip strength. EMG is a method that is commonly used to measure and record the electrical signals produced when forearm or upper limb muscles are doing activities that involve gripping [7]. EMG had been known as the gold standard for the research of muscle contraction [8]. As a result, many recent advances using EMG developed for a better improvement, such as using a machine learning or classification method as well as multimodal measurements. Thus far, one of researcher conducted a study to increase the clinical evaluation by using programming platform based on EMG and also performing the hand grip strength exercise [9]. As the conclusion, hand grip achieved 40.2% of increased performance than normal hand grip strength method while gain higher motivation to recover without having stress.

Factors influencing hand movement either forearm, wrist, grasping or finger have been explored in several studies. Also, other studies discussed about the prediction of hand grip force with extreme learning machine (ELM) using EMG from different forearm muscle and then compared with another two features which are support vector machine (SVM) and multiple nonlinear regression (MNLR) [10]. The output was useful on prediction hand grip force of myoelectric prostheses. Feature extraction is the transformation from raw data to dataset with reduced number of variables that are manageable when processing is run. Feature extraction also a process to reduce the error in classification process thus increases the accuracy while computation time decreases significantly [11]. EMG signals have three types of features extraction which are the time domain, frequency domain and also on time frequency domain [12]. Up to now, a few studies have been using time domain features to detect muscles from upper limb muscle movement [13] because they have good discrimination power and are less computationally intensive [14]. The difference of posture produces of result of Root Mean Square (RMS) [15] and Mean Absolute Variance (MAV) had been used by [16], were it values measured by EMG signal amplitude in a segment.

Previous studies concentrating on the use of smartphones repetitively for a long period have reported that it can lead to musculoskeletal injuries [17, 18]. Furthermore, the high usage of smartphones is now led by the COVID-19 pandemic whereby most classes, conferences, and workshop are now being conducted online. A recent study by Radwan et. al [19] reported on the impact of hand grip strength among the younger population when using smartphone repetitively with fixed body postures as their activity daily lives (ADL). In most of the studies, Electromyography (EMG) analysis was used to investigate the activity of the muscle and the relation with musculoskeletal injuries. A study had reported the comparison among students with and without chronic neck-shoulder pain using different hand posture while texting either using one or two hands when handling smartphones and while typing on a computer [20]. Kim et. al [21] in another study found that there was muscle activity response recorded by the EMG during sitting and standing when using a smartphone. These studies investigate the comparison between the handling’s techniques of a smartphone and to identify the method that causes fatigue and muscle weakness due to a repetition that leads to musculoskeletal injuries. To the best of our knowledge, there are several reports on the musculoskeletal injuries and hand grip strength (HGS) using EMG. The aim of this study is to investigate the effect of EMG time domain during standing and sitting while gripping and to identify the postures that are riskier for musculoskeletal injuries. The findings from this study will create awareness among the students to improve their body postures while handling their smartphones.

2. Methodology

2.1. Data acquisition
The subjects were recruited among students from Universiti Teknologi Malaysia (UTM). They were two males aged 23 and 29 years old, weighted 90 and 80 kg with height 189 cm and 160 cm respectively. The consent form and medical form that contain a few questionnaire are prepared for subjects before the experimental process begins. By completing the questionnaire, subject’s dominant hand is identified
for gripping exercise to measure the hand grip strength. Subjects were excluded if they reported any type of disease, upper limb dysfunctional, or perform any surgery at the upper limb for 3 months. Three electrodes are placed on the subject’s skin i.e. on extensor carpi radialis muscle (ECR), flexor digitorium superficialis (FDS) and a reference electrode is placed on the bone on your wrist as it cannot produce any electrical activity. Then, the subjects are asked to perform the hand grip strength activity with two different body posture i.e. sitting and standing. Data for the hand grip strength are collected using digital hand grip analyser while the data for EMG signals are recorded using BioMedix equipment. When the data collection are complete and useable, the experimental data are analysed. Figure 1 shows the placement of electrodes on the skin of the subject.

![Electrode placements](image)

**Figure 1.** Electrode placements

### 2.2. Hand grip strength measurement

Next, the subjects were asked to perform the hand grip strength activity with two different body postures, which were sitting and standing. The hand grip measurement was conducted according to the standard posture protocol of American Society Handgrip Therapy (ASHT). The standard protocol for body posture is sitting position. The subjects were seated with shoulders adducted and neutrally rotated, the elbow was flexed at 90°, while the forearm and wrist at standard position [22]. For standing position, the elbow was fully extended, with the wrist at a neutral position. A digital grip analyser (MIE Medical Research Ltd, Leeds, UK) was used for hand grip strength estimation grasping force. The handle of the analyzer was adjusted to suit the hand of the subjects. For the strength test, the grip span was set at 1.0 cm. Strength tests were repeated three times and 5 s for each test. The average value of the measurements was used as the strength value. The subjects rested between the tests for 2 s to avoid any possible fatigue effect. Prior to actual data collection, participants were allowed to practice with the digital analyzer until the participant could handle properly and understand the instructions. Figure 2 shows the body posture from the experimental setup.

![The body posture experimental](image)

**Figure 2.** The body posture experimental
2.3. **Surface EMG**

The extensor carpi radialis (ECR) muscle and flexor digitorum superficialis (FDS) muscle and of the forearm are the common forearm muscles that contribute to gripping task of handgrip strength [23]–[26]. The flexor produces higher value than extensor during gripping task [27]. Prior to data collection, the skin needs to be properly prepared so that it can provide good signals and to avoid various of noise. Before applying electrodes on the skin, the skin surface must be cleaned using alcohol wipe and allow to dry. The classification using various features can be achieved by analyzing using Matlab R2017 b software. In order to obtain good signal and prevent from noise, filtration needs to be done using high-pass filters which are the appropriate method for filtering process. Therefore, for this study a set of features is extracted to characterize the EMG data for classification of the intended movements. Mean Absolute Value (MAV), Root Mean Square (RMS), and Variance (VAR) are common features that had been used in EMG.

3. **Result & Discussion**

The result shows three features extractions namely Mean Absolute Variance (MAV), Root Mean Square (RMS) and Variance (VAR). Figure 3 shows the number of repetitions during sitting and standing with respect to number of repetition. The value of repetition on 1 second to 5 second, 9 second to 13 second and 17 second to 21 second of Root Mean Square (RMS) at sitting which are 0.0189 μV, 0.0948 μV and 0.118 μV respectively and at standing which are 0.1204 μV, 0.1215 μV and 0.1455 μV respectively.

Then, for value of Mean Absolute Value (MAV) at sitting which are 0.012 μV, 0.0522 μV and 0.0613 μV respectively and at standing which are 0.0743 μV, 0.0685 μV and 0.0843 μV respectively. Lastly, value of Variance (VAR) at sitting which are 0.0003 μV, 0.009 μV and 0.0139 μV respectively and at standing which are 0.0145 μV, 0.0148 μV and 0.0148 μV respectively.

A t-test were performed and found that there is a statistically significant difference between every repetitions time with three feature extractions (p < 0.05) for different body posture. Based from Figure 4 and 5, the result shows the feature extractions values with respect to body posture while gripping activities are performed to compared which features were better although the result produces with small number of values only. Furthermore, there is a statistically significant difference between standing and sitting posture (p < 0.05) for the three feature extractions. Furthermore, there is a statistically significant difference between standing and sitting posture (p < 0.05) for the three feature extractions. Figure 6, 7, and 8 showed the raw signal of Mean Absolute Variance (MAV), Root Mean Square (RMS), and Variance (VAR) when both muscles are measured by EMG.

![Figure 3. The VAR, MAV and RMS values of experimental repetition at three time-domains (5 sec for each repetition) (a) sitting; (b) standing](image-url)
Figure 4. The effect of different body postures on the three feature extractions; VAR, MAV and RMS (a) ECR; (b) FDS

Figure 5. The effect of different body postures on the three feature extractions; VAR, MAV, and RMS (a) ECR; (b) FDS.

Based on the raw signal Figure 6, 7 and 8, the amplitude reaches the maximum at early stage for both muscles because the subject started to grip with maximum hand grip strength at early stage of the experiment. Furthermore, the signal amplitude decreases during gripping for a long time. This happen because the frequency of the signal is changing over time [28, 29]. Based from Figure 6(b), 7(b) and 8(b), FDS produced significantly higher amplitude than ECR during the gripping task as shown in Figure 6(a), 7(a) and 8(a). This prove that the extensor and flexor muscles had slightly different characteristics [27, 30].
Figure 6. MAV raw signal for (a) ECR; (b) FDS

Figure 7. RMS raw signal for (a) ECR; (b) FDS.
The repetitions when doing the gripping task are particularly important for performance accuracy to provide the highest test-retest reliability. The values of feature extractions increased as the number of repetitions increased. This happen because from previous study, the researcher stated RMS produces values related to the force and postures [11]. The MAV has higher than RMS because it has a good characteristic that can represent the EMG accurately [27]. It is observed that both subjects performed poorly during the first measurement of the hand grip strength and apparently did not use their maximum strength for the gripping task. After the subjects are comfortable with the handle, the gripping performance increased for next two trials. From a previous study, an investigation was conducted on the relationship between the feature extraction with the difference weight of dumbbell but using difference muscles [31]. The result shows that the value of feature extractions have responded differently with the different body posture although the values is small. This study shows that EMG for upper limb studies can produces slightly difference values while standing and sitting and not only studies regarding relationship hand grip strength and postures. The raw data shows that both muscles had slightly difference characteristics between them because the FDS muscle had slightly higher peak value signal than ECR. In this study, the flexor produces higher value than extensor that can be can prove by previous study that during gripping task had significant value between the muscles [26]. Based on the raw signal, subject male and the both muscles start to contract at 2.5 because they start to grip using the hand grip strength with maximum at 2.5 s.

4. Conclusion
In conclusion, the upper limb muscle strength was significantly affected by different body postures; standing and sitting, based on EMG analysis. EMG can produce significantly different values based on three feature extractions namely RMS, MAV and VAR. The results also showed that gripping force during standing posture was significantly higher than the force during sitting. There are several limitations in this study which include a small sample size as there were only two males subjects that participated in this experiment; only standing and sitting postures were tested and the task only involved the gripping force according to the standard protocol with no difference angle of the upper limb.

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