

ORIGINAL ARTICLE

Application of Electromyography Technology to Predict Chronic Diseases for COVID-19 Patients

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Abstract

Purpose: Electromyography (EMG) is widely used to measure grip strength to evaluate neuromuscular activity, and thus it is possible to predict the health status of the heart muscle of those infected with the Coronavirus (COVID-19) and the extent of its relationship according to gender and age.

Materials and Methods: Fifty participants, equally divided between males and females, ages 18 to 65, were recorded for muscle force in kilogram and potential for action signal in mV (3-10 KHz) using skin surface EMG models with grip strength data acquisition. The outcomes were then compared to the volunteers' health status, familial relationships, case history, and history of COVID-19 variation infection.

Results: Based on the analysis of recorded data related to force, frequency, intervals, and amplitude, it was found that females exhibited a significant variation ($p < 0.05$) in force and frequency over 5 minutes, in contrast to males, who showed a significant variation ($p < 0.05$), particularly after 3 minutes when both genders showed signs of fatigue. However, certain chronic diseases such as hypertension, diabetes, and sudden deaths may have contributed to these variations. Particularly, SARS.CoV-2 variant infection showed a significant variation ($p < 0.05$) in the EMG result for the delta variant more than the omicron for females and more impact in male smokers.

Conclusion: Findings indicated that EMG testing can predict the likelihood of Cardiovascular Disease (CVD) disease and health status based on a family history of chronic diseases like hypertension, diabetes, and CVD, which are independently connected to COVID-19 variant infections in both genders.

Keywords: Chronic Diseases; Electromyography; COVID-19; Corona-V Variant; Cardiovascular Disease.

1. Introduction

Many previous papers have proven that Electromyography (EMG) signals are a helpful tool for assessing muscle activation [1]. A popular technique for measuring and logging the electrical signals generated by gripping activity in the forearm or upper limb muscles is called EMG. In order to improve performance during data collection, this strength measurement is often used for EMG assessments of upper limb muscular strength and hand grip strength. It should address the deficiency in digital hand grip strength [2, 3]. Using EMG data from several forearm muscles, the Extreme Learning Machine (ELM) predicts the handgrip force. Such prediction is compared to two additional features: Multiple Nonlinear Regression (MNLR) and Support Vector Machine (SVM). However, three different feature extraction methods are available for EMG signals: time domain, frequency domain, and time-frequency domain [4, 5]. Simplified two-channel skin surface neurotransmitter capacity to identify nerve hyperexcitability Bipolar surface recording of neurotransmitters is a quick, inexpensive, and noninvasive method of gathering data on muscle activation. EMG can readily assist in the patient selection process for prospective treatments aiming at mitigating acute symptoms in Oxaliplatin-Induced Neurotoxicity (OIN), [6, 7].

Few pieces of research have looked at the relationships between muscle strength and all-cause mortality in patients with hypertension as well as Cardiovascular Disorders (CVD). Male participants, however, did not exhibit any comparable outcomes with hypertensive individuals [8]. The connection between handgrip strength and CVD has yet to be well-established in research [9]. Furthermore, handgrip strength was linked to heart and blood vessel mortality in males rather than women, according to a recent UK Biobank study [10]. Several research institutions have shown grip strength to be a better predictor of all outcomes than systolic blood pressure, particularly in terms of morbidity and death in certain circulatory system illnesses. Moreover, grip strength was ultimately discovered to be closely related to lung function tests, respiratory muscle strength, and other possible risk factors. In certain patients, there may

even be a connection between handgrip strength and the severity of COVID-19 [11-13].

An analysis of grip strength in males and females at all ages reveals that men have stronger grips, while an analysis of grip strength by age group shows that both genders' grip strength peaks around the age of 40 and then gradually declines after that.

2. Materials and Methods

Fifty participants (25 males and 25 females) in good health who were between the ages of 18 and 21 showed the type of EMG with muscular strength in the forearm muscles in the processing of reading the topic utilizing a non-invasive surface EMG frequency of 3 to 10 KHz (IWork IWX/214 system and LabScribe software-USA). This survey was conducted after the COVID-19 pandemic at Basra University. A motor unit is made up of every muscle fiber that is supported by a single motor neuron. A continuous muscle contraction involves the recurrent operation of multiple motor units. The quantity of motor units in a muscle that are activated simultaneously determines the force of the muscular contraction. When a muscular contraction occurs, an EMG is recorded. These vibrations resemble seismic signals captured during an earthquake, and their duration roughly corresponds to the period of the muscle contraction. The quantity of electrical effectiveness in a muscle is directly symmetric to the force of a striated muscular contraction. However, if the raw EMG data is processed, it becomes simpler to identify electrical activity in muscles. The integration of the absolute values of the EMG signal amplitudes is one of the most used transformations. It has been discovered by this transformation that the strength of the muscle contraction is linearly related to the area under the graph of the absolute integral of the EMG.

With the electrode stick on the forearm and the individual's handedness forearm resting on the tabletop, the person should sit quietly. The electrode on the wrist is linked to the green "C" lead (the ground), the electrode in the center of the forearm is connected to the black "-1" lead, and the electrode close to the elbow is linked to the red "+1" lead as depicted in Figure 1.

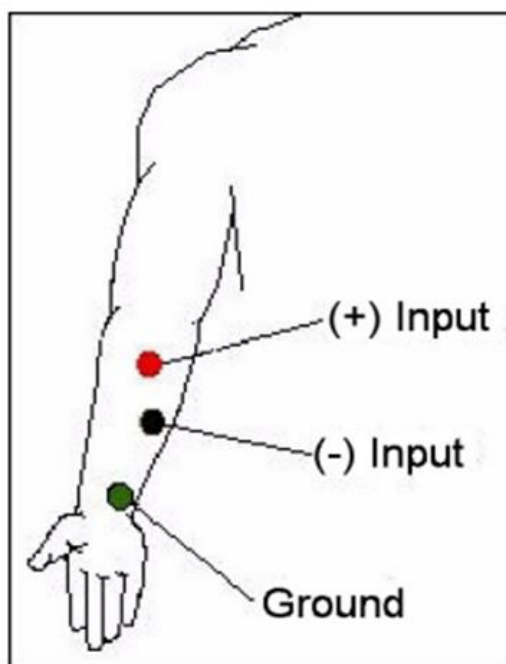


Figure 1. The electromyography electrode connections on the forearm

Five times, participants clench their first around the hand force device (dynamometer); each contraction lasts for 2 seconds, followed by a relaxation period of two seconds. The final contraction must be at maximum strength, as illustrated in Figure 2, and each subsequent contraction should be around 2, 3, and 4 times harder than the first contraction.



Figure 2. The electromyography dynamometer pad

According to the graph's parameters, the one-way H test analysis (Kruskal-Wallis) of variance (ANOVA) was employed to evaluate if there were any statistically significant differences between the group and patient means.

3. Results

We paid close attention to the connection between force, frequency, amplitude, and duration [14], as depicted in Figure 3 when analyzing the EMG of participants.

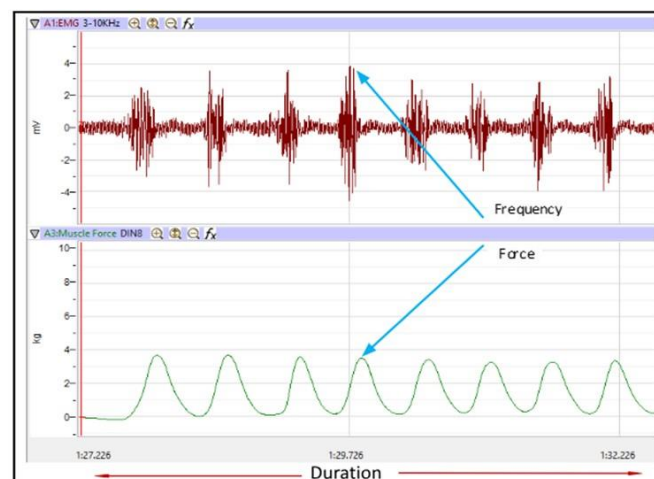


Figure 3. Show the EMG chart with frequency and force waves

To find out if any significant differences appear between the male and female grip strength EMG force and frequency test, a Kruskal-Wallis nonparametric one-way ANOVA test is performed, as indicated in Table 1.

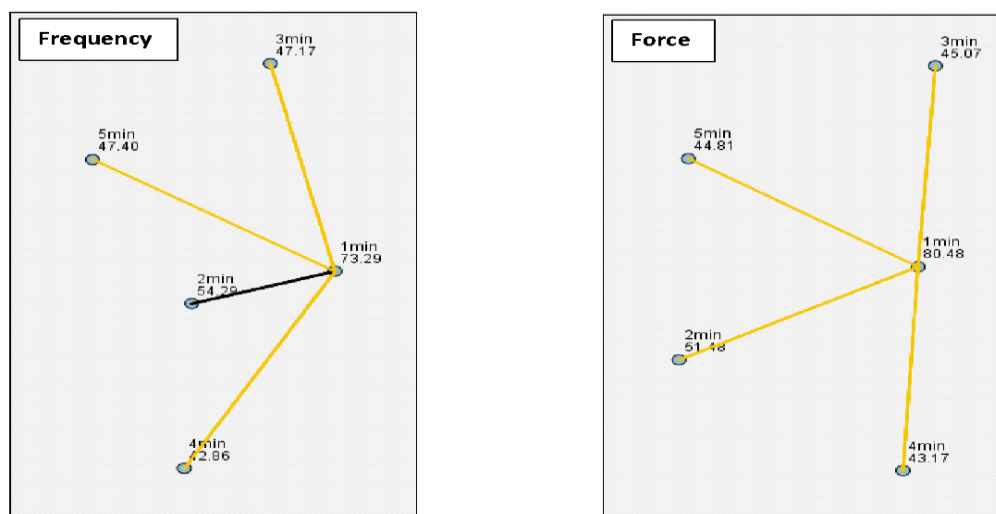
When the hand muscle contracts and relaxes while gripping strength movement from 1 to 5 minutes (3.114 – 1.708 mV) of record. Table 1) explains the normal distribution for selectively reading of muscle with nerve frequency in females. The variation in results is similar for males (2.854 – 1.487 mV). In contrast, the force value for the same period in males does not seem to change significantly, except the first minute (2.459 kg). In females, force amplitude is seen from 2 to 5 minutes (2.45-0.9 kg), excluding the first minute (2.45 kg).

Additionally, the force value indicates a significant difference (P value <0.05) between the one-minute frequency and the 3 to 5-minute record times (average range 73.29, 47.17, 42.86, and 47.4 correspondingly) as well as between all record times 1, 2, 3, 4, and 5-minute at the same tempo. The significant differences (P value <0.05) between these combinations were made clear by the interaction average rank of the group amongst females, as illustrated in Figure 4.

Table 1. One-way ANOVA test (Shapiro-Wilk) for electromyography (EMG) records of men and women

Parameter	Time	Male		Female	
		Mean/SDs	<i>P value</i>	Mean/SDs	<i>P value</i>
Frequency mV	1 min	2.854 2.203	0.001*	3.114 2.089	0.000*
	2 min	1.974 1.946	0.009*	2.37 2.337	0.000*
	3 min	2.287 2.07	0.008*	1.613 2.17	0.000*
	4 min	2.054 2.280	0.001*	1.417 2.004	0.000*
	5 min	1.487 2.14	0.000*	1.708 2.31	0.000*
Force Kg	1 min	4.043 1.256	0.136	2.459 0.972	0.256
	2 min	2.881 1.419	0.114	1.1756 1.1897	0.005*
	3 min	2.498 1.383	0.225	0.902 1.1211	0.000*
	4 min	1.959 1.671	0.082	0.871 1.152	0.000*
	5 min	1.67 1.614	0.018*	0.922 1.1878	0.000*

* The mean difference is significant at the 0.05 level

**Figure 4.** Comparing frequency and force variables in females at different dates in a paired manner

Male results contrast, as [Figure 5](#) illustrated, particularly in frequency, where no discernible variation was found. Nonetheless, there are clear variations in force values (average range of 54.28, 45.11, and 25.07, respectively) between 1, 2, and 5 minutes.

[Table 2](#) indicated that there was no discernible difference for some time in both males and females with respect to the asymptotic significance (T-test value) between them in the intervals (mean 164)

Table 2. The t-test for distribution between men and women

Time	Mean	SDs	<i>P value</i>
1 minute	3.006	2.110	0.485
2 minute	2.205	2.162	0.825
3 minute	1.894	2.126	0.202
4 minute	1.682	2.116	0.252
5 minute	1.616	2.212	0.825
Intervals	164.694	94.332	0.03

* The mean difference is significant at the 0.05 level

between each frequency amplitude and records of force (P value <0.05).

Table 3 presented the comprehensible results of bioinformatics in the context of men's and women's family history and chronic disease and SARS.CoV-2 infection for volunteers.

Table 4 displays the results of the chi-square test used to analyze a family case history with volunteer infection records with COVID-19 variations.

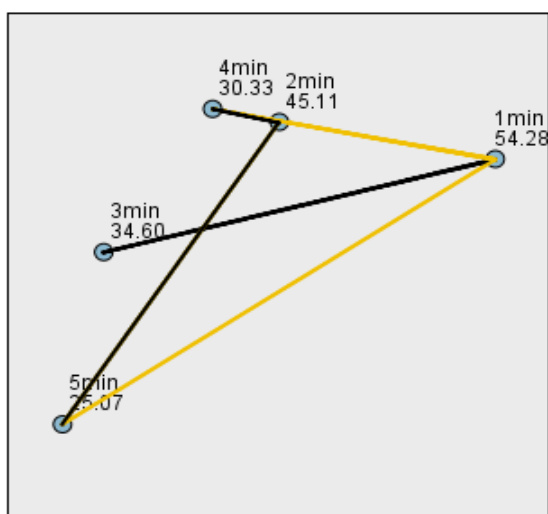


Figure 5. A pairwise comparison of the male force factor times

For males with a family history of sudden death, the above table explains the significant differences (Pvalue <0.05) in some chronic conditions like diabetes and hypertension. However, there is a significant difference (P value <0.05) in the volunteers' COVID-19 infection history, particularly in first and Delta variant infections, but not in Omicron. In the familial case history, Omicron infection only manifests a markedly different pattern in females compared to other variants and equivalent outcomes in males. Because smoking is considered unethical in Iraq, smoking is a significant factor for both males and females.

4. Discussion

The frequency amplitude in females achieves its ultimate at an early stage (1 minute) for muscles (mean 3.1 mV), according to Table 1 data, because the subject started to grab the maximum strength of the grip early in the experiment. Additionally, during the prolonged grasping period, the signal amplitude falls (mean 1.7). However, in males, it varies throughout the entire five minutes (means 2.854, 1.97, 2.28, 2.05, and 1.48 mV) in a sequential manner. This is due to the signal's fluctuating frequency over time [15, 16].

Table 3. Families case history and SARS.CoV-2 infection report

No.	Age	Family chronic diseases				Case COVID-19 infection			Smoker status	
		heart	hypertension	thrombus	diabetic	1st	delta	Omicron	Sudden death cases	
1	46	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No
2	45	Yes	Yes	Yes	No	No	No	Yes	No	No
3	19	No	Yes	Yes	Yes	Yes	No	No	Yes	No
4	19	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	21	No	Yes	No	Yes	No	No	Yes	Yes	No
6	21	No	Yes	Yes	Yes	Yes	No	No	No	No
7	20	No	Yes	No	Yes	Yes	No	No	Yes	No
8	20	No	Yes	No	Yes	Yes	No	No	Yes	No
9	21	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
10	22	No	Yes	No	Yes	Yes	No	No	No	No
11	21	Yes	Yes	No	Yes	Yes	No	No	No	No
12	28	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
13	61	No	No	No	No	Yes	No	No	No	No
14	21	Yes	Yes	Yes	Yes	No	Yes	No	No	No
15	46	No	Yes	Yes	No	Yes	No	No	No	yes

Table 4. Chi-square analysis of the COVID-19 infection data and the case history of the family

Family case history		Male <i>P value</i>	Female <i>P value</i>	Interaction <i>P value</i>
Heart disease		0.796	0.827	0.150
Hypertension		0.001*	0.005*	0.776
Thrombosis complications		0.439	0.275	0.547
Diabetics		0.004*	0.005*	0.704
Sudden death		0.004*	0.127	0.751
Volunteer COVID-19 infection	1 st variant	0.02*	0.127	0.505
	Delta	0.02*	-----	0.324
	Omicron	0.071	0.001*	0.547
	Smoking	0.796	-----	0.018*

Graduation diminishing with a pronounced gender disparity was an important force. The findings unequivocally demonstrated that, in comparison to females, males had lost more strength by the conclusion of the work than had the baseline. Variations in fatigue resistance between genders are prevalent [17]. That hypothesis is supported by the fact that males showed greater utter strength than females for both wrist flexion and extension. Scientists discovered that in other muscles, such as the tibialis anterior [18], a comparable relationship may be seen between final strength and force stability. Stronger men have more blood flow obstruction during more intense contractions, which causes metabolites to accumulate more, oxygen to be depleted, and contractions to last longer. It is worth noting that numerous studies have investigated the association between grip strength and cardiovascular outcomes, including hypertension. Some of these studies have reported significant findings indicating that lower grip strength is associated with an increased risk of cardiovascular events, mortality, and death, particularly in hypertensive individuals.

The strength and significance of these correlations can vary across different studies, as they are influenced by factors such as sample size, study design, follow-up duration, population characteristics, and statistical methods used. Additionally, the presence of gender differences in these associations has been reported inconsistently in the literature, with some studies suggesting that the relationship between grip strength and cardiovascular outcomes may differ between males and females. This is because, depending on the forces generated within the muscle, there will always be some blood flow obstruction to the working muscle during a contraction [19].

At both 30% and 75% of the maximal contraction, the EMG was higher in females, and it increased in direct proportion to the effort's intensity. The intensity of the exertion affects how long it takes to become exhausted [20]. In both male and female slender persons, higher final grip strength was linked to a lower risk of type 2 diabetes, while in the same group, diabetes was linked to lower skeletal muscular strength and quality [21-23]. However, a number of studies have demonstrated the correlation between grip strength and a range of metabolic dysfunctions, including central adiposity risk, dyslipidemia, hypertension, insulin resistance, and impaired glucose tolerance. This correlation may result from the use of absolute grip strength as opposed to non-invasion EMG with grip [24]. A portion of the relationship between grip strength and glucose levels may be explained by exercise. Even after accounting for physical activity, the connection persisted, indicating that the underlying mechanisms may still be in place [25].

At baseline, grip strength and hypertension were assessed. Major CVD and death were monitored concurrently, which is in line with the observation that there is a temporal correlation between hypertensive and normal inhabitance as well as a strong correlation between grip strength and the risk of cardiovascular disease incidence, mortality, and death in hypertensive individuals [26]. In both genders, there is a substantial correlation between the relative handgrip strength and higher levels of beneficial cardiovascular biomarkers. Furthermore, there is a connection between handgrip strength and cardiovascular disorders and nutrition. To ascertain the genuine validity of handgrip strength as a diagnostic and applied approach to identifying

cardiovascular disease risk, studies involving the general population are necessary [27].

The impact of reduced muscle strength on susceptibility to SARS-CoV-2 infection and the severity of COVID-19 illness has been a topic of interest in recent research. Association Between Grip Strength and COVID-19 Outcomes: The researchers found that lower grip strength was associated with an increased risk of severe COVID-19 illness and mortality [27]. The study suggested that grip strength could serve as a simple and accessible tool for risk stratification in COVID-19 patients. Muscle Strength and COVID-19 Mortality: The findings indicated that reduced muscle strength, as measured by handgrip strength, was independently associated with an increased risk of mortality in COVID-19 patients. This suggested that muscle strength could be a potential prognostic factor for COVID-19 outcomes.

Results from recent research are presented along with acknowledged delayed consequences of SARS-CoV-2 infection. In fact, the persistence of clinical symptoms or laboratory abnormalities after the acute phase of the illness has given rise to the term "Long-term COVID." It has also been disputed whether a reduction in muscle strength makes one more susceptible to an infection with SARS-CoV-2 or a more serious illness [28, 29].

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