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Analysis of Grip Strength on Visual Reaction and its Application

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Abstract. In the current study, we adopted a combination of sEMG (surface electromyography) and self-manufactured digital hand grip interfaced with software in order to analyze agility, power, and endurance of grip strength in response to visual reactions. In the results of agility assessment which measures time takes to generate grip strength against visual reaction, it was shown to be 351.7 ± 55.06 ms while an electromechanical delay in the generation of grip strength was demonstrated upon the activation of EMG ($p < 0.05$). Secondly, the power of grip strength was expressed as time takes to reach up to 90% of rising time and acceleration work; as results, the acceleration work was 40.47 ± 13.44 kg/s. Lastly, in the endurance exercise, the medial frequencies of EMG signal of the initiation of exercise and the last one second were 79.42 ± 24.76 Hz and 67.63 ± 20.65 Hz, respectively which was decreased indicating that subjects in the study experienced muscle fatigue during the endurance exercise.

Keywords: Grip strength, Physical ability, sEMG, Visual reaction, Muscle fatigue

1 Introduction

Measuring the grip strength for assessing hand functions possesses own merits in terms of costs and its simplicity, yet it is warranted to develop a novel method with accuracy as well as reproducibility because it is not easy to appraise various hands functions simultaneously [1]. In the current study, we utilized a combination of sEMG (surface electromyography) that is easy to extract signals and able to quantitatively analyze muscular activity and the self-manufactured wireless digital grip in order to quantitatively assess five phases of grip strength measurement, reaction, contraction, maintenance, relaxation, and resting [2]. Furthermore, it has been generally accepted that the processes of visual information account for 80% of all information processes of brain in response to external responses [3], and trainings for concentration improvement utilizing visual reactions are critical components for rehabilitation training in attention-deficit disorder children as well as cognitive development, and improvement of visual attention. Therefore, we measured 1) the agility of grip strength in response to visual reactions, 2) the power of grip strength against momentarily applied force in the reaction and contraction phases, respectively while

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3) the endurance of grip strength was assessed via measuring the degree of maintenance in the maintenance phase. Based on these previous results, we would like to assess hand functions more accurately via implementing the software which quantitatively analyze changes in grip strength in response to visual responses as well as functional contents, encouraging patients to participate hand exercises for agility, power, and endurance.

2 Material and Methods

A total of 10 male participants, 21-29 years old, who do not have any history of musculoskeletal diseases (e.g., shoulder, and arm) were enrolled for the study. Given that grip strength is consisted with a number of joints combinations (e.g., abduction, adduction, and flexion extension of shoulder, elbow and wrist), angles of shoulder, and elbow may result in different grip strength. Therefore, as suggested by the ASHT (The American Society of Hand Therapists), EMG electrodes were attached on the palmaris longus muscle which bends wrist and fingers while the shoulder and elbow angles were being maintained at 0° and 90°, respectively in a seated position.

To pursue various methods for measuring hand grip strength as well as quantitative analysis, the software was developed. Meanwhile implementing the exercise contents (e.g., agility, power, and endurance tests), EMG signals and grip strength were being measured and analyzed. In addition, it was able to measure maximal grip strength, the rising time (i.e., defined as time takes from initiation to point where reaches at 90% of maximum grip strength) and its association with grip strength (i.e., defined as acceleration work), EMG signals and reaction time for grip strength in response to visual reactions, static-endurance which represents the changes in grip strength shown when it was being sustained over a random period of time, and dynamic-endurance which shows how long grip strength can be maintained constantly [4].

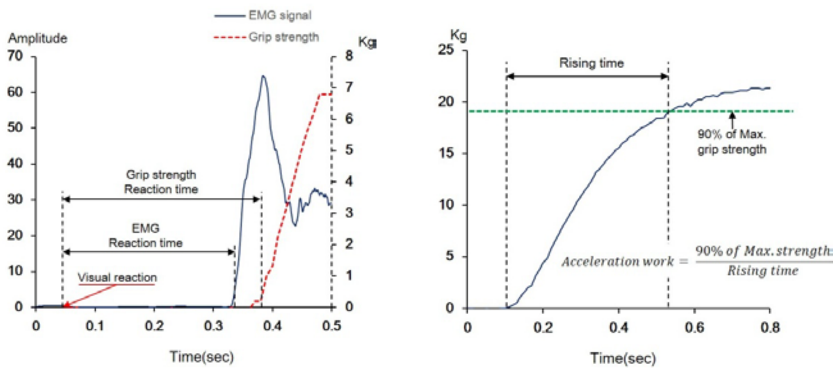
3 Experimental Results

3.1 Results of Agility Exercise Content

For the results of agility exercise content, changes of EMG signals as well as grip strength are shown in the Figure 1(a). Upon the target appeared in the contents, EMG signals and reaction time for grip strength were 304.5 ± 72.7 ms and 351.7 ± 55.06 ms, respectively. As demonstrated, EMG signals were obtained 55.7 ± 18.29 ms earlier than the reaction time of grip strength which was statistically significant ($p < 0.05$). This result indicates that an electromechanical delay might be present in between the initiation of EMG signal activation and generation of actual grip strength [5].

3.2 Results of Power Exercise Content

The Figure 1(b) shows the acceleration work utilizing the rising time which was defined as time takes for a subject to provide 90% of their maximum grip strength. The average of 90% of maximum grip strength was 17.33 ± 3.76 kg while the rising time and acceleration work were 453 ± 126.93 ms, and 40.47 ± 13.44 kg/sec, respectively. Based on these results, power exercise may quantitatively evaluate and analyze differences in power found in motor dysfunction of hands.



(a) (b)

Fig. 1. (a) Changes in grip strength and EMG signals in agility exercise (b) Rising time and acceleration work in power exercise

3.3 Results of Endurance Exercise Content

Results of endurance exercise were summarized in the Figure 2. In results, the average grip strength that maintains for 5 seconds was found to be 17.83 ± 0.53 kg. In addition the static-endurance and dynamic endurance were 98.14 ± 0.04 % and 364.8 ± 110.74 ms, respectively. Upon reached on 90% of maximum grip strength, the EMG signals of first and last one second of endurance exercise were transformed [i.e., FFT (Fast Fourier Transform)]; in results, the median frequencies were 79.42 ± 24.76 Hz and 67.63 ± 20.65 Hz which was decreased. This reduction indicates that subjects in the study experienced muscle fatigue while they were maintaining grip strength for 5 seconds [6].

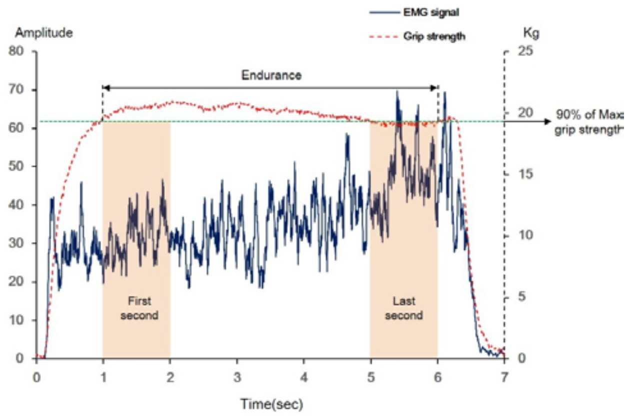


Fig. 2. Changes of grip strength in static/dynamic endurance

4 Conclusions

In the present study, we utilized the self-manufactured handgrip to analyze changes in grip strength as well as EMG signals in response to visual reactions thereby assessing agility, power, and endurance. In addition, we applied various game contents in conjunction with the handgrip so that inducing active participations and interests. While performing contents, subjects' grip strength and EMG signals were being analyzed in real time and then quantified for the analysis of agility, power, and endurance. Firstly, as shown in the results of agility exercise, we were able to demonstrate differences in subjects' concentration as well as hand agility; upon the EMG signal generation, there was an electromechanical delay as well. Second, in the power exercise content, we aimed to assess the power via analyzing the acceleration work using both the rising time and grip strength for more accurate evaluation because it is difficult to evaluate momentary power with rising time only. Lastly, in the endurance exercise content, most subjects represented good static endurance which is defined as ability to maintain certain level of grip strength, and noticeable changes in grip strength was not noted. Therefore, bradykineasia symptoms in Parkinson' disease patients might be quantitatively assessed by virtue of agility and power exercises whereas the endurance exercise content would allow to measure symptoms related with rigidity. Particularly, these might be effectively applied for muscle growth of hand and prevention of wound in rehabilitation trainings while grip strength exercise against visual reactions would enhance upper limb functions in stroke patients as well as brain activation in infants.

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