Research on the Correlation Between Mechanical Stimulation and sEMG Signals of Human Body

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Abstract: The correlation between Mechanical stimulation of human body and sEMG signals is discussed. Based on a multi-information sampling system, the mechanical stimulation and sEMG signals of human body can be obtained. The results indicate there is a remarkable relationship between the mechanical stimulation and sEMG signals, and may provide theoretical basis and significative information for finding out the mechanism of massage that massage could improve muscle performance.

Key Words: Mechanical stimulation, sEMG, Correlation, Human body

1 INTRODUCTION

Certain mechanical stimulation on human body surface will cause a variety of physiological parameters of human body to change. It is of great significance to study the correlation between mechanical stimulation and human muscle, nerve, blood and other systems. Many studies at home and abroad have shown that mechanical stimulation will have a significant effect on the electrical signals of related human muscles[1-4]. The study of Verena Kise Capellini found that certain mechanical stimulation (Massage) causes pain relief and electromyographic (EMG) change[5]. Harsimran S. Baweja compared the amount of muscle activity change following massage with the change in muscle activity following quiet sitting, and found some pressure massage can change muscle activity measured by surface electromyography (sEMG)[6]. Ruidong Ge using sEMG to study the effect of acupressure acupoint in inducing muscle excitability, and the research found acupressure can change sEMG of the maximum isometric contraction of muscles they studied[7]. Recently, a lot of researches have proved that mechanical stimulation has an impact on EMG of some muscle, but the correlation between mechanical stimulation of human body and sEMG signals is to be studied as the quantitatively measure of mechanical stimulation is lacked. In this paper, the mechanical stimulation and sEMG signals of certain muscle are measured by a multi-information sampling system, and the correlation between mechanical stimulation and sEMG signals is explored in more detail.

This research is likely to be of great significance in constructing flexible human kinetics model based on muscle changes, and help to promote scientific research of massage therapy technique.

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2 MULTI-INFORMATION SAMPLING SYSTEM

Multi-information sampling system consists of pressure sensor, data sampling system and data processing system. The detection principle is shown in Fig 1.

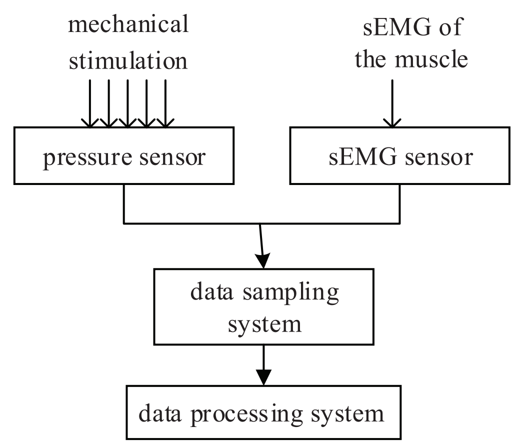

Fig 1. Detection principle of multi-information sampling system

First of all, mechanical stimulation is measured by pressure sensor, then after the signal is filtered and AD converted by data sampling system, it is exported to a computer for data processing. According to the characteristics of mechanical stimulation, the Flexiforce sensor is chosen to sample the force information, which is enough flexible and thin that the mechanical stimulation loaded on human body will not be impacted. The detection principle and circuit board are shown in Fig 2.

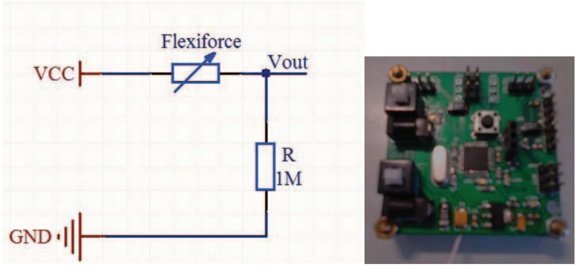

Fig 2. The circuit schematic (left) and circuit board (right) of the detection circuit.

The sampling circuit, which is driven by a +5v voltage source, produces analog signals based on the variations of the sensor resistance and feedback resistance. Then the analog signal is processed by AD converter and output as digital signal.

The sampled data is used to calibrate Flexiforce, according to its calibration curve shown in Fig 3, the linearity of Flexiforce is good enough to satisfy the demand of system design.

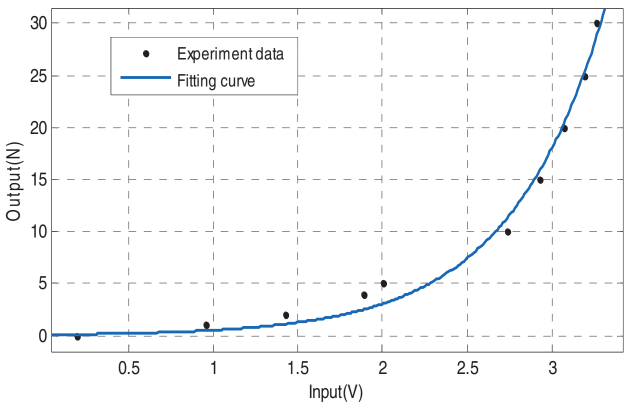

Fig 3. The calibration curve of Flexiforce

According to the calibration curve shown in Fig 2, the fitting formula is below:

$$F = 0.0828 \times \exp(1.904 \cdot V_{out}) \quad (1)$$

where, F is external force and V_{out} is output voltage of sampling circuit.

3 EXPERIMENTS AND ANALYSIS

3.1 Experiments

As the lateral deltoid endpoint of upper arm is chosen as force position, experimental scheme is as follows:

(1) A healthy male, who doesn't undergo any intense physical activity in 24 hours before the experiment and is familiar with the experimental contents, can be chosen as subject. The subject should also volunteer and cooperate with the test. During the experiment, the subject needs to sit still on the checking chair with both arms hanging on according sides of the body naturally.

(2) Flexiforce sensor prober is placed at the force position, where it takes several cycles of vertical mechanical stimulation. Then the force information is sampled by the force measurement system and transferred to computer.

(3) The sEMG signal of unilateral upper limb deltoid muscle was sampled by surface electromyography acquisition equipment simultaneously as shown in Fig 4. The measuring electrode which is Ag / AgCl electrode is placed on the lateral side of the deltoid muscle, and the positive electrode and the negative electrode are parallel to the muscle fibers.

The contact point of each electrode with the skin is disinfected and defatted using 75% alcohol to reduce the contact resistance between electrode and skin surface and increase the conductivity.

(4) Repeat the experiment three times under the same conditions and without any interference, each experimental interval is 10 minutes which is for the physical recovery of the subject.

Fig 4. The sEMG signal of unilateral upper limb deltoid muscle was sampled by surface electromyography simultaneously.

3.2 Data processing and analysis

(1) Force signal processing

During the experiment, the performer stimulates at the force point repeatedly and samples the force information using force measurement system, and the sampling frequency is 30Hz. Take the first test as example, the force signal sampled is shown in Fig 5.

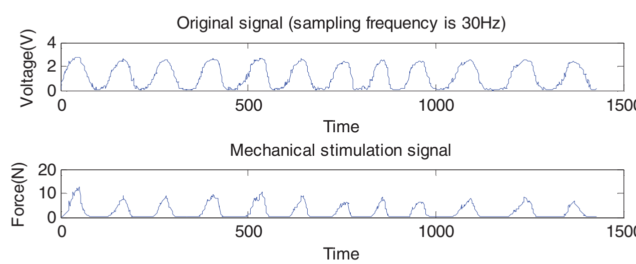

Fig 5. The force signal sampled of the first test

(2) sEMG signal processing

Taking into account the characteristics of the EMG signal, as well as the impact of the noise caused by the experiment, the 50Hz power line interference is removed using notch filter firstly, then the EMG signal effective components are achieved after data processing of the sampled signal. The original sEMG signal sampled is shown in Fig 6, and the sampling frequency is 1kHz.

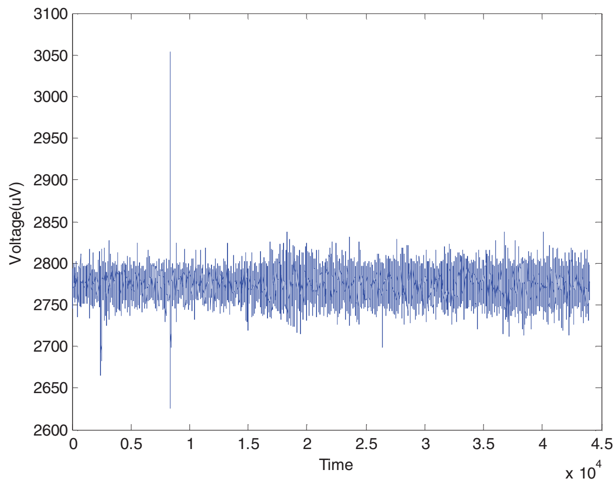

Fig 6. The original sEMG signal of the first test

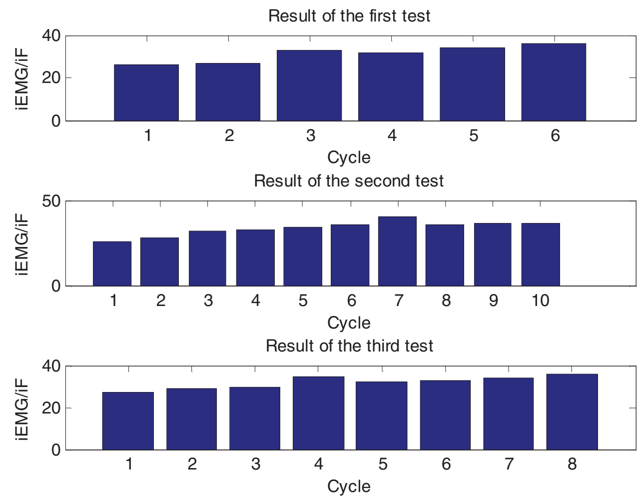

Fig 7. Results of three tests

After comparing the parameters of the time domain analysis, we choose iEMG as a parameter to measure the sEMG signal variation in this experiment.

The iEMG value is calculated for each cycle corresponding to the sEMG signal [8]. The results are shown in Table 1.

$$iEMG = \int_{t}^{t+T} \left| EMG(t) \right| dt \quad (2)$$

where, *iEMG* is the integral of sEMG detected, *EMG*(*t*) is the data of sEMG at time t.

Table1. The results of iEMG

Cycles of press loaded	iEMG
T1	341.55
T2	348.22
T3	298.31
T4	324.88
T5	379.54

With the finger press method, as the experimental time of each cycle of loading force is different, it's difficult to discover any pattern. Therefore, the average integral value of iEMG of each period is calculated based on the effect of 'force and time', and we use the integral of force loaded on human body in one cycle to measure 'force and time'. The integral of force loaded on human body can be expressed as follows:

$$iF = \int_{t}^{t+T} \left| F(t) \right| dt \quad (3)$$

where, *iF* is the integral of force loaded on human body, *F*(*t*) is the magnitude of the force loaded at time t.

The results of the three tests are shown in Fig 7. It can be seen that iEMG rises with the increase of the time of applying force.

4 CONCLUSION

In this paper, the impact of mechanical stimulation and sEMG of muscle on human body is proved, and the correlation between external stimuli to human body and sEMG signal is studied by taking deltoid muscle as research object. The results indicate that discharge magnitude of triangular muscle is increasing gradually with the increase of external force. The results may provide theoretical basis and significative information for finding out the mechanism of massage that massage could improve muscle performance.

The cause of this phenomenon may be related to stimulating human body with external force, regulating the corresponding nervous system and reducing muscle tension. However, only the deltoid muscle is studied in this research, electrophysiological activities of other muscles are not considered yet. The effect of mechanical stimulation on the sEMG of the relevant muscle will be studied deeply in future.

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