Experimental study on the sEMG of "joint angle effect" of human muscle strength—Taking biceps brachii as an example

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Abstract. In the experiment, the author used wave plus wireless surface electromyography system (SEMs + 3-axis acceleration sensor) made in Italy and wave wireless EMG software system, high-definition high-speed camera and human joint angle measuring instrument. Taking human biceps brachii as an example, the static and dynamic isometric contraction of biceps brachii was completed surface electromyography. In the experiment, the surface electromyography of biceps brachii was measured at 30°, 60°, 90°, 120°, 150°, 180° and the surface electromyography of biceps brachii was measured at the same time when the biceps brachii was not loaded or when the biceps brachii was loaded. Secondly, the surface electromyography of biceps brachii was measured at the same time when the biceps brachii completed the whole process of flexion and extension of the elbow (centripetal and centrifugal). Finally, the paper combined with HD The effect of joint angle on the contraction of biceps brachii muscle was analyzed by camera technique. The results show that the static contraction force of biceps brachii is different when the elbow joint is at different angles; in addition, when the dynamic contraction, the contraction force of biceps brachii is inversely proportional to the angle of elbow joint.

1 Introduction

Skeletal muscle is composed of muscle abdomen and tendon. The beginning and end of tendon are connected with bone across joint. When muscle abdomen contracts, tendon pulls bone to complete movement. "Joint angle effect" refers to that in the process of human joint movement caused by skeletal muscle contraction, because human skeletal muscle is mostly single joint or multi joint muscle, the starting and ending points of skeletal muscle are generally located on different bones [1]. When skeletal muscle contracts and pulls skeletal movement, the bone levers formed by different bones and joints will form a certain angle when the joint is not At the same angle, due to the influence of external resistance and the joint influence of bone lever, the mechanical characteristics and values of active muscle to overcome resistance contraction will also change with the change of bone lever angle. For the convenience of physical education and scientific research, we call this phenomenon of muscle strength changing with joint angle "joint angle effect" of muscle mechanics [2]. Electromyography (EMG) refers to the one-dimensional time series signal pattern of the voltage changes obtained by the electrode guidance, amplification, recording and display of the bioelectricity changes generated by single and multiple muscle cells or some muscle tissues during their activities. According to the different methods of electrode guidance, EMG can be further divided into needle electrode EMG and surface electrode EMG. As a means and method of electrical diagnosis and detection, sEMG evaluation is widely used in rehabilitation medicine, clinical medicine, sports research and sports research. Muscle strength is the ability of muscles to resist external resistance, is one of the most important physical qualities of human body, and is also the physical basis to support human body movement [3]. The study of human body movement is inseparable from the evaluation of muscle strength. Therefore, it is of great theoretical and practical significance to study the measurement of joint angle effect and muscle strength. Based on mathematical analysis and experiment, this paper takes the measurement of human joint angle effect and muscle strength as the research object, aiming to provide basis for strength training in sports, mastering and improving sports technology, scientific fitness of mass sports, prevention of sports injury and sports teaching and research [4].

2 Subjects and methods

2.1 Basic information of subjects

Subjects: 20 students majoring in physical education from the Physical Education College of Jiangxi Normal University, who have no injury history of biceps brachii or elbow joint activities, are volunteers of this

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experiment. Because the subjects are students majoring in physical education, they have developed biceps brachii with clear muscle contour, which is convenient for sticking and measuring the surface muscle electrode [5]. Experiment time: 2018-2019 in stages. Experimental units: College of art, Nanchang University, Jiangxi Province, College of physical education, Jiangxi Normal University and Zhejiang Shao Yifu hospital. Experimental supplies: Italian cometa brand, wave plus wireless surface electromyography system (SEMs + 3-axis acceleration sensor), high-speed high-definition camera, human joint angle measuring instrument, notebook computer, concentration alcohol, absorbent cotton, surface electrode, elastic bandage, medical tape, scissors, razor, body surface muscle map, tights, towels, dumbbells of different weights, etc.

Table 1. The bsdic shape statistics of the subjects

	Index	Result
1	Sex	Male
2	Population(n)	20
3	Age (y)	20.1±1.8
4	Height(cm)	173.5±6.2
5	Body mass(kg)	68.60±4.6
6	Forearm length(cm)	23.5±2.1
7	Extention surrounding(cm)	28.70±1.88
8	Bend surrounding(cm)	34.33±1.96
9	Upperarm length(cm)	30.40±2.52
10	Ratio	0.87±0.97

Note: Extention surrounding: The maximum surrounding of upper arm when the elbow is extending; Bend surrounding: The maximum surrounding of upper arm when the elbow is bending; Ratio: Ratio of forearm length and upper arm length.

2.2 Experimental process and steps

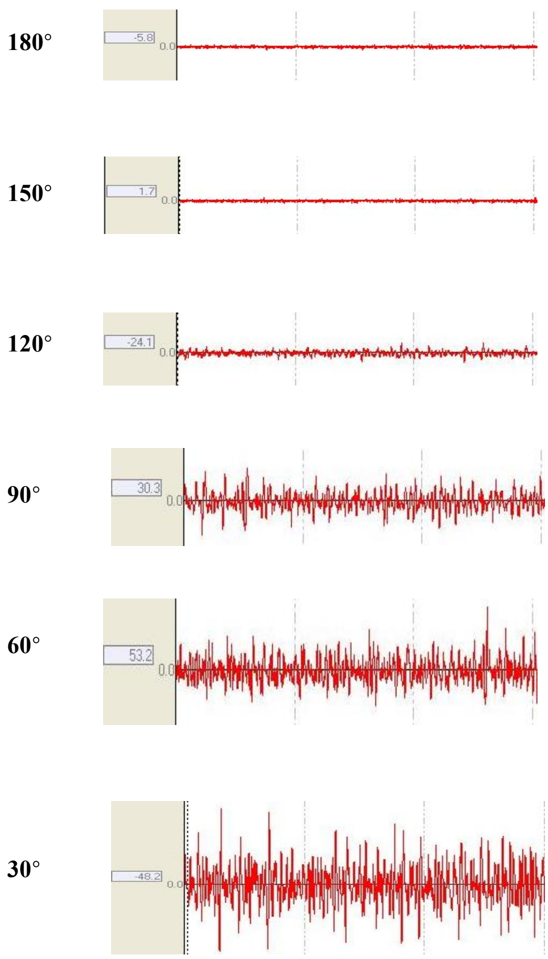
In the experiment, the surface electromyographic signal of biceps brachii was measured by the method of double electrodes. The sticking position of the surface electrode was the most protuberant part of the muscle abdomen of biceps brachii. The orientation of the electrode sticking was the same as that of biceps brachii muscle fiber. The distance between the two electrode sticking centers was 2cm. The reference electrode was placed in other muscles of the subject that did not involve elbow joint activity. During the measurement, bandage or tape shall be used to fix the electrode to prevent the electrode from slipping or falling off. Before electrode placement, the skin surface of biceps brachii was cleaned with 65% alcohol cotton ball to keep the skin impedance within a certain range.When the subjects completed the static contraction of biceps brachii, the tester accurately measured and recorded the surface electromyography test results of biceps brachii when the elbow joints of the subjects were at 30 °, 60 °, 90 °, 120 °, 150 °, 180 °. When the subjects completed the dynamic (centripetal, centrifugal) contraction of biceps brachii, the subjects used high-speed HD camera to record the synchronous dynamic changes of contraction and surface electromyogram of biceps brachii when there was no load and when there was load. The camera mainly used plane fixed camera [6].

3 Page layout The research results of sEMG of joint angle effect

3.1 Surface electromyogram analysis of static muscle contraction

Static contraction (also known as isometric contraction) is a form of human muscle contraction, which can be divided into support work, reinforcement work and fixation work. The body maintains a certain posture when the human muscle is in static contraction [7]. Although it seems that the muscle length has no obvious change, the muscle is doing work to overcome the resistance. In the experiment, the surface electromyography of biceps brachii was measured when the angle of elbow joint (the angle between forearm and upper arm) was fixed at 30 °, 60 °, 90 °, 120 °, 150 ° and 180 ° respectively. (Figure 1 for test results)

No load bearing



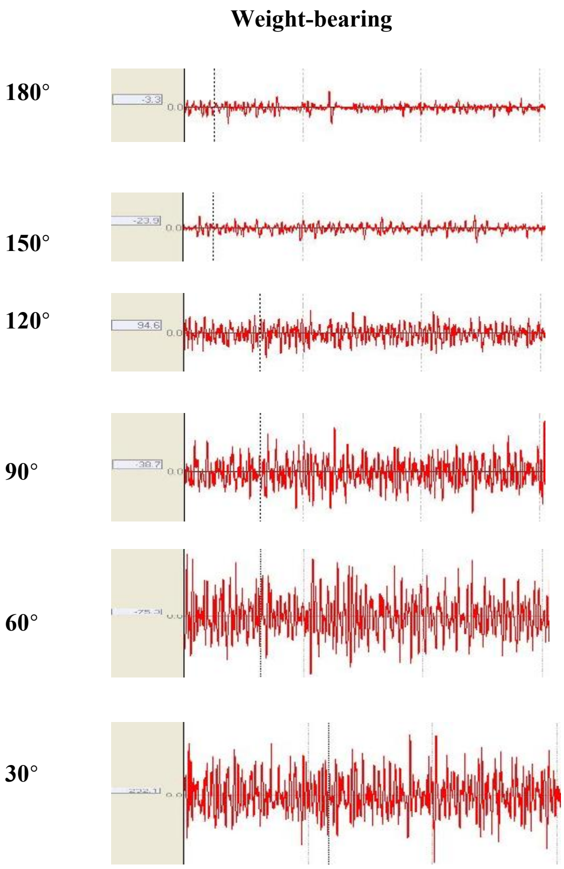


Fig.1. The basic static isometric surface electromyography of biceps brachii in different angles of elbow joint

3.2 Surface electromyography analysis of dynamic muscle contraction

Dynamic contraction (also known as isotonic contraction) is also a form of human muscle contraction, which can be divided into centripetal and centrifugal work [8]. In the dynamic contraction of human muscle whether it is centrifugal or centripetal contraction, the muscle contraction force changes with the external resistance and joint angle. In the experimental test, the surface electromyography of biceps brachii muscle contraction in the dynamic change of elbow joint angle (the angle between forearm and upper arm) was completed. (Figure 2 for test results)

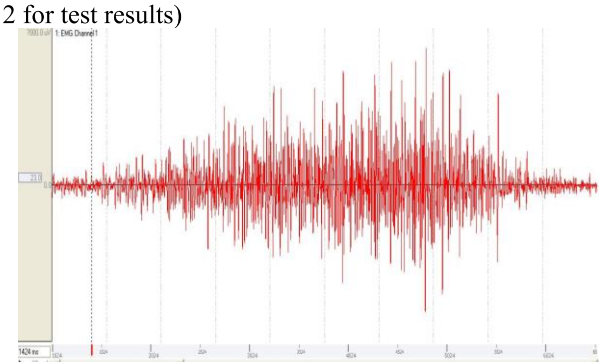


Figure 2 Data of surface electromyogram of biceps brachii in subjects with dynamic isotonic contraction (centripetal first, then centrifugal) during elbow joint angle change

4 Conclusions

This paper aims to analyze the surface electromyography of "joint angle effect" of human muscle strength and the conclusions are as follows:

It can be seen from the experimental EMG effect that: when the biceps brachii completes static contraction, the muscle strength will change in direct proportion to the elbow joint angle (the angle between the forearm and the upper arm). When the elbow joint angle is 30 °, the biceps brachii has the largest surface muscle strength, and when the elbow joint is closed. The surface muscle strength of biceps brachii was the lowest when the angle of the segment was 180 °. In addition, the muscle strength of biceps brachii will change with the increase of external load [9].

It can be seen from the experimental EMG effect that when the biceps brachii completes dynamic contraction (centripetal, centrifugal), the muscle strength will change obviously with the change of elbow joint angle (the angle between forearm and upper arm). When the human biceps brachii completed the centripetal contraction, from the video of high-speed HD camera, combined with the angle value of the joint measuring instrument and the peak change of electromyogram, it was found that the contraction force of the biceps brachii also changed from the big to the small in the process of the elbow joint angle [10]. When the elbow joint angle was 30 °, the peak electromyogram of the biceps brachii was found, it also reached the maximum.

Acknowledgement

This research was financially supported by the Science and Technology Research Project of Jiangxi Education Department in China (Grant NO. GJJ161329).

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