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ABSTRACT: Two homogeneous groups of elite sportsmen - eight sprinters (60-100m) and eight cyclists (road) – are selected. It is assumed that biomechanical characteristics – contraction parameters of various skeletal muscles are significantly different in both groups. The expectation is based on hypothesis that muscles in sprinters are faster than those in cyclists. The question is how to access and evaluate the time and velocity parameters as responses to a single twitch electrical stimulation.
A simple and non-invasive measurement method has been used. Typical contractile properties: contraction time, sustain, and half relaxation of six muscles are considered. (m. biceps brachia, m. vastus lateralis, m. rectus femoris, m. erector spinae, m. biceps femoris and m. gastrocnemius). The proposed technique is a useful tool for studying contractile properties of skeletal muscles in sportsmen. Muscles were assessed by measurement based on magnetic displacement sensor, measuring the muscle belly response. The muscle response to single twitch electrical stimulation was measured. The pulse width was 1 ms and voltage of stimuli was adjusted up to 40 V from threshold of contraction and respectively. Bipolar surface electrodes were applied in order to elicit single muscle response. The time responses of muscle contractions were analyzed. The contraction time, sustain time, and half relaxation time were taken into account as representative parameters of the records. The results show significant differences (sometimes in range of up to 100 percent) when all parameters are compared among different muscles. Between groups of cyclists and sprinters the significant difference is obtained in contraction time and no significant difference in other parameters. The results answered the question how muscles significantly differentiate in sprinters and cyclists.
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THE COMPARISON OF DYNAMIC CHARACTERISTICS OF SKELETAL MUSCLES IN TWO GROUPS OF SPORTSMEN – SPRINTERS AND CYCLISTS

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Key words: Biomechanics, skeletal muscle, sport medicine, electrical stimulation, tenziomiography

INTRODUCTION

An important characteristic of a motor system is its adaptability. When subjected to an acute or chronic stress (training), the motor system can adapt to the altered demands of usage. These adaptations can be extensive and have been shown to affect most aspects of the system, both morphological and functional. Sports physiologists have always been interested in the study of muscle adaptations, which are the result of a long and targeted training process. In elite sportsmen the morphological and functional muscle characteristics are combinations of their inherited and specifically targeted cumulative changes in the training process, which makes them a very interesting target group. But the study of contractile muscle characteristics in sportsmen has usually been very difficult because adequate methods have so far not been available. For this reason we have designed and tested a new noninvasive method for the study of contractile properties of six muscle groups. Using a new method, the action of a single muscle within a given muscle group can be measured. Two homogeneous groups of elite sportsmen were selected (cyclists and sprinters), which are different in the type of chronic adaptations and their inherited characteristics. We would assume that these differences also pertain to contractile properties of the tested muscles. The above-mentioned method could also be useful in the study of chronically and acute adaptation influences on contractile muscle properties in humans.

MATERIAL AND METHODS

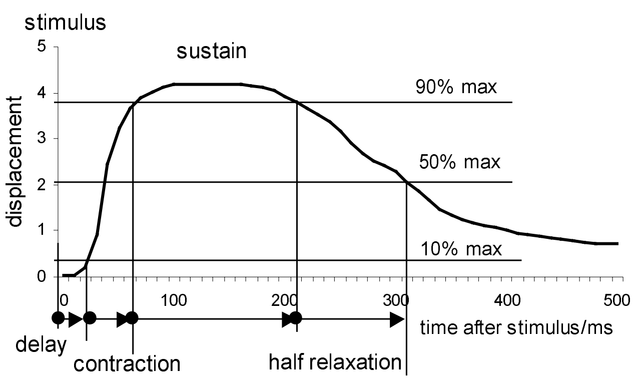

Figure 1. Time parameters definition in typical twitch response.

A simple method for the measurement of skeletal muscle contraction has been used [1]. The method is based on the assumption that radial muscle belly displacement detected by a magnetic sensor is proportional to muscle force. By muscle belly displacement is the globulisation or the rounding of the muscle surface due to contraction. The procedure has been evaluated in healthy subjects [1], subject after above knee amputation [2] and denervated pretibial muscle group. It has been shown that the method can be applied as a substitute for mechanical brace measurement systems, which are based on force transducers. With the method proposed one can measure the action of a single muscle within a given muscle group. The transducer is mechanically constructed on a supporting frame with a micromanipulator for the precise positioning of the transducer directly on the belly of the muscle. The subject is sitting or lying on a special table during the experiment.

Sixteen subjects, eight sprinters (national athletics team) and eight cyclists (national road team) aged 20 to 32 were measured by the system in isometric conditions. The measurements were conducted on the following muscles: m. biceps brachia, m. vastus lateralis, m. rectus femoris, m. erector spinae, m. biceps femoris and m. gastrocnemius. The forearm was fixed to the mechanical brace with an initial flexion of 90 degrees (biceps brachii), the knee was fixed to the flexion of 40 for vastus lateralis and rectus femoris and 10 degree for gastrocnemius and biceps femoris. The erector spinae muscle was measured while the subject was lying flat on his frontside. The displacement sensor was positioned at the surface of the belly of the muscles where the maximal enlargement (globulisation) of the belly was observed if the muscle contracted. In the experiment single-twitch stimuli were used in order to study the dynamic response of the muscle. In response (time displacement curve) three parameters were observed (Fig. 1): contraction time, sustain time and half relaxation time. The stimulation was provided cutanously by two surface electrodes (radius of 5 cm). The positive electrode was placed over the muscle up to 5 cm above the measuring point and the negative one up to 5 cm below the measuring point. The duration of the stimuli was adjusted to 1 ms and the voltage amplitude was gradually increased from up to 40 V above threshold muscle contraction response. The impulses were generated by the Grass S88 stimulator with isolation unit.

The significance of differences between time parameters of both groups was tested by the two-sample Student's t-Test. A *P*-value lower than 0.05 was considered statically significant.

RESULTS

In comparison between cyclists and sprinters three parameters were observed in six different muscles.

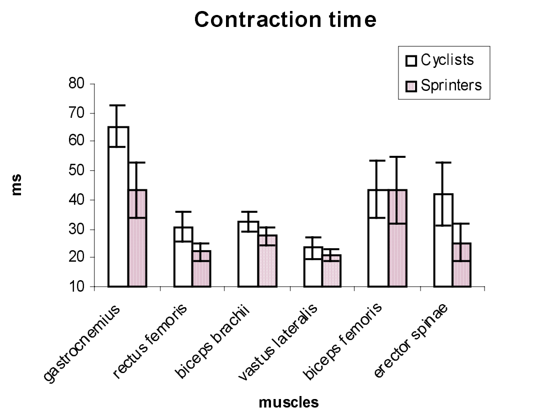

Figure 2. The comparison of twitch contraction time among different muscles,

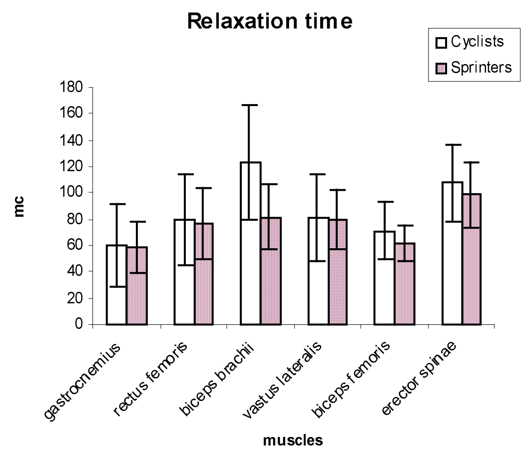

Figure 3. The comparison of twitch half relaxation time among different muscles

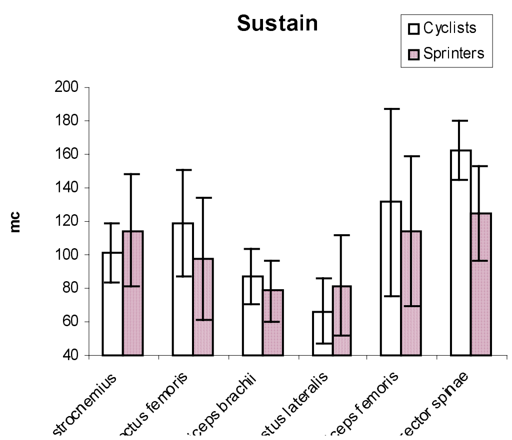

Figure 4. The comparison of twitch sustain time among different muscles

The comparison of contraction time (table 1 and Fig. 2) shows that statistically the following muscles are significantly different: m. gastrocnemius ($p<0.001$), m. rectus femoris ($p<0.01$), m. biceps brachii ($p<0.05$) in m. erector spinae ($p<0.01$). The difference in vastus lateralis is not significant while it is not obtained in biceps femoris.
The comparison of sustain time (table 2 and Fig. 3) between cyclists and sprinters does not show a statistically significant difference in the observed muscles. In half relaxation time (table 3 and Fig. 4) the difference exists only in Erector spinae ($p<0.05$).

DISCUSSION

Our objective was to find out whether the method, which measures muscle belly displacement, was suitable for the study of contractile properties in different muscle groups and for the comparison of different sportsmen regarding to the type of chronic adaptations that these sportsmen are exposed to. Training adaptations are specific to the cells and their structural and functional elements that are overloaded [3]. If an individual performs a strength-training program, only this characteristic (strength) and not others (e.g., endurance) will exhibit an adaptation [4,5,6[.
The results of our measurements show that there are significant differences in contractile properties of different muscle groups between individual muscles of the same subjects (minimum contraction time 17.4 ms and maximum contraction time 54.5ms) or two groups of subjects (cyclist and sprinters). Significant differences in contraction time are the result of variation in enzyme myosin

ATPase, the rate at which Ca^{2+} is released from and taken up by the sarcoplasmatic reticulum [7] and the architecture of the muscle.
comparison between cyclists and sprinters significant differences in contraction time were observed. The exception was biceps femoris. And re was a slight (nonsignificant) difference in vastus lateralis. The remaining two observed parameters do not show significant differences except in erector spinae in the case of half relaxation time. The greatest difference between the two groups was observed in the muscle gastrocnemius which is considered to be among the slowest [8]. The explanation for relatively small differences in muscles with short contraction time is most probably the fact that conventional stimulus waveframes are

known to preferentially activate large diameter motor units in contrast to the small-to-large recruitment order that occurs with voluntary activation [9]. Therefore the participation of slow fibers in the measured muscles is “not detected” because the contraction amplitude is considerably smaller (20 times) and contraction time longer [10]. As a surprise comes a relatively short contraction time in erector spinae in sprinters. The data obtained in general, healthy population indicate that it is a slow muscle [11[, but almost no data in sportsmen are available for this muscle.

The above mentioned method seems suitable for the study of individual muscles and comparison of the same muscle in different subjects. In the future it could enable us to draw an atlas of individual muscle fiber types distributions (contractile properties) in different important muscles for various groups of sportsmen.

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