SECTION – SPORT SCIENCES

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BIOELECTRIC ACTIVITY OF THE KNEE JOINT ANTAGONISTS IN SPRINTERS DURING RUNNING START

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D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
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Abstract

Study aim: Bioelectric activity of antagonists of the knee is one of the key factors in accelerating sprinters' center of mass in during the first seconds of a race. This significantly determines the final result of the sprint.

Basic procedures: The study involved three sprinters from AZS AWF Krakow, members of the national team. The evaluation assessed the bioelectric activity of the *rectus femoris* and *biceps femoris* muscles and their share in total employment of both legs during the start between the 3rd and 6th seconds of the run. In addition, maximum activity was assessed in terms of the MVC muscle in isometric contraction. On the basis of the analyzed involvement of mass of both muscles, we measured the sprinterss acceleration during the initial seconds of the run, relative to their maximum capacity to generate muscular strength and the asymmetry of bioelectrical activity of the muscles in both legs.

Main findings: There has been similar interest in antagonist activity in total employment of the knee joints in both legs and muscle involvement giving a distinct advantage in acceleration of CoM on the side of the dominant right limb. Average values of bioelectrical activity of individual muscles were not significantly different ($p<0.05$) when monitoring first the 3rd and 6th seconds of the run, which indicates a high degree of fixation patterns of recruiting muscle motor units under the influence of training. During the test, we recorded much higher values in the MVC for the knee extensors.

Conclusion: The effective use of the knee joint flexor muscles in accelerating CoM are largely determined by neuromuscular coordination, and to a lesser extent, the maximum potential force. The opposite situation was observed in the group of muscles straightening the knee joints of athletes. They received similar values as in the case of MVC, and their effective use during the run is characterized by distinct asymmetry, indicating the development of the individual athletes bioelectric activity of individual stereotypes.

Introduction

Bioelectric activity of the knee joint antagonists is one of the key factors in propelling sprinters' center of mass in the first seconds of the race. This significantly determines the final result of the race. A competitor, from the onset, must fulfill two main objectives: to raise the center of mass of the body while at the same time accelerating it by moving along a track in the manner optimal for the construction of their somatic and motor capabilities. Shifting body mass and reflection carried out by alternate operating of the limbs require optimization not only of the synergistic muscle work, but antagonistic work as well. Studying bioelectrical activity of muscles during the run was not often taken up by researchers. Significant reports on this topic were presented by McClay et al. [1], Neptune et al. [2] and Hamner [3]. Muscle work during the first steps after the start in sprinting aims to generate the appropriate value and direction of the ground reaction force. The aim of the study is to assess the influence of the cooperation of the antagonist muscles and symmetry of their activity in both lower limbs on the effectiveness of the take-off and the first steps during the race.

Study material and methods

The study involved three sprinters from AZS AWF Krakow, members of the national team, aged 25.7 ± 7.0 years, body height 177 ± 8.5 cm and body mass 72.7 ± 4.1 kg.

We evaluated bioelectric activity of the *rectus fem*. and *biceps fem.* muscles, as well as their share in the total work of both lower limbs during bunch-start take-off between the 3rd and 6th seconds of the run. Each of the study participants made ten attempts at bunched-starts. Additionally, we assessed maximum MVC muscle activity under isometric contraction. On this basis, we analyzed the involvement of both muscles in accelerating the sprinters' center of mass during the initial seconds of the run, in relation to their ability to generate maximum muscular strength and asymmetry of bioelectrical activity of the muscles in both lower limbs.

The study was performed using the NI-DAQmx, Mega Electronics Ltd., 8-channel wireless system for EMG signal registration. The methodology of global EMG signal registration was used by sticking surface electrodes to the skin, above the *rectus fem*. muscle and the *biceps fem*. (long head) bellies at a frequency of 1000 Hz. Measurements were carried out in accordance with ISEK and SENIAM standards [4]. The EMG record obtained during measurements was filtered through a high-pass filter with a cutoff frequency of 30 Hz. For computer analysis, we used the variable of the surface area under the graph of the integrated electromyogram [5] according to the equation (1):

$$A_i = \int_{to}^{t} U_i(t)dt \qquad (1)$$

where:

Ai – the surface area under the graph averaged using the RMS functional biopotential of muscles method between the 3rd and 6th seconds, expressed in [μVs] Ui(t) - the value of the integrated functional biopotential of muscles expressed as [uV] t - time of the analyzed integrated functional biopotential of muscles in the 3rd and 6th seconds.

Subsequently, we calculated the total work of the antagonists in the knee joints of both lower limbs and their share in the total work of the analyzed muscles. The results were subjected to statistical analysis involving the assessment of the significance of the differences between bioelectrical activity mean values for the corresponding muscles in both of the lower limbs.

Results

In Figures 1 and 2, we present the values of functional biopotentials and relative averages of the share in the total work of the analyzed muscles while monitoring the first 3 and 6 seconds of the run from a bunch-start position.

We noted a similar share of antagonist activity in total work of the knee joints in both lower limbs and a distinct advantage of the involvement of muscles in CoM acceleration on the side of the dominant (right) limb. Average bioelectrical activity values of individual muscles were not significantly different ($0.05<p$) while monitoring the first 3 and 6 seconds of the run, which indicates a high degree of fixation in the recruitment pattern of the muscle motor units under the influence of training.

During the examination of MVC, much higher values were recorded in the extensor knee joint group.

Discussion

While running, the muscles of the lower limbs perform the task of propelling the center of body mass forward, and also balance the weight during the support phase. Hamner et al. [3] suggest that the quadriceps plays an essential role in supporting the first part of the support phase concerning the amortization of body mass, while the triceps of the shank, to a large extent, is responsible for the acceleration of the body during the push-off phase. However, Dickinson et al. [6] indicate that elastic energy also plays an important role in propel-

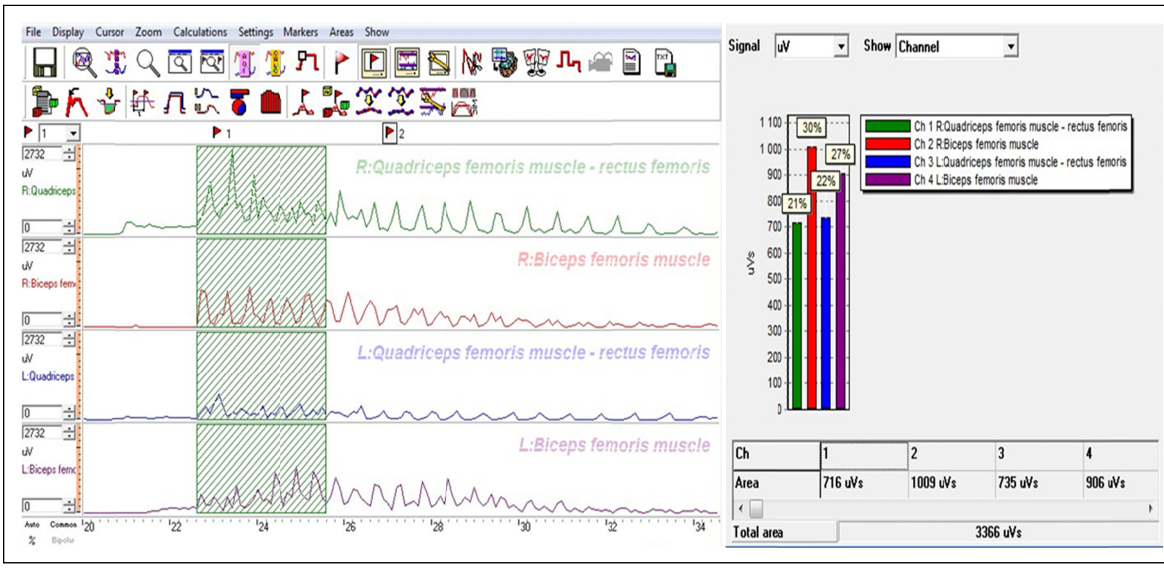

Fig.1. Bioelectric activity and the average share in total work of the *rectus fem*. and *biceps fem*. muscles of both lower limbs when starting from bunch-position within the first 3 seconds of the run

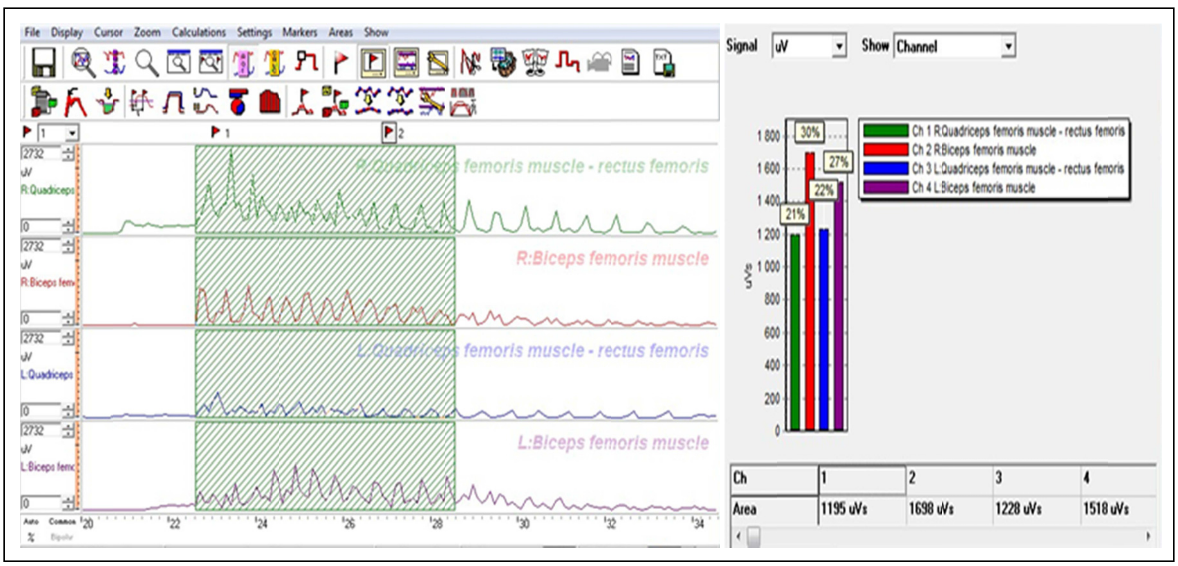

Fig. 2. Bioelectric activity and the average share in total work of the *rectus fem*. and *biceps fem*. muscles of both lower limbs when starting from bunch-position within the first 6 seconds of the run

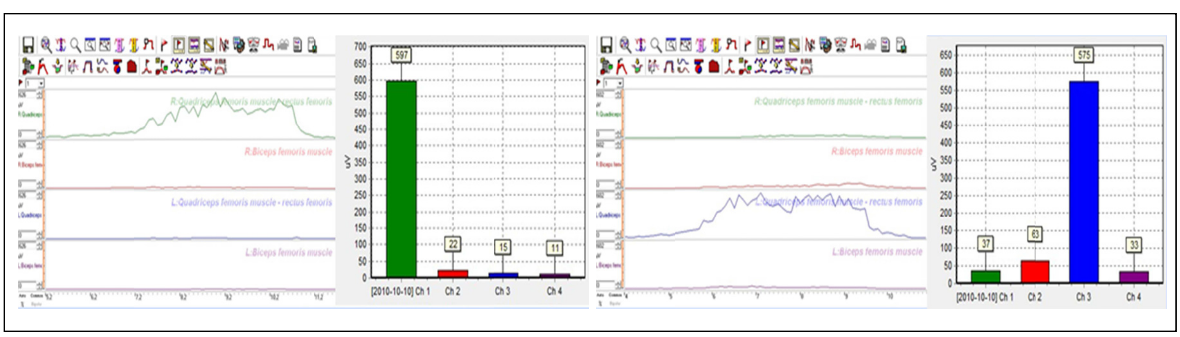

Fig. 3. The maximal value of bioelectrical activity of the *rectus fem*. muscle of the right and left lower limbs in an isometric MVC attempt

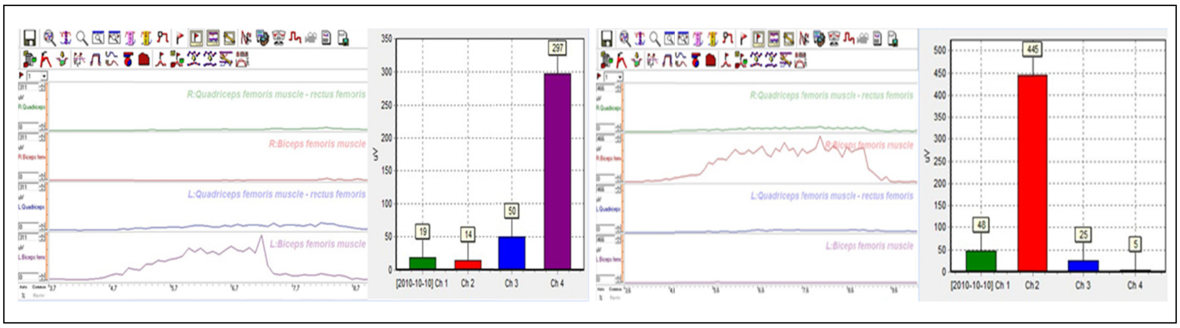

Fig. 4. The maximal value of bioelectrical activity of the *biceps fem*. muscle of the right and left lower limbs in an isometric MVC attempt

ling the body. Often, in the course of testing, the effects of muscle work are presented in a theoretical way, using the model of elastic mass [7, 8]. These concepts were further developed in the experimental studies by Neptune et al. [2] and Liu et al. [9].

However, research on bioelectrical activity of muscles in sprinting was undertaken by Jönhagen et al. [10]. The results of this team indicate the significant role of both the *biceps fem.* and the *rectus. fem*. muscles in balancing body mass in the phase of stance, although they have different patterns of bioelectric activity. The knee joint extensor, in addition to the activity in the phase of contact, also showed significant involvement in the swing phase. Furthermore, they point to the nature of their work resulting from the two-joint action. Schach et al. [11], in turn, indicate the significant damage to hamstring muscles during sprinting, when eccentric work is performed at high overload values and with a high level of muscle stretching.

Nonetheless, the subject of analysis did not include the evaluation of shares in the total antagonist work in a single joint. Therefore, the results obtained in the present study deserve attention. A particularly interesting observation seems to be that the relative shares of the antagonist muscles did not change significantly during both time intervals of sprinting registration (3 and 6 seconds) and were at an average level of approx. 43% for the *biceps fem*. muscle compared to 57% for the *rectus fem*. muscle for both lower limbs. This indicates a high level of automaticity in the recruitment of motor units in the tested sprinters. Another important observation is the occurring significant asymmetry of the maximal strength potential of the analogous knee joint flexors in both lower limbs during the MVC attempt, indicating the clear (above 20%) dominance of one of the limbs. Within extensors, there were no similar phenomenon in the MVC attempt. Despite the noted differences in MVC during the sprint, there were no significant asymmetries in the work of the *biceps fem*. muscle. There was, however, domination of the knee joint extensor muscles in the right lower limb of the sprinters.

Referring the maximal bioelectrical activity of the analyzed muscles during sprinting to the MVC test results, it should be noted that it was within a range of 75 to 87% for both antagonists.

Conclusions

The effective use of the knee joint flexor muscles in CoM acceleration is largely dependent on neuromuscular coordination, and to a lesser extent, the maximum power potential. The reverse case was observed for the group of knee joint extensor muscles of the competitors. They obtained similar MVC values, and their effective use during running is characterized by clear asymmetry, indicating that the competitors develop individual bioelectric activity stereotypes.

References

[1] McClay I, Lake MJ, Cavanagh PR: Muscle activity in running. In: Cavanagh, P.R. (Ed.), Biomechanics of Distance Running. Human Kinetics Books, Champaign IL, 1990. p. 165–186.

[2] Neptune RR, Sasaki K, Kautz SA: The effect of walking speed on muscle function and mechanical energetics. GaitPosture, 2008; 28 (1): 135–143.

[3] Hamner SR, Seth A, Delp SL: Muscle contributions to propulsion and support during running. J Biomech. 2010 Oct 19;43(14): 2709-2716.

[4] Hermens HJ, Freriks B, Merletti R, Hägg G, Stegeman DF, Blok J, Rau G, Dissel-horst-Klug C. SENIAM 8: European Recommendations for Surface Electro Myo Graphy, Roessingh Research and Development b.v. 1999.

[5] Chwała W, Płaszewski M, Kowalski P: Variations in bioelectric activity during symmetric loading and asymmetric stretching of paraspinal extensors in young adult women with mild single curve scoliosis. Stud Health Technol Inform. 2012; 176:129-132.

[6] Dickinson MH, Farley CT, Full RJ, Koehl MAR, Kram R, Lehman S: How animals move. An integrative view. Science, 2000;288 (5463):100–106.
[7] McMahon TA., Cheng GC: The mechanics of running: how does stiffness couple with speed? J. Biomech. 1990; 23 (Suppl. 1): 65–78.
[8] Seyfarth A, Geyer H, Gunther M, Blickhan, R: A movement criterion for running. J. Biomech. 2002; 35: 649–655.
[9] Liu MQ, Anderson FC, Schwartz MH, Delp SL: Muscle contributions to support and progression over a range of walking speeds. J. Biomech. 2008; 41 (15): 3243–3252.
[10] Jönhagen S1, Ericson MO, Németh G, Eriksson E: Amplitude and timing of electromyographic activity during sprinting,1996; Feb; 6 (1):15-21.
[11] Schache AG, Dorn TW, Blanch PD, Brown NAT, Pandy MG: Mechanics of the Human Hamstring Muscles during Sprinting. Med. Sci. Sports Exerc. 2012;Vol. 44, 4: 647–658.

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