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Motor model of fencing lunge of Sylwia Gruchała – olympic vice-champion in foil

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Introduction

A fencing fight, which is composed of dozens unexpected situations requires from athletes to learn a lot of motor patterns. In result of the long-term training, open motor habits reach the highest level of automation [Borysiuk, Cynarski 2009].

Fencing lunge is a basic component of fencer's movement on the piste and the most important component of the footwork technique. Therefore it constitutes the main element, besides the balestra, of offensive action together with fencing steps and leaps [Borysiuk 2009].

In fencing lunge two phases can be distinguished: an offensive action, which is finished with hitting the opponent and the return to the "en garde stance". Do, Yiou [1999], Hassan, Klauck [1998] evaluated the fencing action technique with application of EMG signal. The purpose of their study was to evaluate the speed of moves, acceleration of lower limbs and the weapon arm, as well as the arm of force and angles of joints during the fencing lunge.

Kędzior, Rzymkowski [1992] came to a conclusion, that after identification of criteria, utilized by the optimally operating system during performance of specific activity, a so-called master's pattern could be determined. Having that in mind, it is worth analyzing the motion technique of high class players.

The aim of this study was to describe a motor model of the fencing lunge based on EMG signal. Bioelectric tension of muscles was tested in the forearm of a dominant forearm (musculus extensor carpi radialis) and a straight muscle of the right front leg (musculus rectus femoris). The analysis was made in terms of EMG signal value [microvolts] assessment and duration of muscles activation [ms].

Methods and tools

the sportswoman selected for the tests was Sylwia Gruchała, a 30-year old, right handed, experienced Polish foilist, the team Olympic vice-champion and the world champion, height: 172 cm, weight 60 kg.

The fencer's task was to perform the fencing lunge ahead and return to the "en garde" stance, at her own pace, making her own choices with the accent on the quality of the action performance. Testing was conducted in the course of the preparatory camp for the starting season 2011, without using the weapon.

The testing tool applied was an EMG system of the Noraxon company, which records the bioelectric activity of muscles, so-called dynamic EMG in training conditions with the wired communication between preamplifiers and the signal collecting unit. The digital signal which records EMG parameters is sent using telemetric transmission to the computer. Pre-gelled surface electrodes of SENIAM type were placed between the motion point and tendon trailers, along the longitudinal axis of the muscle. Data analysis was made with MyoResearch XP MT 400 software.

Results

Sylwia Gruchała – fencing lunge ahead with the right leg and right arm attack. Electrodes on

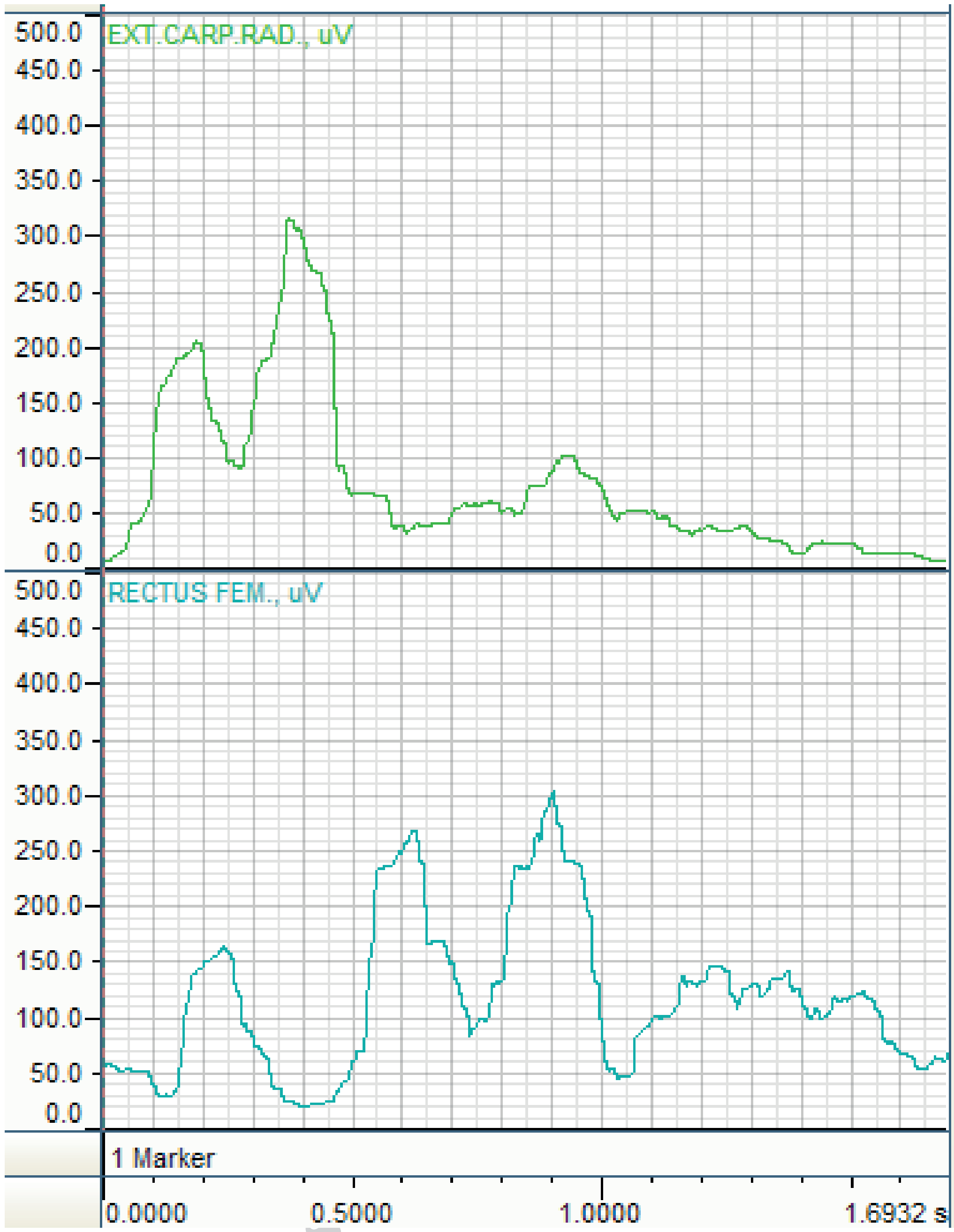

Fig. 1 "Smoothened" EMG Signal during the fencing lunge. Green - musculus extensor carpi radialis. Blue - musculus rectus femoris.

extensor carpi radialis i rectus femoris muscles of the right part of the body.

Muscle activation starts from the arm (musculus extensor carpi radialis), which strives to straightening. Activation in the leg muscle (musculus rectus femoris) occurs 136 ms later than arm activation. The elbow of the attacking arm is straightened after 291 ms, and after 202 ms from arm straightening, the foot of the front leg is put on the ground, that is 493 ms from arm activation. Activation in the arm muscle (musculus extensor carpi radialis) has three peak values. The first appears after 183 ms from the moment of activation, it is at the level of 204.6 μV and it is related with the attack start with the arm. The second one occurs in 374 ms from the muscle activation start and its value is 315.4 μV. This activity is related with reaching the maximum straightening of the attacking arm. When EMG activation curve reaches maximum it goes down, despite the fact that the arm is still straightened in the elbow joint. The third peak of activation occurs after 939 ms from the beginning of upper limb muscles activation, and reaches the value of 102.5 μV and occurs in the moment when the arm returns to the "en garde" stance. From that moment, the bioelectric tension of the extensor carpi radialis muscle has a decreasing trend and shows no significant fluctuations. The EMG signal of the leg muscle (musculus rectus femoris) also has three peaks of its activation which occur after: 241 ms, 624 ms and 902 ms, and their activation is respectively: 163.4 μV, 268.1 μV and 303.6 μV. The first peak value is caused with the move to straighten the leg after taking the foot off the ground. The second peak is observed after putting the foot on the ground, and it is associated with inhibition of the body momentum. The third peak falls on the phase when body comes back to the initial position. Total time of the entire lunge was 1830 ms. During the full move, the average activation in extensor carpi radialis was 69.8 μV, and in musculus rectus femoris was 112 μV.

Conclusions

Performed tests show that the fencing lunge starts activation of arm muscles, which occurs 136 ms earlier than the front leg activation. It is consistent with research of many authors among others Tsolakis, Vagenas [2010].

The extensor carpi radialis muscle demonstrated its highest bioelectric tension in the moment when the attacking arm was totally straightened. At that time this muscle's work has an isometric character. The other tested muscle, rectus femoris, demonstrated the greatest activation, when the foot takes off the ground after the lunge, performing concentric action.

A similar sequence of bioelectrical activity was found in case of three leading women foilists from the Polish national team. It means that the master class athletes begin attack according to canons of attack techniques with the initial move of the weapon arm, and then a strong activation of the front leg muscle appears. The main phase of the attack and the task of hitting is characterized by a rapid increase of arm EMG signal and front leg relaxation. This phase takes only about 400 ms and is decisive with respect to the effectiveness of offensive actions in foil fencing. It shall be noted that the weapon arm demonstrates a kind of "suspension" between 200 and 300 ms interval, when we observe the bioelectrical voltage drop in the arm and voltage rise in the front leg. This is due to the phase of the lunge range extension and acceleration of movement before the weapon finally reaches the target. Zissu and Silva [2008] came to the same conclusions, and demonstrated, that arm acceleration appears later than the rear leg, but hitting takes place before the fall of front leg, which in the case of lower-class athletes is not obvious, as they tend to end the attack when touching the ground with the front leg. In respect to offensive actions, it reduces the effectiveness of the attacks and makes them more predictable for opponents. The last phase of the fencing lunge, described as a complete return to "en garde" stance, showed the synergy of EMG signal for both tested limbs, with significantly higher bioelectric tension of musclus rectus femoris muscle.

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Wzorzec ruchowy wypadu szermierczego wicemistrzyni olimpijskiej we florecie Syliwii Gruchały

Słowa klucze: wypad szermierczy, sygnał EMG, czas ruchu

Streszczenie

Z przeprowadzonych badań wynika, że wypad rozpoczyna pobudzenie mięśni ręki, które wyprzedza o 136 ms aktywację nogi wykrocznej. Jest to zgodne z badaniami wielu autorów m.in. Tsolakisa i Vagenasa [2010].

Największe napięcie bioelektryczne przejawiał mięsień *extensor carpi radialis*, występowało to w chwili całkowitego wyprostu ręki atakującej. W tym czasie mięsień ten wykonuje pracę o charakterze izometrycznym. Drugi z badanych mięśni *rectus femoris*, wykazywał największe pobudzenie, podczas odbicia nogi od podłoża po wykonanym wypadzie, pracując w tym

momencie koncentrycznie.

Biorąc pod uwagę obie krzywe sygnału EMG można zauważyć, że mięśnie kończyny górnej wykazywały maksymalne pobudzenie na początku ruchu, natomiast mięśnie kończyny dolnejsą szczególnie aktywne w środkowej fazie aktu ruchowego. Ponadto największe pobudzenie mięśnia *extensor carpi radialis*, przypada w momencie najmniejszego w mięśniu *rectus femoris* nogi wykrocznej. Z analizy sygnału EMG wynika, że noga oraz ręka zaczynają powracać do postawy zasadniczej w tym samym czasie.