THE EMG ANALYSIS OF HURDLERS' UPPER LIMB MUSCLES IN THE PERIOD OF SPECIALIZED EXERCISES

Katarzyna **HYJEK-MŁYNARCZYK**(1) A,B,D,E, Katarzyna **PIECHOTA**(2)B,C **,**
Janusz **ISKRA**(2) B,F,G , Michał **PIETRZAK**(1) B,F

1. The Academy of Physical Education in Katowice, Poland
2. Faculty of Physical Education and Physiotherapy, University of Technology in Opole, Poland

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- athletics,
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Abstract:
The aim of this study was to evaluate the work of the upper limb muscles during selected specialized exercises. During the study the following exercise was used: a hurdle walk over six hurdles without and with load of 2kg for each upper limb. The subject of analysis was a high-level hurdler (male age 28, body height: 185cm, weight: 82kg). His personal records are 50.40 and he was in the final of the Olympic 4x400m relay. All the examinations that allowed authors to present the bioelectric muscular activity were carried out using a specialized measurement apparatus. Those analyzed showed that there are fundamental differences in bioelectricity between the upper limbs were noticed, with and without load. The results show that the bioelectric work of the individual upper limb muscles is high during specialized fencing exercises which can have a significant effect during hurdle run.

1. INTRODUCTION

Technology for diagnosing various aspects of sports techniques and motion patterns is increasingly gaining its peak points. On this basis it is possible to accurately record data in real training conditions. An important point of reference for data recorded through measurement tools is the ability to observe to counter and prevent injuries among athletes.

The high hurdles are among the technically most demanding of track and field events. According to some researches carried out so far the hurdle clearance technique is one of the key elements defining the competition result [Čoh, Iskra 2012]. In hurdling races, assessment of technique focuses on particular phases of clearing the hurdles. These phases consist of complex and dynamic forms of movement [Iskra 2012].

The biomechanical analysis is a well-known method for evaluating hurdle run technique [Iskra, Čoh 2006]. One of the frequent methods of analysis includes observation of the muscle activity during running and special exercises. The majority of kinematic research studies of hurdling conducted so far have been limited to the analyses of selected fragments of hurdles races only. Previous analyses concerned the work of the most important muscles of the hurdlers' lower limb. The involvement of the upper limbs in hurdle race was ignored [Mero, Peltola 1989].

Bioelectric activity of the muscles (the so-called timing) mainly examines the onset time and the offset of the muscular activity during the movement. Muscle tensions, or the EMG signal values determine the amplitude of the muscle activity. It is believed that the muscle fatigue among healthy athletes is higher, the muscle tension is falling. Based on the EMG values, it is possible to verify the motion sequences repeatedly based on the known patterns of motion [Piechota, Borysiuk 2004].

2. THE AIM OF STUDY

The aim of the study was to evaluate the work of the upper limb muscles during selected special exercises in the hurdles race with and without load.

3. MATERIAL AND METHODS

The study involved a hurdler man (age 28, body height: 185cm, weight: 82kg) of top sport level. His personal records are 50.40 and he was in the final of the Olympic 4x400m relay.

During the study the following exercise was used: a hurdle walk over six hurdles. At each pass 91cm hurdles with 1.20m distance were walked over. Two variants were included. Pass over the center without and with load of 2kg for each upper limb.

The studies were pilot studies made during the sprint preparation period. Applied research method - qualitative analysis of obtained research results. The NORAXON DTS technical specification was used to carry out the study, which provided a detailed analysis EMG signal in MyoResearch XP Mater Edition: 1500Hz sampling frequency, basic noise of the device, less than 1 uV RMS, input impedance above 100 Momh, CMR (Universal Rejection Ratio) greater than 100 dB, and 500x amplification were used to evaluate the activity of the upper limb muscles.

Bioelectric tension of the muscles was evaluated according to the SENIAM recommendations. Muscle tension was measured: biceps brachii L and R, triceps brachii L and R, deltoid muscle (clavicular part, acromial part, spinal part) and extensor pollicis longus. During the study period, according to the literature, the following time intervals (moments) were taken into account: the hurdle, the flight moment (OSC over the hurdle), the fall behind the hurdles, the post-hurdle.

On the basis of the conducted research and its results, a processing of the EMG signal has been done. The processing consisted in the preliminary filtration of the signal including the “removal” of the, so-called, artefacts [De Luca, Gilmore, Kuznetsov, Roy 2010] from the recorded low-pass amplitude up to 50ms. Moreover, the processing was to rectify the data (changing the impulses from positive to negative) and to even the data with the algorithm: medium, and the window: value 50ms [Konrad 2007].

4. RESULTS

Below presents the motion history of the athlete under scrutiny. In order to increase clarity of a single hurdle transition was generated four moments were included in the two variants of upper extremity load.

The analysis of recorded trace (Fig.1, Fig. 2) shows an algorithm that satisfies the detection of the upper limbs as well as the entire attitude of the athlete during the hurdle walk. Time to overcome a single cycle is similar in both variants, which testifies to the very good preparation of the sport of the athlete.

Tables 1 and 2 show the mean amplitude values of the active muscle EMGs, the lowest and highest values and the mean of all detected local peaks in the left and right upper limbs. Table 1 is all the mean values obtained during a walk without a load. Table 2 is already a variant in which the examined upper limbs are loaded with 2 kg of weight.

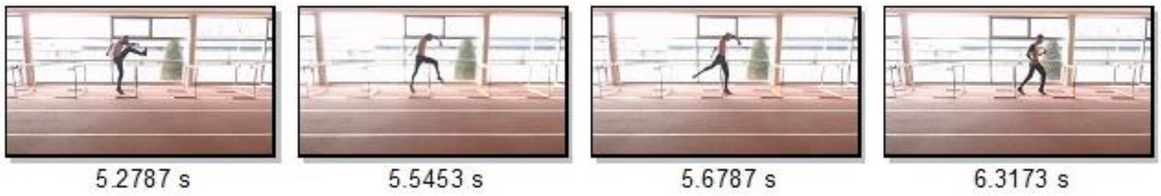


Figure 1. Walking cycle with 4 moments without load

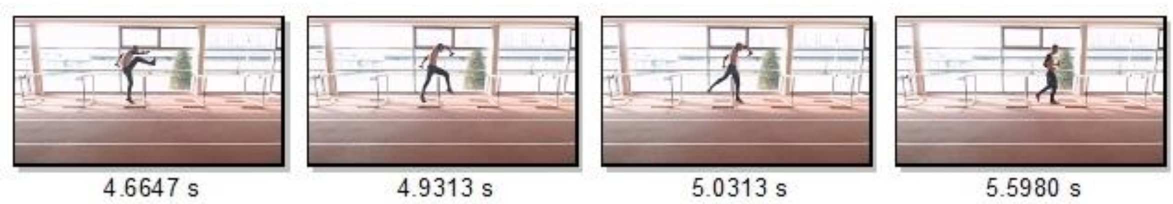


Figure 2. Walking cycle with 4 moments with 2kg load

Table 1. Characteristic of bioelectrical analysis of muscles without load

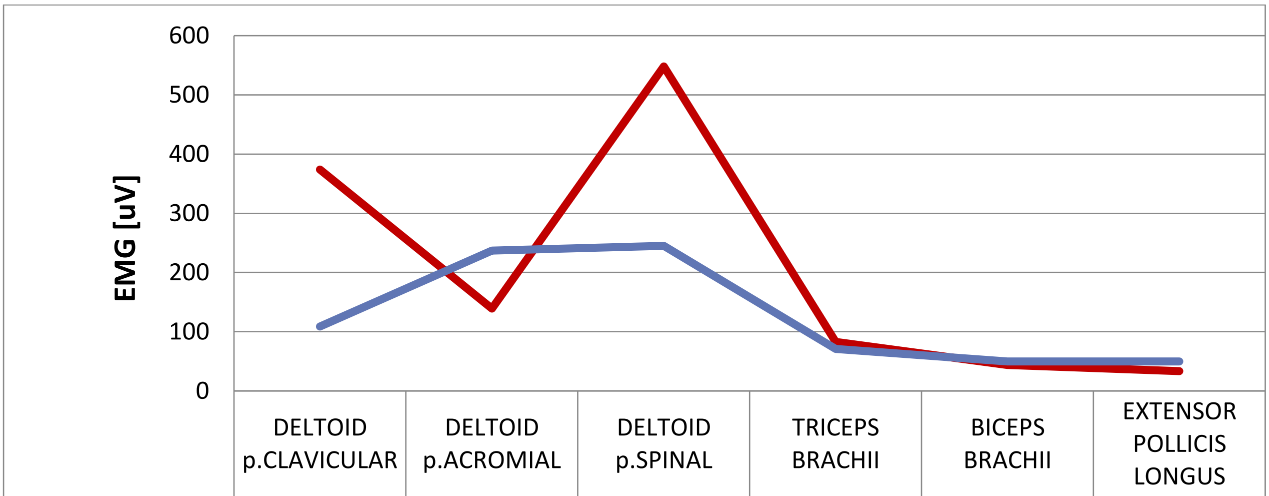
	Muscle	**Mean** [μV]	**Min.-Max.** [μV]	**Av. Mean** [μV]	**Av. Peak** [μV]
RIGHT ARM					
1.	Deltoid part Clavicular	374	26,9 - 1945	775	1217
2.	Deltoid part Acromial	139	18,5 - 472	225	339
3.	Deltoid part Spinal	548	36,4 - 1939	621	963
4.	Biceps brachii	43,7	8,13 - 136	50,8	83
5.	Triceps brachii	82,8	15,6 - 281	111	168
6.	Extensor Pollicius Longus	33,4	5,68 - 97,1	45,6	61
LEFT ARM					
1.	Deltoid part Clavicular	109	13,6 - 477	179	248
2.	Deltoid part Acromial	237	31,5 - 954	504	748
3.	Deltoid part Spinal	245	21,8 - 1026	421	733
4.	Biceps brachii	49,8	11 - 236	79,5	121
5.	Triceps brachii	70,9	15,4 - 225	106	161
6.	Extensor Pollicius Longus	50	8,3 - 166	58,7	78,5

Table 2. Characteristic of bioelectrical analysis of muscles with load 2[kg]

	Muscle	Mean [µV]	Min.-Max. [µV]	Av. Mean [µV]	Av. Peak [µV]
RIGHT ARM					
1.	Deltoid part Clavicular	434	28,4 - 1594	637	1003
2.	Deltoid part Acromial	146	30,6 - 454	216	320
3.	Deltoid part Spinal	489	88 - 1551	681	942
4.	Biceps brachii	61,5	21,9-268	83,4	92,5
5.	Triceps brachii	93,7	27,7 - 364	166	235
6.	Extensor Pollicius Longus	122	54,7 - 235	142	191
LEFT ARM					
1.	Deltoid part Clavicular	73,1	14,5 - 191	93,7	166
2.	Deltoid part Acromial	271	26,9 - 718	354	525
3.	Deltoid part Spinal	546	43,4 - 1544	687	999
4.	Biceps brachii	84,6	16,4-394	246	394
5.	Triceps brachii	99,6	32,9 - 215	133	215
6.	Extensor Pollicius Longus	112	20,1 - 471	197	279

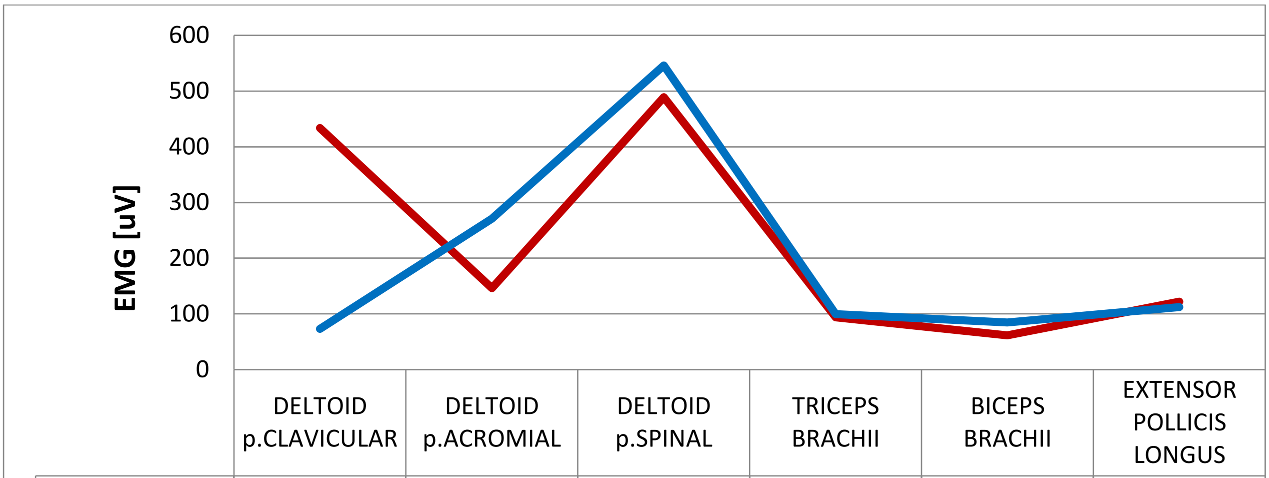
Figure 1. presents 12 numerical values for the average EMG of the individual upper limb muscles. The analysis shows that the bioelectric activity of the right hand of the competitor is higher than the left. The highest EMG values of the right upper limb were reported in the deltoid muscle of the 548µV in spinal part and 374µV in the clavicular part. Next, the activity of the deltoid muscle left upper limb in the spinal part was recorded, which amounted to 245µV.

Figure 2 shows significant differences in bioelectric activity compared to the earlier variant. The greatest variability was noted in the muscle of extensor pollicis logus in the left upper limb (546µV) and in the right upper limb (489µV). Increased activity was also noted in the deltoid muscles part clavicular of the upper right clavicular muscle.



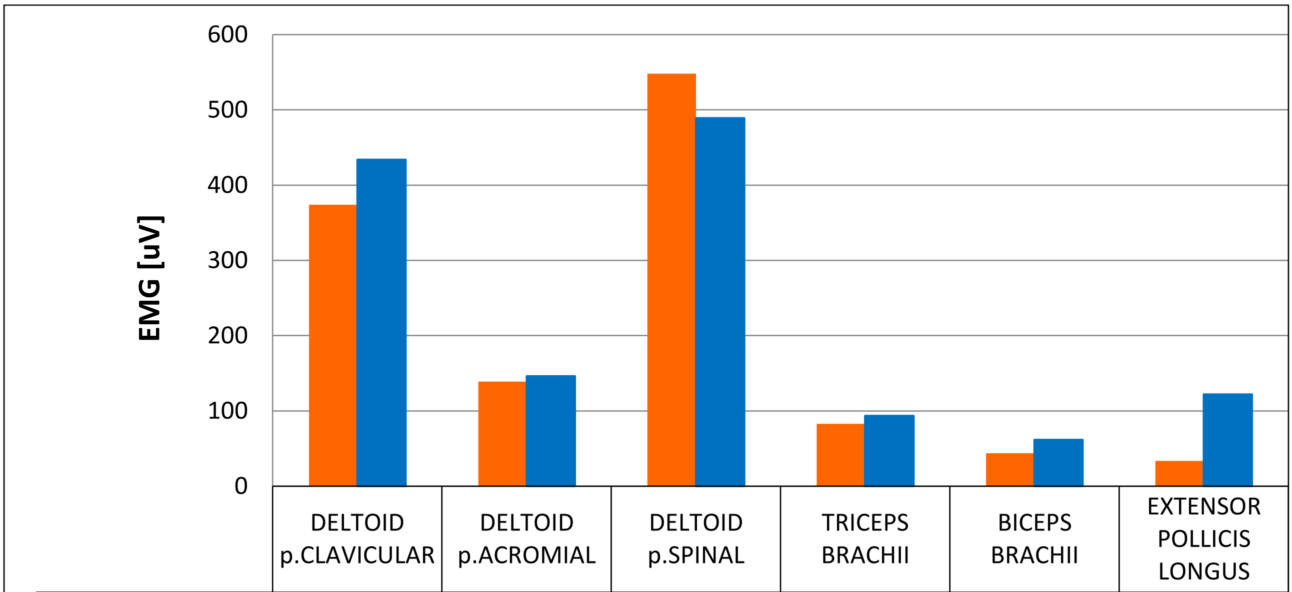
	DELTOID p.CLAVICULAR	DELTOID p.ACROMIAL	DELTOID p.SPINAL	TRICEPS BRACHII	BICEPS BRACHII	EXTENSOR POLLICIS LONGUS
RIGHT ARM	374	139	548	82,8	43,7	33,4
LEFT ARM	109	237	245	70,9	49,8	50

Figure 1. Mean EMG values in hurdles walk without load



	DELTOID p.CLAVICULAR	DELTOID p.ACROMIAL	DELTOID p.SPINAL	TRICEPS BRACHII	BICEPS BRACHII	EXTENSOR POLLICIS LONGUS
RIGHT ARM	434	146	489	93,7	61,5	122
LEFT ARM	73,1	271	546	99,6	84,6	112

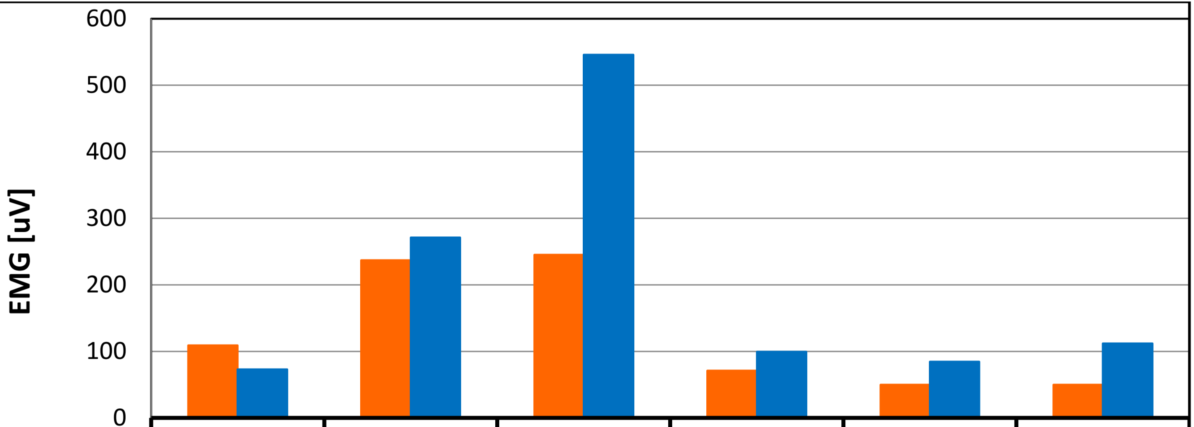
Figure 2. Mean EMG values in hurdles walk with a load of 2[kg]



	DELTOID p.CLAVICULAR	DELTOID p.ACROMIAL	DELTOID p.SPINAL	TRICEPS BRACHII	BICEPS BRACHII	EXTENSOR POLLICIS LONGUS
WITHOUT LOAD	374	139	548	82,8	43,7	33,4
WITH LOAD (2KG)	434	146	489	93,7	61,5	122

Figure 3. Mean EMG values of right upper limb in two variants

From the above graph, the load on the right upper limb increases the EMG activity of the examined muscles. Only the deltoid muscles part acromial of the comb are retrograde, the difference in bioelectric activity with and without load is 10.76%.



	DELTOID p.CLAVICULAR	DELTOID p.ACROMIAL	DELTOID p.SPINAL	TRICEPS BRACHII	BICEPS BRACHII	EXTENSOR POLLICIS LONGUS
WITHOUT LOAD	109	237	245	70,9	49,8	50
WITH LOAD (2KG)	73,1	271	546	99,6	84,6	112

Figure 4. Mean EMG values of left upper limb in two variants.

Figure 4 compares the bioelectric activity of each muscle both with and without load in the left upper limb. You can see two muscles that have significantly increased their activity; deltoid acromial part (271µV) and spinal part (546mV). A slight increase occurred in the triceps muscle of the arm (99,6µV). The activity of the remaining muscles did not increase despite the 2kg load.

Creating the right habits of movement, based on the appropriate technical standards, allows the fencers to safely implement training without risk of injury [Patla, Prentice 1995]. The values of the EMG parameters obtained confirmed the high level of sport of the investigator as well as the necessity to carry out further research in the direction of recording the electromyographic signals of the upper limbs [Piechota 2015].

There is little scientific work related to the work of upper limb hurlers. Keep in mind the importance of technique and hand-to-hand running through hurdles [McKinnon, Prendergast 2012]. Combining the motion of the upper limbs with bioelectric measurement will help develop the theoretical and practical knowledge of the technique of working the upper limbs at a distance of 100m and 110m by hurdles.

5. CONCLUSIONS

Analysis of the results obtained shows that:

• In the case of highly homogeneous patterns of walking in hurdles, differences in the electromyography signal between the upper limbs of the examined person are visible. Apparently, it is visible in the shoulder muscles of the comb and clavicular parts of the right hand of the investigator. This may be due to the different trajectory of the upper limbs, whose movement is the consequence of the leg attacking the fence.

• Additional stress on upper limbs during hurdles walk affects high EMG values. This is most pronounced in the deltoid muscle and brachioradialis.

• The analysis and thorough knowledge of the functioning of the muscles increased the awareness of the work of upper limbs during specialist fencing exercises. This involves the need to develop techniques and to shape the strength of the hands throughout the entire training process of the hurdlers.

6. REFERENCES

1. Čoh M., Iskra J., (2012), *Biomechanical studies of 110m hurdle clearance technique*. Sport Science 5, (1): pp. 10-14.
2. Iskra J., (2012), *Scientific research in hurdle races.* AWF Katowice.
3. Iskra J., Čoh M., (2006) *A review of biomechanical studies in hurdle races*. Kinesiology Slovenica, 1, pp. 84-102.
4. Mero A., Peltola E., (1989) *Neural activation in fatigued and no fatigued conditions of short and long sprint running.* Biology of Sport 6 (1): pp. 43-57.
5. Piechota K., Borysiuk Z., (2004) *The influence of motor preparation on the effectiveness of low- sprint strat (SEMG).*, Medsportpress 4 (4): vol.30, pp. 295-306.
6. De Luca CJ., Gilmore LD., Kuznetsov M, Roy SH., (2010) *Filtering the surface EMG signal*: *Movement artifact and baseline noise contamination*. Journal of Biomechanics; 43(8):1573-9.
7. Konrad P., (2007) *ABC EMG Practical introduction to electromyography*. Kinesiology, Gliwice; pp. 5-55.
8. Krzeszowski T., Przednowek K., Wiktorowicz K., Iskra J.: *Estimation of hurdle clearance parameters using a monocular human motion trackig mothod.* Computer Methods in Biomechanics and Biomedical Engineering. 2016, 1-11. IF=1.77.
9. Patla A.E., Prentice S.D., (1995) *The role of active forces and intersegmental dynamics in the control of limb trajectory over obstacles of different height.* Journal of Biomechanics (30), 2, pp.115-120.
10. Piechota K., (2015) *Zastosowanie EMG w lekkoatletyce (biegi krótkie),* [in:] Elektromiografia w sporcie. Wybrane zastosowania praktyczne., pp. 41-72
11. Prendergast K. (2012) *Panel discussion on hurdles lead arm action*. Modern Athlete and Coach 5, pp. 19-22
12. Przednowek K., Iskra J., Krzeszowski T.: *The analisis of hurdling steps using an algorithm of computer vision: the case of a well-trained athlete*. Medycyna Sportowa. 2014; 4(4); Vol.30, 307-313.
13. McKinnon G. (2012) *Hurdle performance. Lead arm technique advancement*. Modern Athlete and Coach 5, pp. 26-29.