# ELECTROMYOGRAPHY PATTERNS AT PROFESSIONAL SPORTSMEN

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**Abstract:** Electromyography (EMG) represents a recording technique of the action potentials produced by the skeletal muscular fibres during repose state, voluntary muscular contraction and after muscle direct stimulation or nervous fibres that innervate the studied muscle indirect stimulation.
The objective of our study was to observe the electromyography activity at two categories of professional sportsmen, fencers and volleyball players and to identify specific electromyography patterns, correlated to the practiced professional sportive discipline, in order to increase sportive performance, by correctingthe athletes' selection and improving the professional training.
We have studied a group formed of 22 male athletes, 11 fencers and 11 volleyball sportsmen, active for between 6 and 12 years, exclusively in either one of the studied sports, with homogenous average ages, heights and weights and training regime.
Was recorded superficial electromyography (sEMG) to athletes, in the same time with mechanogram, during, maximum isometric contractions, sustained through fatigue, of the hand fingers flexors, obtained by force traductor squeezing, both for right and left hand. For recording muscular biopotentials, were used surface electrodes (BIOPAC) made from silver (Ag), recording was performed simultaneously on EMG BIOPAC MP 150 two channels and were used two active electrodes for each channel, reference electrode was placed on forearm distal extremity, connected to PC Pentium IV.
The highest values for indexes like intercept, slope, percent variation, in the area of time and mixed parameters were recorded at fencers, frequency parameters define superior values for volleyball players.
EMG patterns contribute to an accurate selection of the professional sportsmen and to performance'simprovement, thus, becoming an important guide for trainers, very useful to establish complete and complex specific professional trainings.
*Keywords: electromyography patterns, professional sportsmen, fence, volleyball.*

## Introduction

Electromyography (EMG) represents a recording technique of the action potentials produced by the skeletal muscular fibres during repose state, voluntary muscular contraction and after muscle direct stimulation or nervous fibres that innervate the studied muscle indirect stimulation.
The objective of our study was to observe the electromyography activity at two categories of professional sportsmen, fencers and volleyball players and to identify specific electromyography patterns, correlated to the practiced professional sportive discipline, in order to increase sportive performance, by correcting the athletes' selection and improving the professional training.

## Material and method

We have studied a group formed of 22 male athletes, 11 fencers and 11 volleyball sportsmen, active for between 6 and 12 years, exclusively in either one of the studied sports, with homogenous average ages, heights and weights and training regime.
By analysing the age histogram for the entire studied group, was remarked the age homogeneity.
Thus, there were significant weight differences between the selected sport disciplines, the analysed group was homogenous both from the point of view of weight, height and of training regime.
The recordings were performed in equivalent conditions for all athletes, so, the determining factor for the different behaviour of the administered tests were the changes induced by the practiced sport disciplines.
Investigations were performed under current ethical rules, each participant being informed of the experimental processes.
For testing the effector component of human kinetic system, we preferred to use an investigation technique, which can offer the biggest amount of information, so, the one that combined the previous desideratum, was the surface EMG.

Were recorded superficial electromyography (sEMG) to athletes, in the same time with mechanogram (muscular force curve), during maximum isometric contractions, sustained through fatigue, of the hand fingers flexors, obtained by force traductor squeezing, both for right and left hand. For recording the muscular biopotentials, were used surface electrodes (BIOPAC) made from silver (Ag), the recording was performed simultaneously on EMG BIOPAC MP 150 two channels and were used two active electrodes for each channel, the reference electrode was placed on the forearm distal extremity [3, 4].

Recordings were performed in the morning, approximately at the same hour (9.00), in confortable conditions (pleasant external temperature, minimum noise and light, athlete mental relaxation, no sensations of hunger, thirst, pain), the subject was taught to maintain the forearm in a horizontal position on the table form the lab, keeping in one hand the force traductor and squeezing it.

Electrodes were connected to a complex acquisition and processing system BIOPAC MP 150, also, connected to a PC Pentium IV, whose program processes the data offered by BIOPAC system. The used force traductor, belongs to BIOPAC system, being a SS25L hand dynamometer, with a isometric interval of 0-100 kg and a nominal output of 20μV/kg, whose output was also, connected to MP 150 acquisition unit connected to PC Pentium IV.

The analogue/digital conversion was performed with a 16 bite resolution, at a sample rate of 5000 Hz.PC Pentium IV software is realised by BIOPAC Systems and hardware is under AcqKnowledge license, the AcqKnowledge program allows the filtration, recording and processing of the sEMG and mechanogram [3].

**Results**

For an easier interpretation of the obtained parameters, they were divided in 4 categories: of time (maximum amplitude of the straighten signal rAmax, straighten signal median amplitude rAmed, straighten signal average amplitude rAav, points return median amplitude of straighten EMG signal rAmed-Ip, points return average amplitude of straighten EMG signal rAav-Ip, root mean square Rms, straighten signal integral Isr, ratio mean area/mean amplitude Raa, power maximum density Smax), of frequency (median frequency Fmed, average frequency Fav, power frequency maximum density Fsmax, Burch median frequency IFmed, Burch average frequency IFav, points return number Npi, passes to zero number Ntz), mixed (medium suddenness of EMG waves Stav, efficiency index of excitation with contraction coupling ECCEI) and of mechanogram (average muscular force, force integral Force int.).

For each parameter, have been calculated other characteristic indexes: intercept, slope, primary indexes and percent variation (percentage ratio slope/intercept), a secondary index, obtained from the primary ones. Thus, were emphasized specific neuromuscular patterns for time, frequency, mixed and mechanogram parameters, at tested sportive disciplines. Because were obtained many data and a large amount of values, we used the percentage expression of the raw values, recorded for each group, confronted to the ones of the entire lot (that will represent 100%).

For time parameters, the intercept measure, for the two groups of sportsmen, percentage expressed, reveals the highest values for fence players and low values for volleyball players, as presented in Table 1.

**Table 1.Percentage values of intercept time parameters at studied sports, related to the entire lot**

| | rAmax (mV) | rAmed (mV) | rAav (mV) | rAmed-lp (mV) | rAav-lp (mV) | Rms (mV) | Isr (mV.ms) | Raa (ms) | Smax (mV²/ms) |
|---|---|---|---|---|---|---|---|---|---|
| **Fence** | 111.43 | 111.70 | 111.70 | 111.50 | 111.85 | 111.72 | 109.64 | 102.16 | 97.72 |
| **Volleyball** | 80.52 | 84.92 | 84.12 | 83.58 | 83.44 | 83.33 | 85.89 | 95.12 | 104.67 |

Frequency parameters intercept index analyse, shows the highest values for volleyball group, for most of the parameters, exception Fsmax, a reverse aspect in confront with the one met at time parameters, the other group presented medium values, with two exceptions (Table 2).

| Table 2. Percentage values of intercept frequency parameters at studiedsports, related to the entire lot | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fmed (Hz) | av (Hz) | Fsmax (Hz) | Ifmed (Hz) | p (nr/s) | zc (nr/s) | av (Hz) |
| Fence | 97.61 | 99.66 | 123.16 | 97.51 | 97.90 | 93.51 | 98.08 |
| Volleyball | 104.47 | 100.83 | 55.12 | 105.60 | 104.50 | 105.51 | 104.17 |

For the third parameters' category, mixed and mechanogram ones, intercept evaluation pointed, the lowest values at fencers and average ones at volleyball players (Table 3).

| able 3. Percentage values of intercept mixed and mechanogram parameters related to the entire lot | | | | | |
|---|---|---|---|---|---|
| | Stav (mV/ms) | Force (kgf) | ECCEI (kgf/Hz) | uration (s) | rce Int. (kgf.s) |
| Fence | 109.58 | 85.31 | 87.88 | 83.85 | 79.30 |
| Volleyball | 90.72 | 102.62 | 97.92 | 87.00 | 96.90 |

The values obtained for slope index, sustained the existence of the same pattern, as the one evidenced for intercept index, as showed in Table 4.

| Table 4. Percentage values of slope time parameters at studied sports, related to the entire lot | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | rAmax (mV) | rAmed (mV) | rAav (mV) | Amed-lp (mV) | rAav-lp (mV) | Rms (mV) | Isr (mV.ms) | aa (ms) | Smax (mV²/ms) |
| Fence | 111.44 | 111.70 | 111.70 | 111.50 | 111.84 | 111.71 | 109.63 | 102.17 | 97.73 |
| Volleyball | 75.67 | 83.94 | 82.41 | 81.22 | 81.31 | 81.02 | 83.52 | 92.76 | 106.99 |

Slope index values measure, reveals highest values for volleyball group, for fencers, the values are medium, as observed in Table 5.

| Table 5. Percentage values of slope frequency parameters at studied sports, related to the entire lot | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Fmed (Hz) | Fav (Hz) | FSmax (Hz) | IFmed (Hz) | p (nr/s) | Nzc (nr/s) | Fav (Hz) |
| Fence | 97.60 | 99.66 | 123.87 | 97.51 | 97.90 | 93.52 | 98.07 |
| Volleyball | 106.31 | 101.29 | 46.34 | 108.76 | 106.86 | 102.90 | 106.38 |

The slope index for mixed and mechanogram parameters, at fencers presented medium values and at volleyball players the lowest ones (Table 6).

| Table 6. Percentage values of slope mixed and mechanogram parameters related to the entire lot | | | | | |
|---|---|---|---|---|---|
| | Stav (mV/ms) | Force (kgf) | ECCEI (kgf/Hz) | uration (s) | orce Int. (kgf.s) |
| Fence | 109.59 | 85.30 | 87.88 | 83.84 | 79.31 |
| Volleyball | 93.01 | 87.96 | 82.66 | 63.99 | 73.94 |

If, in the case of indexes specific to primary parameters, was emphasized a pattern characteristic to each sportsmen group, for secondary indexes obtained through primary parameters processing, the specific changes are structured different.

Thus, the percent variation (percentage ratio slope/intercept) values, obtained by the fencers, were the highest (confirming the previous aspects), at most of the parameters. Also, was remarked the profile changing, volleyball players, at all parameters recorded values, almost identical with the ones of the entire lot (Table 7).

**Table 7. Percentage values of percent variation time parameters at all studied sports, related to the entire lot**

| | rAmax (mV) | rAmed (mV) | rAav (mV) | rAmed-lp (mV) | rAav-lp (mV) | Rms (mV) | Isr (mV.ms) | aa (ms) | Smax (mV²/ms) |
|---|---|---|---|---|---|---|---|---|---|
| **Fence** | 96.66 | 111.02 | 110.64 | 109.82 | 109.70 | 110.38 | 110.92 | 127.54 | 92.94 |
| **Volleyball** | 107.32 | 98.24 | 99.20 | 99.40 | 100.59 | 99.26 | 97.45 | 111.68 | 148.52 |

Percent variation values of frequency parameters at volleyball players were the highest, for most of the parameters and for fencers there were medium (Table 8).

**Table 8. Percentage values of percent variation frequency parameters at all studied sports, related to the entire lot**

| | Fmed (Hz) | av (Hz) | FSmax (Hz) | IFmed (Hz) | lp (nr/s) | zc (nr/s) | av (Hz) |
|---|---|---|---|---|---|---|---|
| **Fence** | 92.94 | 101.08 | 102.32 | 117.18 | 102.84 | 101.06 | 101.01 |
| **Volleyball** | 148.52 | 134.59 | 133.13 | 115.66 | 109.22 | 118.16 | 128.28 |

For frequency and time parameters, the values were higher at fencers, the volleyball athletes being in an intermediary position, as in Table 9.

**Table 9. Percentage values of percent variation mixed and mechanogram parameters related to the entire lot**

| | Stav (mV/ms) | Force (kgf) | ECCEI (kgf/Hz) | uration (s) | Force Int. (kgf.s) |
|---|---|---|---|---|---|
| **Fence** | 109.30 | 117.66 | 127.93 | 83.85 | 79.31 |
| **Volleyball** | 105.23 | 75.89 | 48.27 | 87.00 | 96.90 |

**Discussions**

By selecting professional sportsmen, active for at least 6 years, exclusively in either one of the studied sports, were avoided reactivity differences between beginners and experienced ones. Due to the neuromuscular adaptation, gained by trainings and competitions, at professional sportsmen, the motor units' activation is very high [1].

The obtained resultscannot be compare with the ones from the literature [2, 3, 4, 5], because, on one hand, the analyse program of the lines is originaland on the other hand, there are very few tests performed for the sportive disciplines studied by us.

As, the results showed, we established electromyography features for each sports, not only for frequency and mechanogram parameters, but also, for time and mixed ones, that were not evaluated by other studies. Intercept, slope and percent variation indexes values, measured for the two sport categories for time parameters and related to the entire lot, revealed fencers with the highest values, followed by volleyball players.

The big amplitude of fencers' potentials indicate the higher proportion of glycolytic fibres, type IIb, present in upper limbs muscle, fibres organized in big motor units. The fibres present preponderantly at fencers are in tight connection with the specific demands of this sport, great reaction speed, short period contractions.

Slope parameter values for fencers were the highest; this affirmation sustains once more, the previous affirmation, regarding the highest proportion of anaerobe fibres in the upper limbs muscle structure, fibres with ample, rapid contractions that get tired quickly.

The highest suddenness was recorded at fencers, proving at these sportsmen the presence of the biggest conduction speed in muscular fibres, feature extremely necessary for the characteristic effort of this sportive discipline.

Regarding, the frequency parameters, the highest values were present at volleyball players, in

comparison with fencers, taking into account, that these one perform an effort partially aerobe, partially anaerobe, the morphologic support being preponderantly represented by type I and IIa muscular fibres [1, 3].

**Conclusions**

Fencers, due to their sportive effort specificity, recorded the highest values in comparison to the other sportive discipline, for indexes like intercept, slope, percent variation, in the area of time and mixed parameters.

Frequency parameters define superior values for volleyball players, which perform an effort partially aerobe/anaerobe, with a morphological support represented preponderantly by muscular fibres type I and IIa.

EMG patterns contribute to an accurate selection of the professional sportsmen and to performance's improvement, thus, becoming an important guide for trainers, very useful to establish complete and complex specific professional trainings.

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**Author contribution**

All authors have contributed equally to this article.