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ORIGINAL RESEARCH

TRAINING INFLUENCE ON ELECTRONEUROPHYSIOLOGIC PROFILE OF PROFESIONAL SPORTSMEN

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ABSTRACT

Purpose. The objective of our study was the electroneurophysiologic characterization of performance sportsmen, including the selection of future participants, objective evaluation of training quality and highlighting the existence of subclinical lesions that may influence sporting performance.
Material and methods. The study included 29 performance sportsmen, with an average age of 18 years, who practice handball, volleyball and fencing for at least 5 years. For each subject of the studied group were recorded symmetrically the peripheral motor response and motor conduction velocity for the median nerve.
Results. When comparing the group of sportsmen with that of the sportswomen, the most numerous statistically significant differences were recorded for the peripheral motor response.
Also, when comparing data obtained for the entire group with the subgroups of tested sports, as well as between sports, significant differences for amplitude, area and duration of motor response were recorded.
Comparing the values of motor conduction, only the ones of the handball-fencing subgroups were different.
Conclusions. The present study allows the highlighting of specific functional adaptations, obtained by training, which might shape a neurophysiologic profile for performance sportsmen.
Key words: professional sportsmen, compound muscle potential, motor nervous velocity.

REZUMAT

Scop. Obiectivul studiului nostru a fost caracterizarea electroneurofiziologică a sportivilor de performanța, cu scopul selecției pe viitor a sportvilor ce se încadrează în acest profil electroneurofiziologic, precum şi evaluarea obiectivă a calității antrenamentului şi aducerea în prim plan a prezenței unor afecțiuni subclinice care pot influența performanța sportivă.
Material şi metodă. Studiul a fost efectuat pe un număr de 29 de sportivi de performanță, cu vărsta medie de 18 ani, care practică handball, volei şi scrimă de cel puțin 5 ani. Pentru fiecare subiect al grupului de studiat au fost înregistrate, simetric, răspunsul periferic motor şi viteza de conducere motorie pentru nervul median.
Rezultate. Comparând grupul fetelor cu cel al baieților, au fost înregistrate cele mai multe diferențe statistic semnificative ale răspunsului motor periferic.
De asemenea, diferențe semnificative ale latenței, suprafeței şi duratei răspunsului motor au fost evidențiate, prin compararea rezultatelor aparținând întregului grup şi subgrupurilor testate pentru aceeaşi disciplină sportivă şi discipline sportive diferite.
Concluzii. Prezentul studiu permite evidențierea adaptărilor specifice funcționale, determinate de antrenamentul fizic, care pot contura profilul electroneurofiziologic al sportivilor de performanță.
Cuvinte cheie: sportivi de performanță, potențial de acțiune muscular compus, viteză de conducere motorie.

INTRODUCTION

Our study was shaped by the necessity of assuring a neurophysiologic characteristic for a sporting discipline, which would be useful both in selecting those that practice the respective sport and for following the efficiency of specific training while avoiding overtraining [4] [7].

Reaction time, coordination and nervous conduction velocity influence the level of sportive performance, therefore, is essential to determinate and track them in sporting activities [5] [11].

Following Helmholtz's pioneer works, many researchers have measured the nervous conduction velocity (NCV) for animals and humans, establishing a relation between NCV and the diameter of nervous fibers (those with a large diameter have a faster NCV) [15] for animals. Soudmand et al. [13] have signaled an inverse correlation between NCV and the subjects' height for the lower members; however, this study has not shown a similar correlation for the upper members, which was also presented by Lang and Bjorkqvist ten years before [8].

K. Takano et al. in 1991[15] obtained clear results, due to the large number of investigated subjects, on the correlation of conduction velocity with the tested subjects' height, higher velocity being present at lower height individuals.

Our research aims at neurophysiologic testing by measuring nervous conduction velocity, to highlight its characteristics for the three groups of sportsmen from different disciplines: handball, volleyball and fencing; sportive disciplines where the use of upper members is asymmetrical.

MATERIAL AND METHOD

Motor conduction velocity (MCV) was tested by stimulating the median nerve at three levels: radiocarpian articulation (1) between the tendons of the flexor carp radial and palmary long muscles, elbow (2) near the brachialis artery and bicipital groove (3), successively, for both arms, for a total group of 29 sportsmen, 19 boys and 10 girls, the average age for the tested group was 18.38 years.

Each individual was initially screened for any history, signs or symptoms of either peripheral neuropathy or compression syndrome of the upper extremities.

All subjects were informed about the study procedure, purposes and known risks and gave their informed consent. This study was conducted according to the guidelines of the Declaration of Helsinki.

Percussion tests of the nerves along their course were performed. Subjects were asked about the presence of any pain or dysesthesia when training.

We practicised a bipolar percutan stimulation of the median nerve after previously degreasing the area, at the three levels previously mentioned, with rectangular impulses, of a duration of 0.1 ms and an intesity value necessary to obtain the maximal muscular response. The stimulation device was provided by the Nihon-Kohden firm, for the aparatus MEP-9600 used for this test. Muscular response was recorded at the level of the tenar muscles (abductor pollicis brevis), using surface electrodes with a diameter of 8 mm and a distance between them of at least 20 mm. Stimulation was made at a distance of at least 70 mm from the proximal recording electrode, according to the schematic in Figure 1.

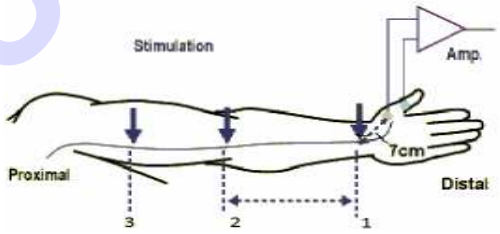


Fig. 1: Illustration of the stimulation points 1 (radiocarpian articulation), 2 (elbow) and 3 (bicipital groove) and of the recording electrodes place at the level of tenar prominence.

Skin temperature was measured at the level of lower third of the forearm.

Recordings were made in the morning, before the sports training, on an ambient temperature that did not vary significantly from one recording to the next [1]. Reference temperature for correcting motor conduction velocity was of 32.5 degrees Celsius. Literal correction was automatic for this value, made through the program provided by the menu of the utilized device. Data obtained by recording the muscular response was processed separately, providing values for: latency, duration, amplitude, area. The utilized software was also used in computing the latency differences of motor responses, obtained by stimulating the three levels: distal (radiocarpian articulation=level 1), elbow=level 2 and proximal (bicipital groove=level 3) (Fig1.).

So, by stimulating the mentioned three levels, the following information was obtained: for level 1 motor response latency, the actual MCV values being obtained through latency difference 2-1 (distal MCV) and 3-2 (proximal MCV), as showed in Figure 1.
The interval, as shown by the program for level 1 is, in fact, the latency of the muscular response, followed by the levels 2 and 3, which are the only ones that show the actual latency difference.
For statistical analysis of the values obtained by processing the recordings of the muscular response and MCV, testing of various groups were made through ANOVA test, T test, Student test and Pearson correlation coefficient.

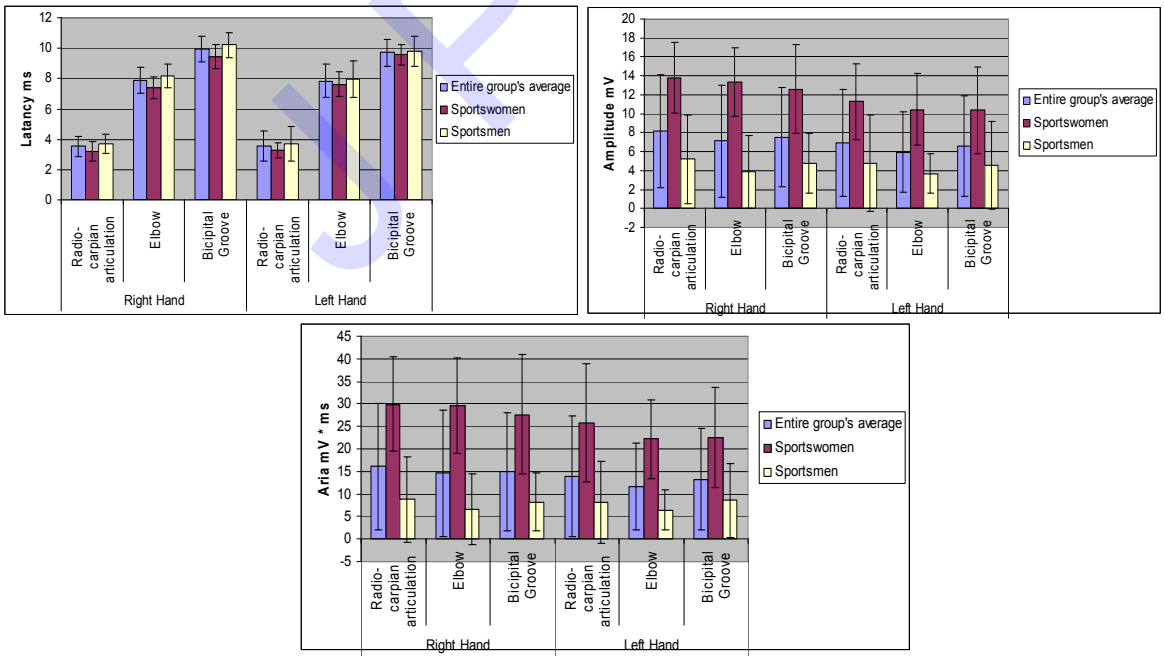
RESULTS

The analysis of results obtained when studying motor conduction velocity imposes the processing of compound muscle action potential (CMAP) parameters values.
The interpretation of data characteristic to CMAP has shown modifications at every tested segment, for both upper limbs. The following parameters were analyzed and statistically processed: latency, duration, amplitude, area and interval (the last one represents the difference between latencies from segments of the same limb).
The processing of the cited parameters values, from the recordings of the motor response, by stimulations in the bicipital groove, elbow and radiocarpian articulation, has led to the data inserted in Table 1.

Table 1. The values of CMAP parameters

		Radio-carpian articulation				Elbow				Bicipital Groove			
		Latency	Dur	Ampl	Area	Latency	Dur	Amp	Area	Latency	Dur	Amp	Area
Right Hand	Average	3.53	5.89	8.16	16.15	7.88	5.90	7.12	14.59	9.93	5.87	7.50	14.94
	St.dev	0.68	1.18	5.99	14.04	0.83	1.44	5.92	14.12	0.85	1.28	5.26	13.12
Left Hand	Average	3.55	6.05	6.94	14.02	7.84	6.09	5.95	11.70	9.72	6.32	6.57	13.25
	St.dev	0.99	0.98	5.61	13.37	1.08	1.16	4.22	9.66	0.89	1.25	5.33	11.27

Statistical analysis has shown that the most significant differences were between values recorded for sportsmen-boys, compared to those for sportswomen.
Unlike the latency for motor response, which presents significant differences between the two subgroups (boys-girls) only when the stimulating from elbow and bicipital groove for the right hand was done, the values of amplitude and area presented highly significant differences for all levels of stimulations and for both upper limbs (as indicated in Graphics 1- 3).



Graphics 1-3. The average values of latency, amplitude and aria for the entire group, sportsmen and sportswomen

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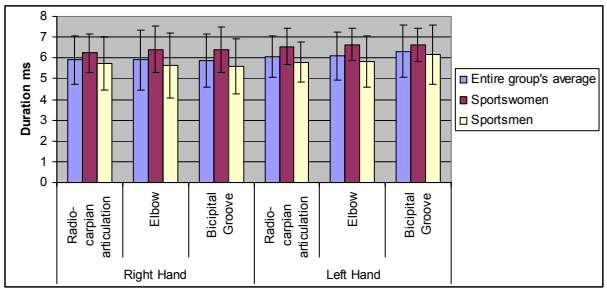
As for the duration of the motor response, when comparing sportsmen with sportswomen, significant differences are only recorded for stimulations of the left hand elbow (as in Graphic 4).



Graphic 4. The average values of the duration for the entire group, sportsmen and sportswomen

The computation of the Pearson correlation coefficient, when comparing left-right hand, for the whole tested group, shows a positive correlation for amplitude, area and duration for all stimulation levels, the exception being the duration for the proximal stimulation (as showed in Table 2).

Table 2. The right-left hand correlation

	Radio-carpian articulation				Elbow				Bicipital Groove			
Right-Left hand correlation	Latency	Dur	Ampl	Area	Latency	Dur	Amp	Area	Latency	Dur	Amp	Area
	0.130	0.623	0.666	0.742	0.228	0.608	0.642	0.708	0.445	0.471	0.528	0.617

The objective of this study being highlighting neurophysiologic particularities for each tested sport, inter-sports comparisons of the motor response parameters values were made.

When comparing the data of the entire group versus the volleyball subgroup, statistically significant differences were recorded for amplitude and area by stimulations of the left hand, elbow and bicipital groove (as indicated in Table 3).

Table 3. The comparison between the entire group and volleyball - left hand

Left Hand	Radio-carpian articulation				Elbow				Bicipital Groove			
Entire group-Volleyball	Latency	Dur	Ampl	Area	Latency	Dur	Amp	Area	Latency	Dur	Amp	Area
	0.808	0.379	0.195	0.108	0.418	0.353	**0.030**	**0.009**	0.745	0.768	**0.013**	**0.007**

When comparing the values of the fencing subgroup with those of the entire group, significant differences have been shown only for the area and latency parameters for the right hand (as appeared in Table 4).

Table 4. The comparison between the entire group and fencing- right hand

Right Hand	Radio-carpian articulation				Elbow				Bicipital Groove			
Entire group-Fencing	Latency	Dur	Ampl	Area	Latency	Dur	Amp	Area	Latency	Dur	Amp	Area
	0.718	0.344	0.060	**0.050**	0.371	0.342	0.178	0.108	**0.025**	0.479	0.829	0.06646

When comparing the handball subgroup with the entire group a difference for the duration of the motor response is noticeable, following the stimulation of the elbow left hand.

No significant differences were recorded for handball-fencing and handball-volleyball. The only statistical difference was recorded for the volleyball and handball subgroups, for area and amplitude obtained by the stimulation the left hand elbow and bicipital groove.

When comparing various sports, for each sex, there were no significant differences for boys, with the exception of the duration parameter, right hand, elbow stimulation, when comparing fencing-volleyball on left hand, distal level stimulation and elbow stimulation, when comparing fencing-handball.

For girls, there were a higher number of statistical differences, which were presented for: area parameter, right hand, stimulation at three levels, amplitude, same hand, only through proximal and distal stimulation. The value of p was at the limit of statistical significance at 0.051 when stimulating the elbow.

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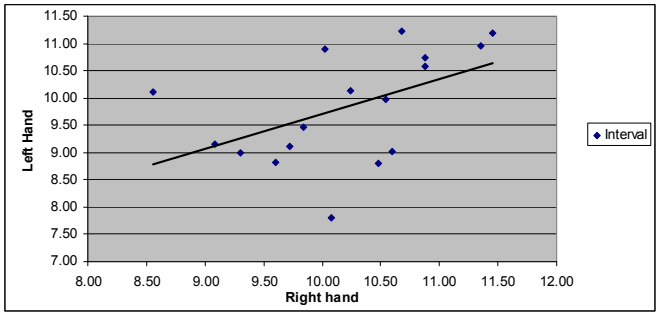
The interval, as the program showed for level 1, is, in fact, the response latency, only at levels 2 and 3, it actually represents latency differences, as shown in table with intervals at 1, 2, 3. It is noticeable that there were no significant differences of the intervals between values from left and right hand and a single positive correlation was recorded, by stimulating the proximal level (as showed in Graphic 5).



Graphic 5. Positive right-left correlation for the interval values

Inter-sports statistical processing, for the interval values, does not show significant differences, both when comparing each sport with the entire group and when comparing handball, volleyball and fencing between them, the exception being handball compared with the entire group, right hand, proximal stimulation.

When comparing handball, the entire group of boys with the subgroup of boys, following stimulation on the right hand, proximal level, significant statistical differences were present.

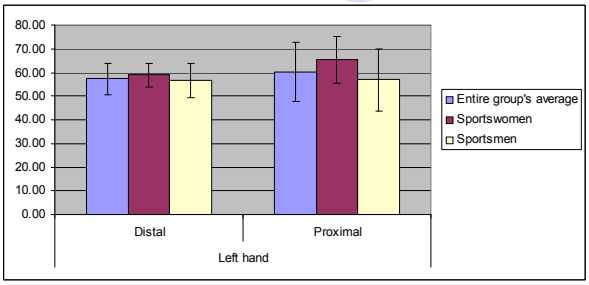
Electroneurographic testing has only targeted the motor aspect, which is determining MCV by stimulating the median nerve.

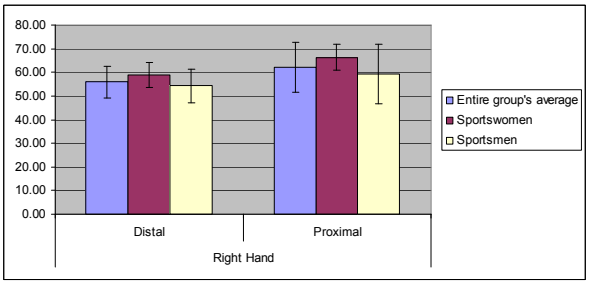
No significant differences for the values of motor conduction velocity were noticed, when statistically comparing girls-boys both arms and for all tested segments (Table 5).

The average values of motor conduction velocity obtained by proximal and distal stimulation of the left and right hand were not significantly different (Graphic 6 - 7).

Table 5. The average values of MCV for the entire group, sportswomen and sportsmen

	Right Hand		Left hand	
	Distal	Proximal	Distal	Proximal
Entire group's average	55.87	62.18	57.28	60.15
Sportswomen	58.76	66.31	58.87	65.28
Sportsmen	54.25	59.32	56.44	56.86





Graphic 6 -7. The average values of MCV obtained by proximal and distal stimulation

When making inter-sports comparisons, the only significant differences for the values of motor conduction velocity were present following stimulation of the proximal segment, for right hand, handball to volleyball subgroups (as indicated in Table 6).

Table 6. The values of MCV for the studied groups

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		Right Hand		Left Hand	
		Distal	Proximal	Distal	Proximal
Entire group	Average	55.87	62.18	57.28	60.15
	St.dev	6.71	10.58	6.59	12.44
Fencing	Average	56.45	67.90	57.73	61.55
	St.dev	7.10	7.94	7.31	13.09
Handball	Average	52.71	59.51	56.93	59.21
	St.dev	7.79	8.68	4.44	11.83
Volleyball	Average	57.56	61.16	56.97	58.40
	St.dev	7.04	18.58	8.83	14.21

The analysis of MCV values obtained data in the case of sportswomen, did not show significant differences, with the exception of fencing-handball at the forearm level (2-1=elbow-distal), left hand, modifications which were not present when analyzing the sportsmen subgroups.

DISCUSSIONS

Retrospective studies showed that the structure of limbs, especially nerve and muscle, tends to adapt as a response to training specific for each sport. Overstepping a certain level of this adaptation may not be benefic for performance and may even mark a higher risk of lesions [3].

Starting from these considerations, we aim at shaping the modifications of MCV, for the three sport disciplines: handball, volleyball, fencing, with varied degrees of use for the upper limbs.

Aside from measuring MCV, the computing of the compound muscle action potential parameters brought additional data to the electroneurophysiologic characterization of performance sportsmen.

As shown previously, the latencies of the motor response, when comparing sportsmen and sportswomen, shows significant differences only when stimulating the median nerve at the elbow and the bicipital groove, with girls presenting lower latencies than boys and slightly higher MCV values, respectively.

Takano [15], when compiling a study in 1991, on a group of 650 healthy volunteers, found slightly higher MCV values for girls compared to boys and for lower height subjects compared to taller subjects, respectively, the relation being apparently easy to notice between the mentioned aspects.

In case of latencies and MCV values, the significant differences between sportsmen and sportswomen can be partially explained by the sex and height differences [2] [9].

Computing the Pearson correlation coefficient, between the height of all our subjects and the values of MCV, did not yield results that sustained those ascertained by Takano.

What is interesting to reveal, also when comparing boys-girls, are the statistic differences between the values of amplitudes, areas and the duration of the motor response, obtained at all three levels of stimulation, for both upper limbs. The higher values recorded for sportswomen compared to sportsmen can be explained by possible functional adaptive modifications (hypertrophy**,** etc) [6] that are reduced for girls, allowing the stimulation of a higher number of axonic fibers on them, with more developed motor responses, of a higher duration and evidently on a larger area.

This aspect of sex differences can also be commented on in the light of discoveries made during games and contests of fencing, where the masculine ones require higher force and engagement, with a heightened risk of lesions, even if only subclinical [16] [10].

Thus, these more numerous subclinical lesions occurring for boys, can take part in explaining the lower values of amplitudes, areas and CMAP durations recorded on them. This aspect is in concordance with that observed by Stecker (2008) [14], whom through experimental research, has shown the sensibility of CMAP parameters to minimal compression, finding decreases of up to 50 % of the amplitude of the motor response. For the same level of compression, the author did not signal MCV modifications larger than 5 %.

Significant differences were also obtained when comparing the values of CMAP parameters for the entire group with those of the volleyball subgroup, for amplitude and areas of motor response, by proximal stimulations (bicipital groove and elbow), left hand. The mentioned data can sustain the particularities of volleyball practitioners, who use the upper limbs more than fencers and handball players (where the use of arms is asymmetrical), amplitudes and areas of the motor response are higher for the non-dominant limb, specific training inducing functional modifications, especially at the proximal level [12].

The other two sports compared with the entire group, yield significant differences only for the CMAP parameters, without being sustained by a morph-functional substrate, explainable through the specifics of the sporting training.

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The inter-sports analysis of values characteristic to the motor response did not show statistic differences between the subgroups handball-fencing and handball-volleyball. When comparing data of the volleyball subgroup with the fencing subgroup, statistic differences were recorded when stimulating the left hand, proximal and elbow level, for the amplitude and area parameters, higher values recorded by the fencing subgroup being in concordance with the characteristics of the effort type made by the practitioners of this sport.

Boys-girls inter-sports comparison showed the presence of functional modifications specific to sports, for both girls and boys and thus, significant sex dependant differences were not present for the same sport, other than non-systemized.

MCV values did not present significant statistic differences for inter-sports comparisons, either. The same analysis made for subgroups of sportsmen and sportswomen did not yield statistic differences between MCV parameters.

CONCLUSIONS

Made on a large scale, the specific trainings induce both structural and functional modifications, which produce variations of the CMAP parameters, influencing the values of MCV in a small measure, very important aspects which can help establish an efficient level training appropriate to the sportsman physical capacities in order to obtain sportive performance avoiding overtraining and extenuation of the athlete.

Simultaneously, these determinations can highlight functional abnormalities, which represent subclinical neuropathies present at professional sportsmen, thus, these affections can be treated in advance, the complications can be shunned and in many cases the sportsmen can take again their physical activity.

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