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Identifying the Muscle Contraction Activity at Athletes Using Brain Mapping

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Abstract: *Background: Understanding the brain function and how it coordinate the motor activity, means to have a map of brain using a lot of modern technologies which can give us information about the role and functions of different brain areas.*
Objective: The aim of our study is to explore the brain activity using electroencephalography (EEG) and make the evaluation of differences in brain functions depend on specific sport activity. Methods: We make the study on two lots of athletes from judo (12subjects) and volleyball (11subjects), yrs. 22. All of them have a great sport activity experience and the anthropometric characteristics are similar. For recording the brain activity we use Nihon EEG product. The protocol of the research includes recording of brain activity during muscle contraction and relax of hand flexors. The parameters that we follow up are alpha1, alpha2 and theta waves. The information have been analysed using statistic methods and Pearson coefficient. Judo players present a little bit increase values of theta waves and we observe also a correlation between alpha waves for dominant hemisphere. For the second lot the values of theta waves are highest. Conclusions: Analyse the behaviour of EEG waves could help the trainer and staff for approach the training results in term of build the brain and motor pattern. This is the result of professional approach of training based on neurophysiologic assessment using the brain mapping.

Keywords: *electroencephalography; brain mapping; athletes; professional training; evaluation.*

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Introduction

Society for Brain Mapping and Therapeutics in 2013, suggested a definition of brain mapping, in concordance with, in generally, represents the study of physiology and anatomy of brain and spinal cord, by using image techniques, neurophysiology and nanotechnology.

It represents a set of neuroscience techniques predicated on the mapping of quantities or properties onto spatial representations of the human or non-human brain resulting in maps (Toga and Mazziotta, 2002).

New motor skills are learn by humans the entire life, so, studying the movements characteristic to a specific sports, is the best way to understand, complex movements connected to the memory process, which appear due to the plasticity (every new taught motor skill is superpose over cortical areas specific for other old activities) of some neuronal structures form two different areas of central nervous system, one is M1 area, responsible for high precision movements and the other is represented by the circuits between cerebellum and corpus striatum (Buonomano,1998).

Considering that many recent research papers about functional anatomy, emphasized strong connections between motor cerebral areas and pre-frontal ones and that professional training performed on a period of time longer than 5 years, produced cerebral hemispheres functional plastic modifications,this connection worth to be study from now on (Doppelmayr & Doppelmayr, 2008).

According to (Aglioti et al., 2000,) EEG is one of the oldest methods, for assessing the relationship between brain and behavior and provides a direct real-time measure of neural activity.

Pretty low number of actual studies regarding cerebral neuronal mechanisms adaptation to a certain type of professional training, correlated to the practiced sports, led us to the research development of the way in which neuromuscular adaptation is realized based on some specific cerebral patterns evolution.

This aspect is correlated to the study of Park et al. (2015,p.117-130), which demonstrated that long used EEG for the analyze of cerebral behavior through neurofeedback, facilitates recognition and modification of mental states, associated with particular patterns of cortical arousal and concomitant behavioral outcomes.

The main area, object of many studies for important researchers, was the 1 motor area (M1), because it was identified as the place where the big precision movements begin (Schiller et al., 1995).

Are mentioned, as related to the motor teaching process, two plasticity processes that aim neuronal structures from two different areas of the central nervous system: M1 area and cerebellum – striated corpus circuits (Jenkins et al., 1994, Nudo et al., 1996).

Electroencephalography (EEG) is a method, to find out some data about the mode the central nervous system is functioning and can be performed by using electrodes, placed on the scalp, which record the cerebral electrical activity during a period of time. The EEG waves can be classified in four types of rhythms alpha 8-13 Hz, beta 14-30 Hz, theta 4-7 Hz and delta 0,5-3,5 Hz, from the point of view of one of the characteristic EEG index, the frequency (Andrew & Pfurtscheller,1997).

The aim of this research was to realize an integrative electro-neurophysiological characterization of the studied sportive profiles, judo and volleyball, following the apparition of some neurophysiological patterns.

Objectives

Very few data or the lack of information from specialty literature, regarding athletes, as well as, the especial technical achievements from the last period, the accuracy' increase of neurophysiological explorations and their possible mathematical analyze, allowed us to establish the following objectives:

- to outline a neurophysiological pattern for the two categories of athletes
- to perform an analyze of neuromuscular system, in the context of a long sport activity
- to emphasize the neural changes characteristic to each studied sport.

Thus, the objective of our research was to identify possible neurophysiologic differences, associated to sportive activities, by studying the electroencephalographic (EEG) activity, using brain mapping, at judo and volleyball athletes.

Hypotheses

- The necessity of performing a correct selection of athletes in order to obtain sport performances
- The necessity of following the evolution of the ability to acquire specific skills through professional training
- Emphasizing the areas of maximum neurofunctional plasticity, which favors neuromuscular adaptations, characteristic to programme

training, optimization of specific sportive preparation and avoidance of over training.

Method and Material

Material

The studied group was formed of 23 athletes, males, 12 judo players and 11 volleyball players, with an average age of 21 years, with experience in one of the sports disciplines of at least 8 years, characterized by homogeneity regarding training regime, height and weight.

We establish to chose for the study, the sports defined by an increased number of plastic changes determined by repetitive movements made during training, performed by the upper limbs, which dominates the motor cortex due to their higher presence at this level.

All tests made to the professional sportsmen, were performed in identical conditions for all tested subjects, that is why, we can affirm that the cause for the variety of obtained results is represented by the changes determined by the sportive disciplines in study. The tests were performed under actual ethical rules, every sportsmen learned about the execution protocol. The research is make on Research Center of Human Body Motricity, University of Craiova. This research was carried out in compliance with the principles of ethics covered by the Declaration of Helsinki (WMA, 2018) and the Law No. 206/2004 and it was approved by the Ethics Committee of the University of Craiova – the Research Center for Human Body Motricity (REB-CE23 -16) which has an ethic committee and it is the Institutional Review Board for this research. All participants acknowledged their willingness to take part in the study by signing a written informed consent document.

Methods

To all subjects, were measured the EEG waves' frequencies, by using the EEG MAPPING QP-220AK programme, part of Nihon-Kohden EEG-9200 device.

In the Laboratory of Physiological Researches from Physiology Department of the University of Medicine and Pharmacy Craiova, under the coordination of Prof. Dr. ValeriuNeştianu, the recordings were performed in the morning, before training, after a frugal breakfast, that must not contain coffee, black tea, chocolate, cocoa, any medication is not allowed in the day of recording, the subjects were relaxed physically and mentally, at a comfortable ambience temperature, under conditions of low noise and light

(Babiloni et al.,2009; Calvo-Merino et al., 2005). EEG responses were recorded with surface electrodes which present a letter to emphasize the lobe (F frontal, Fp frontal polar, T temporal, P parietal, C central, O occipital) and a number to point the hemisphere location (even numbers refer to electrode positions on the right hemisphere, odd numbers to those on left hemisphere), placed on the scalp according to the electroencephalography 10-20 system (Figure 1), bipolar acquisition, 16 channels, the reference being the two ears (A1, A2), using a time constant of 0,3 seconds and a filter below 50 Hz (Constantin et al., 2008, Criciotoiu et al., 2019).

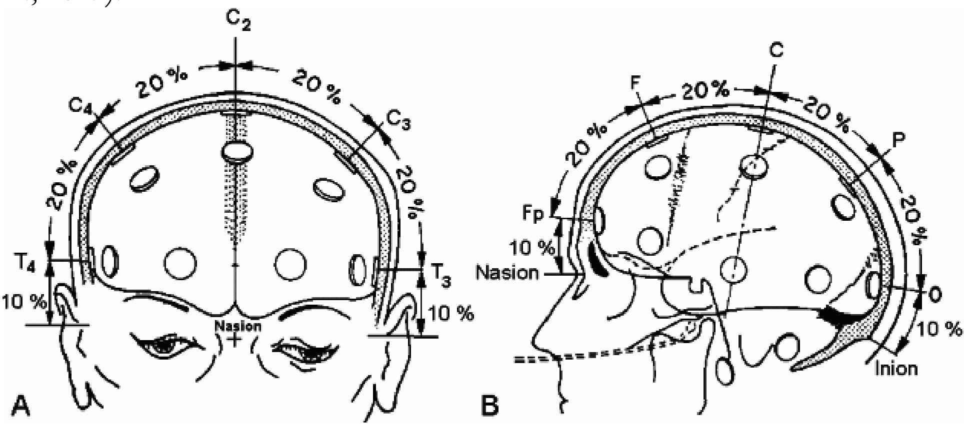

Figure 1 - EEG 10-20 electrode placement system (Constantin et al., 2008)

Taking into account the purpose of our research, EEG activity was registered during some tasks which can show potential cerebral patterns specific to practiced sports.

Were recorded EEG classic rhythms (theta, alpha1, alpha2, beta waves), in time of consecutive tasks, relaxation and contraction of each fist (fist relaxation time-R1, right fist contraction-A (Figure 2), left fist contraction-B, right fist contraction order without performing the move-C, left fist contraction order without performing the move-D), after each named action, was registered a moment to relax (R1-R5).

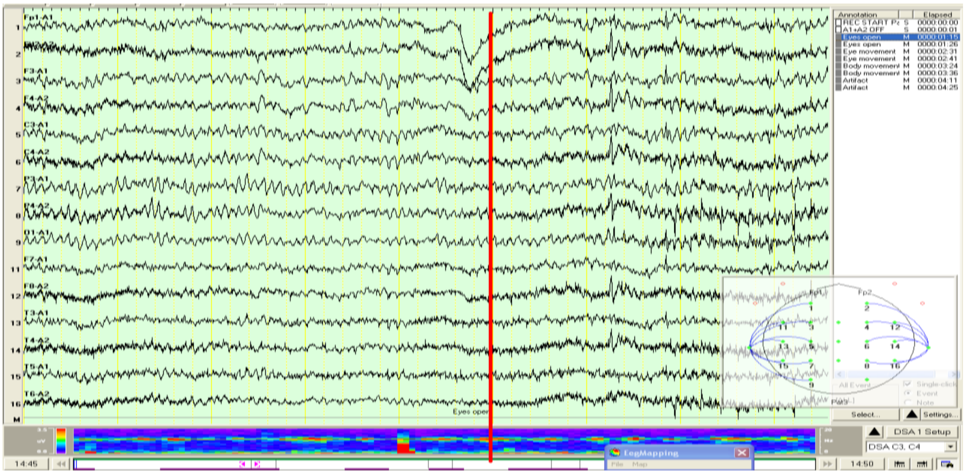

Figure 2 - Modification of EEG line by changing an activity to another (relaxation to right fist contraction) (Enescu Bieru, 2010)

For a facile identification of cerebral changes, specific to commanded actions, was used frequency cerebral mapping, so, the EEG line changes' presented in Figure2, are emphasized in Figure 3, from cerebral mapping point of view.

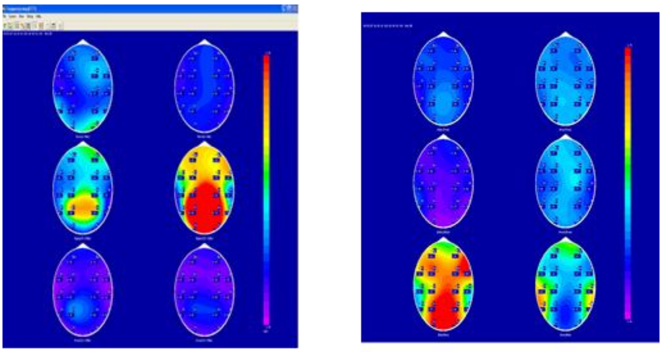

Figure 3- Cerebral mapping changes aspect as a new action is performed (right fist contraction) (Enescu Bieru, 2010)

The spectral analyze of EEG lines, performed with the help of EEG Mapping QP-220AK programme, evaluated the frequencies spectrum for recording electrode (Figure 4).

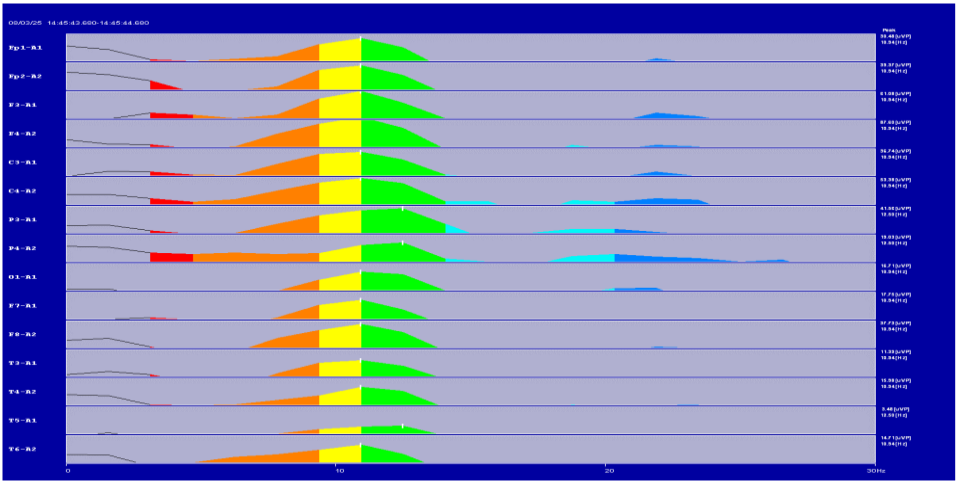

Figure 4 - EEG waves frequencies spectrum for each recording electrode (Enescu Bieru, 2010)

Thus, were obtained different values of EEG waves, compared with the help of Pearson correlation coefficient.

Statistical methods

Many values obtained through recordings or calculations, were statistical processed, in order to define certain characteristics of these parameters or to specify their evolution in time. Statistical processing was necessary, to establish the existence of some correlations between many parameters, for the characterization of the phenomena differentiated on the two sports.

Correlation as generic expression, defines the interdependence or connection between the variables observed at different samples from population. Appears sometimes with a very wide significance, either between quantitative variables, either between qualitative ones, either both types of variables. In a narrow sense, represents a measure of statistical relationship level between quantitative variables, known as correlation coefficient.

In this context, we used the Pearson correlation coefficient (linear correlation coefficient), which allowed the measurement of relationship level between variables (Criciotoiu et al., 2019, pp. 2128-2131).

Pearson correlation coefficient is accompanied by the trust interval of 95%. Is considered that r is significant, when the trust interval is an interval that not contains 0 value (respectively $r>0,5$ or $r< -0,5$). When a correlation coefficient is negative ($r<-0,5$), both correlated variables, vary in contrary way (ex. when one increases, the other decreases). If absolute value of correlation coefficient is weak (near 0), must not absolutely conclude, that is no statistical link between the two variables; but is not a linear one (cannot be described a straight line).

Results

All figures (5-12) show the cerebral mapping representation for every EEG studied wave (theta, alpha1, alpha2, beta) and Tables 1 and 2, present the correlations between all four EEG waves' values for each studied sport.

EEG results of judo players, emphasized a slight increase of theta waves values, during entire recording, as showed in Figure 5.

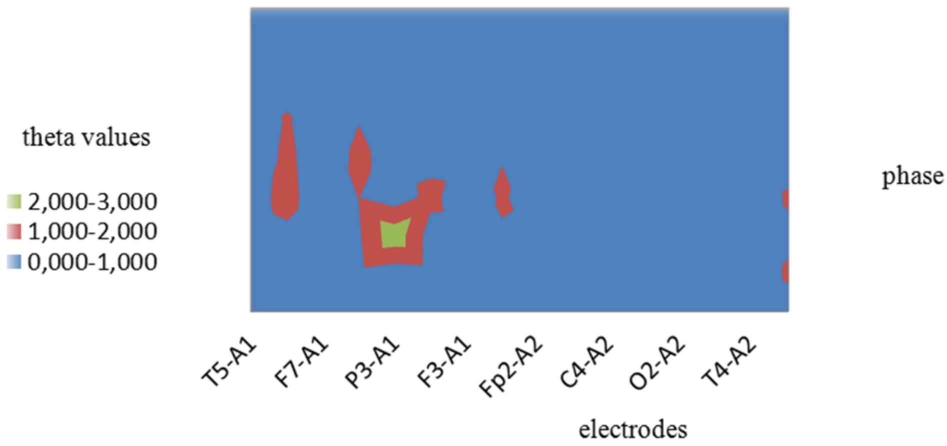

Figure 5 - Mapping representation of theta values at handball group (Enescu Bieru, 2010)

At volleyball athletes, our study emphasized the biggest values for theta waves, in comparison with the judo ones, as in Figure 6.

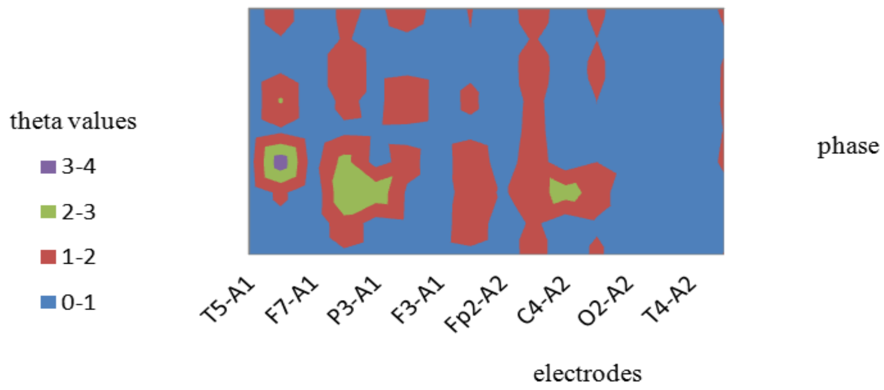

Figure 6 - Mapping representation of theta values at volleyball group (Enescu Bieru, 2010)

Alpha1 activity at judo players showed to be more homogeneous, with values of rhythms, smaller during any activity and bigger during relaxation moments, as for volleyball athletes, alpha1 wave presence was little in the dominant hemisphere, as presented in Figure 7 and Figure 8.

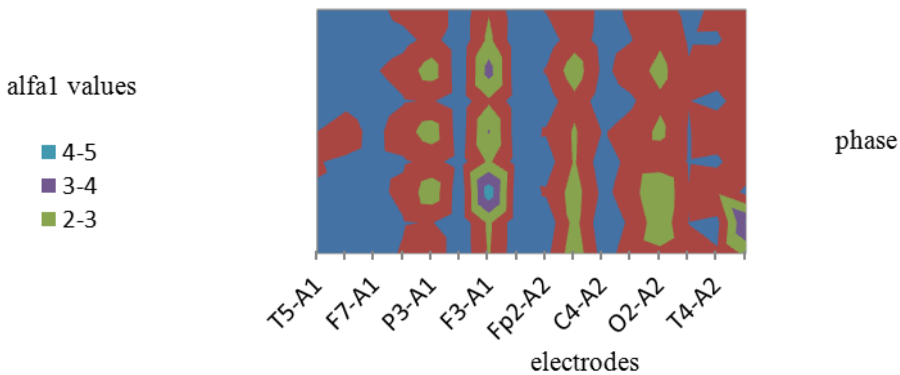

Figure 7 - Mapping representation of alpha1 values at handball group (Enescu Bieru, 2010)

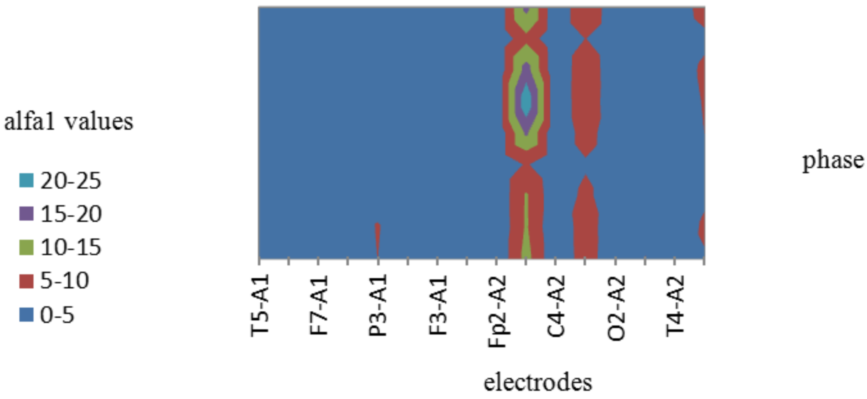

Figure 8 - Mapping representation of alpha1 values at volleyball (Enescu Bieru, 2010)

Comparing the two studied sports, activity of alpha2 index, was smaller for judo players and for volleyball players, was also characterized by a lower activity of the left hemisphere, proving a ˝quiet˝ lead, as is showed in Figure 9 and 10.

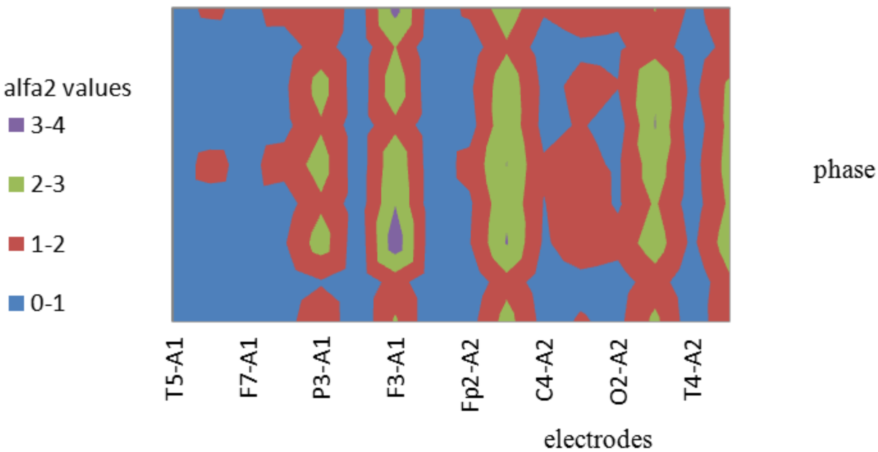

Figure 9 - Mapping representation of alpha2 values at handball group (Enescu Bieru, 2010)

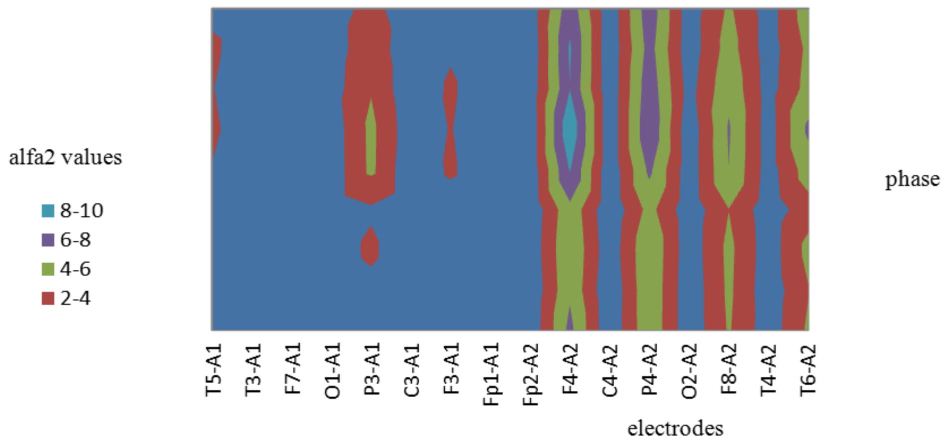

Figure 10 - Mapping representation of alpha2 values at volleyball group (Enescu Bieru, 2010)

Was remarked an identical activity for the two beta frequencies, characterizing the EEG beta wave, in correlation with the studied moments, as well for dominant and for non-dominant hemisphere at judo athletes, for volleyball ones, this beta characteristic is valid only for the non-dominant one, as showed in Figures 11, 12.

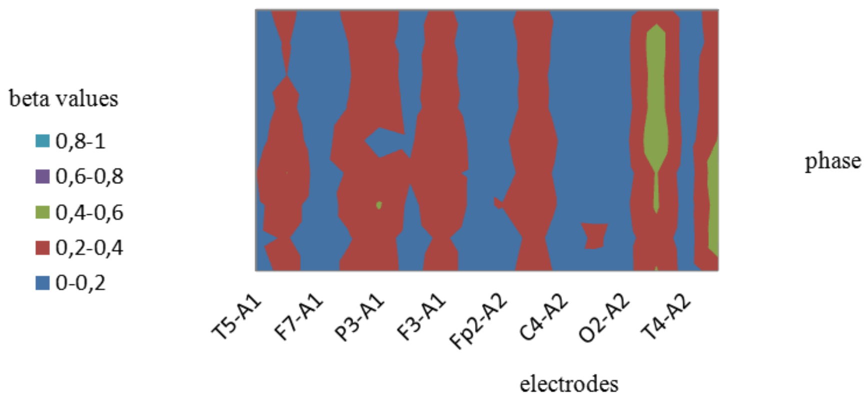

Figure 11 - Mapping representation of beta values at handball group (Enescu Bieru, 2010)

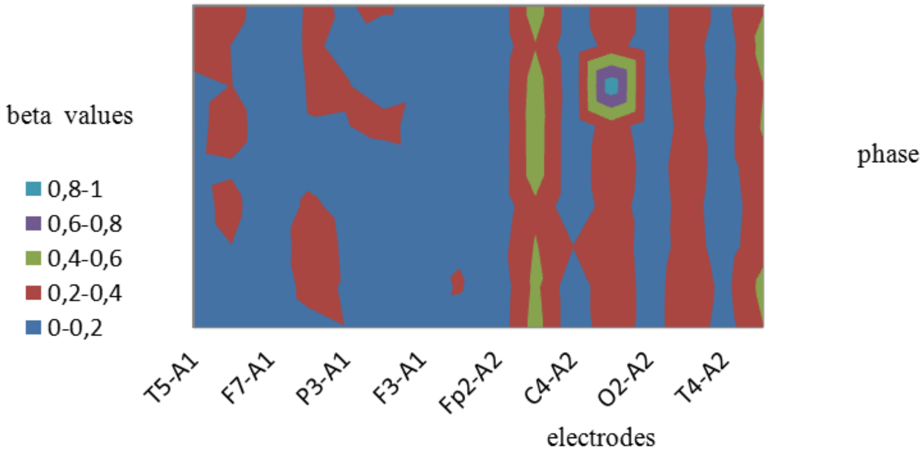

Figure 12 - Mapping representation of beta values at volleyball group (Enescu Bieru, 2010)

The statistical analyzes realized by using Pearson correlation coefficient, emphasized the presence of some correlations between the studied EEG waves.

Regarding the sportsmen who practiced judo, was observed a huge level of correlation for both beta and theta wave, as well a correlation for the two alpha waves, 1 and 2 for the dominant hemisphere (Table 1).

At volleyball athletes, the correlations were not structured equally and were smaller (Table 2).

Table 1. Values of Pearson correlation coefficient for studied EEG waves at judo athletes (Enescu Bieru, 2010)

Channel	theta-beta	alfa1-alfa2	alfa2-theta	beta-alfa1	beta-alfa2
T5-A1	0.9608636	0.7405733	0.3171618	0.5324221	0.3479288
T3-A1	0.8335601	0.7797635	0.2296869	0.5532527	0.3614416
F7-A1	0.6875358	0.7418648	0.404506	0.5663743	0.1793132
O1-A1	0.6556294	0.8079079	0.2794794	0.6064433	0.7437811
P3-A1	0.5524751	0.8616823	0.4703894	-0.0304525	0.0580903
C3-A1	0.9286536	0.6924992	0.5304877	0.9059936	0.5051707
F3-A1	0.8608326	0.568636	0.5069357	0.5950598	0.258417
Fp1-A1	0.84843	0.7590493	0.7877677	0.7234935	0.6937507
Fp2-A2	0.8207278	0.8336191	0.5723488	0.7522409	0.6797538

F4-A2	0.6399374	0.1425278	0.5516582	-0.0516744	0.480521
C4-A2	0.4269136	0.6107754	0.4439933	0.6751589	0.7072292
P4-A2	0.5363437	0.4791343	0.1842602	0.2451065	-0.2197973
O2-A2	0.7632224	0.1613303	0.4053844	0.7399968	0.4612652
F8-A2	0.7604668	0.2905145	0.6197465	0.2167896	0.5148729
T4-A2	0.9037121	0.7911052	0.5678533	0.8333468	0.4688858
T6-A2	0.8369329	-0.2161857	0.05113576	0.3405259	0.5510039

Table 2. Values of Pearson correlation coefficient for studied EEG waves for volleyball players (Enescu Bieru, 2010)

Channel	theta-beta	alfa1-alfa2	alfa2-theta	beta-alfa1	beta-alfa2
T5-A1	0.2582092	-0.7540847	-0.3645368	-0.0768146	0.4939092
T3-A1	0.6519118	0.2751812	0.4944922	0.7540957	0.7283511
F7-A1	0.7001796	0.5934066	0.0172719	0.7101558	-0.0290753
O1-A1	0.8393633	0.7709078	0.1627211	0.2510353	0.1944004
P3-A1	-0.0441773	-0.3417795	-0.1261328	0.2247836	-0.2418007
C3-A1	0.9076206	0.9164744	0.7963528	0.9549176	0.9447176
F3-A1	0.46821	0.7266626	0.3249752	0.6073983	0.768484
Fp1-A1	0.6653416	0.4137965	0.3196749	0.0800388	0.5060266
Fp2-A2	0.9275772	0.6129242	0.1921761	0.919325	0.4256794
F4-A2	0.2677949	0.7858313	-0.1975302	0.869208	0.5542217
C4-A2	0.9921712	0.7603832	0.7212396	0.9909945	0.7517196
P4-A2	0.2937318	0.6747053	0.0742323	0.3877208	0.342871
O2-A2	-0.093662	0.6417044	-0.1443277	0.2434963	0.2490772
F8-A2	-0.1500796	-0.4781296	-0.3480164	0.5035175	-0.5332899
T4-A2	-0.149585	0.3223887	-0.4938668	0.4944788	-0.0852356
T6-A2	-0.4125542	0.5407628	0.4224447	0.2781336	0.172456

Discussions

In specialty literature is studied the mechanism of securing a new learned skill, thus, the learning process is finished by an archiving process, characterized by a long period of latency, 4-8 hours after the training is finished, as is demonstrated by the experiments conducted by (Fattapposta et al., 1996; Geyer, 2000; Karni & Sagi, 1993; Klimesch et al., 1998).

Because the initial studies showed only the importance of high alpha spectrum (Criciotoiu, 2019) and of some areas of maximum activation, during the motor memory processes (Leslie, 2002, p.553-564; Matelli & Luppino, 2004), our researches should have been centered on these frequencies bands and only, in the areas already signaled, in order to be important for the studied process.

Taking into account that recent papers of functional anatomy, which emphasized strong connections between motor areas and prefrontal ones (Matsumoto et al., 2004, p.181-197; Nikolić et al., 2012; Park et al., 2015; Pearce et al., 2000) and the experience of investigated subjects, we considered opportune, the EEG evaluation of a group of athletes, whom neuronal patterns were predicted to be clearly define and well differentiated for the tested sports.

In the present, the information offered by the specialty literature, are able to explain partially the revealed differences between the studied sports, so, it appears that the real reason of these differences, in opinion of other authors, can be represented by some intermediary processes developed in the brain.

We showed that the objective of our research was to identified neurophysiologic models determined by the chronic physical effort characterized by at least 5 years period, of sports professional activity, that is why we focused on these kind of sportsmen, to which was finished the first process of cerebral plasticity and appeared in primary motor area M1, morphologic differences (Sadowski, 2008; Sanes et al., 2000).

Is essential to analyze, understand and evaluate the processes that involve motor memory, because our declared purpose was to improve significantly, the athletes motor performances and on this line, was remarked the relevance of theta and beta EEG waves (Schieber, 2002, 411-416; Schultz, 2012). Accordingly, is known that a lack of synchronization means a low of alpha activity and a synchronization, an improve of theta wave activity, which shows an ability to memorize (Schultz, 2012). During our research, we observed the recorded EEG lines of both studied sports and remarked various results specific to neurological patterns, but unchanged for the same group of professional sportsmen, excepting a few characteristic changes, revealed with the help of magnetic stimulation (Pearce, 2000, p.238-241).

In first place, when we start to record the EEG activity, none of the sportive discipline had theta wave activity. The mentioned moment for recording, pointed out at at judo players, an alpha activity at frontal and occipital lobes, followed by a beta wave rhythm, characterized by a big distribution, but with a lower power, volleyball athletes recorded a alpha and beta waves activity at frontal and occipital lobes, but only for the non-dominant hemisphere, information presented by (Sadowski, 2008,p.5-21). Also, the players who practiced judo, presented just an occipital activity for the dominant hemisphere, affirmation made by (Constantin et al., 2008; Sanes & Donoghue, 2000).

Beside the first phase of recording, the second moment represented by right first contraction movement produced big EEG changes.

Theta wave activity was quite big for volleyball group, having a significant representation in temporal, parietal, occipital and frontal left lobes, very well defined surfaces, whereas theta index was systematized in the dominant hemisphere, unlike the one, for the right hemisphere, which was not systematized.

Judo players during right fist contraction, did not present the same theta activity as the volleyball athletes.

Regarding alpha2 wave, is characterized by small changes at frontal right lobe for volleyball players. Thus, is proved, that for volleyball group, the variations appeared during right fist contraction, were especially for theta wave activity, so this kind of athletes are characterized by a long lasting motor memory for the performed movements (Sanes & Donoghue, 2000).

Both alpha and beta waves registered a significant decline, during second moment of recording, at judo group, revealing a big level of attention (Sanes & Donoghue,2000), thus, other EEG characteristic was emphasized, so,was outlined the inter-sports differences.

R2, second moment of relax, showed for volleyball athletes the growth or maintaining of the activity of theta wave, judo group being characterized by a small increase of alpha2 wave activity at parietal lobe, where the presence of this wave is rare, that is why, this presence we discover is quite difficult to be explained, unlike the increase of the frequencies bands' activity at the lobes, where these one already are present.

Contraction of the left fist, produced identical modifications for alpha and beta frequencies EEG waves as the right one determine, furthermore a small surface from left frontal, temporal and occipital lobes, presented for judo athletes a theta band activity minimum increase.

Continuing to describe this phase of recording mentioned previously, the models specific to EEG belonging to the two studied sports, remain the same, observing a minor increase of theta wave for judo players in the left hemisphere and a major increase of the activity of alpha and beta waves, for both hemispheres, also, for judo group.

At volleyball players was remarked an alpha 1 activity quite smaller in the right hemisphere, in comparison with alpha2 activity, which was bigger in the left parietal lobe.

The differences between first and last recording moments are not so significant for judo group, instead at volleyball players, the theta wave activity remains dominant for temporal and central surfaces.

Due to the particularities of each sport included in this research, was emphasized the thought that some athletes own an imagination of performed move, higher than the rest of the professional sportsmen, determined by morphological changes, revealed by (Pearce et al., 2000).

Entire EEG lines recording' objective was to outline the classic rhythms activities changes, generated by different activities and tasks, like fists successively contractions, movement thinking without performing it, in comparison with moments of repose.

Analyzing the speciality literature, were observed many information about motor memory (Schieber,2002; Schultz,2012; Shadmehr & Brashers-Krug,1997), that is why our study' scope, was to outline the differences between sportive disciplines, an authentic aim, very little studied by other authors, specialized in neurophysiological domain.

Conclusions

At judo athletes was noticed, by analyzing the obtained results, the presence of classic rhythms characteristic to wakeful state at adult, as well during relaxation periods of time as activity, being remarked a decrease of the power response specific to each rhythm, according to the moments when relaxation or activity dominate.

In comparison with the judo players, volleyball sportsmen, where characterized by a dominant aspect, the presence of theta wave activity, both during relaxation and movement thinking, which was described by the literature, as a pair of the motor memory process, always present at volleyball group.

Brain mapping proved to be a useful and objective method for analyze and identification of EEG waves differences, specific to long period sportive activities, determined by the professional training' influence over cerebral activity.

Practical applicability refers to the verification of this research' hypothesis, every one of these, being confirmed, thus: the use of such evaluation algorithm of cerebral activity during professional training, allows a correct selection of athletes, an evaluation of motor learning process, as result of training, avoidance of possible over training and even application in neuromotor rehabilitation processes (Siuly et al., 2016, p. 255; Tarnita et al., 2016; Toga, 2002).

Acknowledgment

All authors have contribute equally to this article.

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