STUDY OF ELECTROENCEPHALOGRAPHIC ACTIVITY AT DIFFERENT CATEGORIES OF PROFESSIONAL SPORTSMEN

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Abstract: Our purpose was to emphasize a neurophysiologic pattern associated to different categories of professional sportsmen, handball and volleyball players, by assessing their electroencephalographic classic rhythms waves (theta, alpha).
The study was performed on a group of 17 professional sportsmen, with average ages, heights and weights, 9 handball players and 8 volleyball players, characterized by different stress degrees of the upper members, active for between 5 and 12 years in one of the sportive activity.
The EEG response was recorded with surface electrodes, placed on the scalp according to the electroencephalography 10-20 system and the EEG waves obtained during some activities (successive relaxation and contraction of both fists), were measured using the Nihon-Kohden EEG-9200 device.
By processing the results recorded at handball group, was remarked the presence of classic rhythms specific to wakeful state at adult, both during relaxation and contraction moments, with a diminution reaction characteristic to each rhythm, depending on relaxation-activity moment.
Volleyball players, unlike handball players, presented during both, relaxation and contractions periods, a theta band activity, aspect mentioned in literature as accompanying the motor memory process, which dominates at volleyball players.
EEG complex testing of professional sportsmen, as well as the outlining of an EEG pattern specific to studied sportive disciplines, represent an original aspect of this study.
Key words: professional sportsmen, electroencephalograph.y, neurophysiologic pattern.

Introduction

The technique of cerebral electrical activity acquisition during a period time, through electrodes placed on the scalp, is named electroencephalography (EEG) and offers only partial information about the functional state of the central nervous system. According to frequency, one of the EEG specific parameters, were identified four types of waves (rhythms): alpha 8-13 Hz, beta 14-30 Hz, theta 4-7 Hz and delta 0,5-3,5 Hz.

Our purpose was to emphasize a neurophysiologic pattern associated to different categories of professional sportsmen, handball and volleyball players, by assessing their electroencephalographic classic rhythms waves (theta, alpha).

Material and methods

The study was performed on a group of 17 professional sportsmen, with average ages, heights and weights, 9 handball players and 8 volleyball players, characterized by different stress degrees of the upper members, active for between 5 and 12 years in one of the sportive activity.

The studied sports were chosed, taking into account the more extensive representation of the upper limbs in the motor cortex, thus, a higher number of plastic changes are possible to appear as a result of repeated complex movements performed during specific training [1].

The testing was performed under current ethical rules, each participant being informed of the experimental processes.

All the investigated sportsmen have been subjected to electric-neuro-physiological investigations by measuring the EEG waves, using Nihon-Kohden EEG-9200 device. The EEG response was registered with surface electrodes which have a letter to identify the lobe (F frontal, T temporal, P parietal, C central, O occipital) and a number to identify 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. In consideration of the study objective, we recorded the EEG line during some

activities which can emphasize the possible characteristic cerebral patterns.
So, the activities followed during EEG recording were: first relaxation time ((R1), right fist contraction (A), left fist contraction (B), right fist contraction order without performing the move (C), left fist contraction order without performing the move (D), after every mentioned moment was recorded a relaxation time (R1-R5) (Figure 2)..

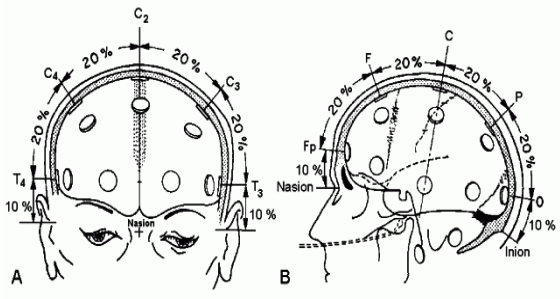

Figure 1. 10-20 electrode placement system

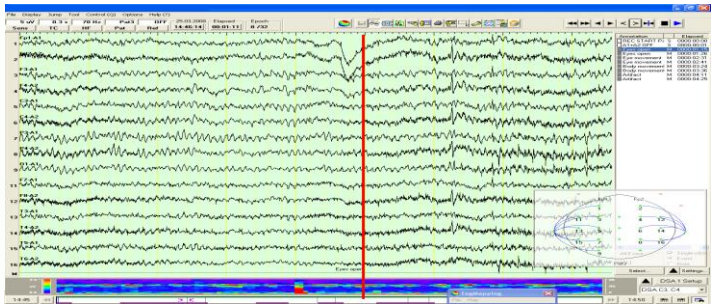

Figure 2. Modification of EEG line by changing an

The EEG analyze was made by assessing the classic rhythms: Theta [4-8Hz], Alpha1 [8-10Hz], Alpha2 [10-13Hz].

Results

For handball group, was remarked a slight increase of the theta wave values, during entire recording, as showed in Table 1.

Table 1. Theta values at handball group for every studied moments

channel	R1	A	R2	B	R3	C	R4	D	R5
T5-A1	0.275	0.582	0.511	0.597	0.263	0.189	0.330	0.252	0.504
T3-A1	0.787	0.681	0.786	1.334	1.259	1.119	0.665	0.739	0.602
F7-A1	0.328	0.237	0.261	0.359	0.285	0.232	0.329	0.254	0.281
O1-A1	0.789	0.700	0.869	1.014	1.263	0.974	0.731	0.670	0.627
P3-A1	0.446	0.445	2.652	0.478	0.531	0.420	0.505	0.444	0.475
C3-A1	0.549	0.546	0.581	1.271	0.736	0.663	0.527	0.641	0.533
F3-A1	0.477	0.373	0.540	0.414	0.654	0.394	0.500	0.489	0.475
Fp1-A1	0.585	0.629	0.912	1.104	0.981	0.748	0.533	0.583	0.619
Fp2-A2	0.428	0.365	0.790	0.576	0.700	0.426	0.445	0.425	0.396
F4-A2	0.512	0.391	0.514	0.423	0.630	0.403	0.520	0.440	0.485
C4-A2	0.391	0.449	0.486	0.523	0.447	0.387	0.399	0.400	0.449
P4-A2	0.362	0.355	0.380	0.349	0.318	0.266	0.345	0.320	0.311
O2-A2	0.273	0.207	0.332	0.261	0.300	0.235	0.262	0.266	0.204
F8-A2	0.452	0.359	0.406	0.376	0.498	0.415	0.488	0.407	0.359
T4-A2	0.216	0.157	0.258	0.187	0.278	0.202	0.229	0.181	0.194
T6-A2	0.551	1.165	0.741	1.142	0.506	0.555	0.607	0.520	0.675

At volleyball players our study emphasized the biggest values for theta waves, in comparison with the handball ones, as in Table 2.

Table 2. Theta values at volleyball group for every studied moments

channel	**R1**	**A**	**R2**	**B**	**R3**	**C**	**R4**	**D**	**R5**
T5-A1	0.325	0.293	0.35	0.565	0.3	0.24	0.29	0.412	0.453
T3-A1	0.748	0.721	1.23	3.696	0.84	2.126	0.87	0.939	1.6
F7-A1	0.188	0.206	0.17	0.534	0.16	0.152	0.15	0.148	0.151
O1-A1	0.845	1.696	2.87	2.379	0.81	1.332	1.91	1.127	1.3
P3-A1	0.57	0.554	2.74	0.634	0.74	0.624	0.62	0.589	0.761
C3-A1	0.716	0.775	0.85	1.373	0.7	2.008	0.78	0.841	1.553
F3-A1	0.559	0.487	0.46	0.439	0.5	0.511	0.53	0.457	0.643
Fp1-A1	0.75	1.731	1.54	1.721	0.74	1.228	0.84	0.974	1.048
Fp2-A2	0.39	0.425	0.88	0.537	0.39	0.313	0.37	0.349	0.424
F4-A2	1.491	1.186	1.52	1.496	1.38	1.329	1.6	1.1	1.569
C4-A2	0.352	0.372	2.49	0.424	0.34	0.315	0.42	0.357	0.45
P4-A2	1.208	0.845	1.55	0.997	0.96	1.006	1.27	0.994	1.255
O2-A2	0.268	0.268	0.24	0.665	0.23	0.263	0.27	0.251	0.329
F8-A2	0.577	0.568	0.53	0.667	0.56	0.572	0.57	0.608	0.569
T4-A2	0.264	0.316	0.31	0.772	0.28	0.236	0.25	0.254	0.415
T6-A2	1.012	0.809	0.9	1.049	1.01	1.086	1.07	0.889	1.129

Handball athletes' alpha1 activity was proved to be more homogenous and with classic reactivity, being lower during any active moment and higher during repose moments, regarding alpha1 EEG activity for volleyball players, that one was lower in the dominant hemisphere, as presented in Table 3 and Table 4.

Table 3. Alpha1 values at handball group for every studied moments

channel	**R1**	**A**	**R2**	**B**	**R3**	**C**	**R4**	**D**	**R5**
T5-A1	0.934	0.711	0.97	1.031	1	0.345	0.91	0.520	1.01
T3-A1	0.792	0.519	0.94	0.887	1.39	0.806	0.8	0.595	0.813
F7-A1	0.661	0.407	0.74	0.675	0.72	0.409	0.91	0.338	0.695
O1-A1	1.085	0.934	1.26	0.865	1.58	0.912	1.44	0.677	1.366
P3-A1	1.717	1.057	2.65	1.293	2.54	1.087	2.5	1.340	1.915
C3-A1	0.313	0.314	0.33	0.609	0.48	0.408	0.35	0.320	0.347
F3-A1	2.093	2.209	4.68	2.174	3.09	1.858	3.45	2.260	1.931
Fp1-A1	0.334	0.323	0.4	0.586	0.45	0.429	0.31	0.312	0.366
Fp2-A2	0.685	0.309	1.11	0.489	1.09	0.447	1.06	0.451	1.054
F4-A2	2.681	2.348	2.46	2.082	2.12	1.706	2.6	1.568	1.793
C4-A2	0.57	0.275	0.71	0.404	0.93	0.414	0.76	0.601	0.664
P4-A2	1.505	1.213	1.61	1.385	1.38	0.854	1.5	0.976	1.159
O2-A2	1.803	2.685	3	1.478	2.24	1.805	2.34	1.836	1.467

F8-A2	1.304	0.979	1.03	0.932	0.94	1.024	1.07	0.906	0.699
T4-A2	1.067	0.757	1.88	0.783	1.66	0.69	1.58	0.893	1.251
T6-A2	2.282	4.076	0.74	1.876	1.68	1.711	1.61	1.581	1.034

Table 4. Alpha1 values at volleyball group for every studied moments

channel	R1	A	R2	B	R3	C	R4	D	R5
T5-A1	2.298	2.210	1.72	1.765	1.46	1.321	1.47	1.504	2.67
T3-A1	1.412	1.166	0.88	1.492	0.9	1.564	1.1	0.963	1.54
F7-A1	0.34	0.353	0.33	0.445	0.36	0.363	0.36	0.358	0.436
O1-A1	0.641	0.568	1.18	0.867	0.57	0.992	1.89	0.858	0.855
P3-A1	5.043	5.418	2.74	3.812	4.14	3.818	4.17	3.302	5.034
C3-A1	0.542	0.540	0.5	0.591	0.58	1.399	0.63	0.55	0.968
F3-A1	1.817	1.411	1.66	1.289	2.24	1.752	1.78	1.716	2.221
Fp1-A1	0.486	0.562	0.71	0.638	0.51	1.129	0.65	0.58	0.729
Fp2-A2	0.41	0.271	0.63	0.362	0.35	0.291	0.37	0.271	0.441
F4-A2	11.92	10.668	10.6	5.542	16	24.13	17.4	8.718	16.61
C4-A2	0.381	0.324	1.14	0.380	0.34	0.328	0.42	0.311	0.452
P4-A2	7.878	8.182	6.49	4.316	7.58	9.223	9	5.108	9.865
O2-A2	0.67	0.514	0.89	0.814	0.98	0.616	0.95	0.658	1.04
F8-A2	5.035	4.832	4.23	4.971	4.76	3.54	4.36	3.509	4.232
T4-A2	1.983	1.484	0.85	0.704	1.29	1.593	1.77	0.935	1.669
T6-A2	4.535	5.823	4.2	2.764	5.04	5.429	6.08	3.871	7.207

Alpha2 values are lower for handball players in comparison with the volleyballs' ones, that are also characterised by a small activity of the left hemisphere, reflecting a ″quiet″ conduct, aspect revealed in Table 5 and 6.

Table 5. Alpha2 values at handball group for every studied moments

channel	**R1**	**A**	**R2**	**B**	**R3**	**C**	**R4**	**D**	**R5**
T5-A1	0.522	0.401	0.7	0.618	0.61	0.469	0.52	0.393	0.577
T3-A1	0.732	0.413	0.75	0.747	1.24	0.616	0.69	0.494	1.202
F7-A1	0.608	0.458	0.73	0.692	0.78	0.613	0.68	0.548	0.736
O1-A1	0.62	0.328	0.9	0.511	1.37	0.719	0.82	0.532	1.412
P3-A1	1.767	0.913	2.52	1.829	2.43	1.881	2.42	1.457	1.973
C3-A1	0.255	0.218	0.35	0.454	0.42	0.425	0.37	0.341	0.429
F3-A1	2.114	1.460	3.64	2.967	2.77	1.783	2.63	2.037	3.363
Fp1-A1	0.232	0.229	0.37	0.381	0.41	0.354	0.25	0.224	0.37
Fp2-A2	0.625	0.243	0.95	0.846	1.33	0.594	0.81	0.490	1.216
F4-A2	2.402	1.679	3.08	2.799	3.02	2.798	2.7	1.860	2.597
C4-A2	0.667	0.394	0.87	0.961	1.13	0.691	0.78	0.498	1.152
P4-A2	1.086	0.752	1.52	1.637	1.3	1.101	1.19	0.883	1.382
O2-A2	0.749	0.527	1.38	0.868	0.85	0.52	1.04	0.827	1.263
F8-A2	2.233	1.531	2.55	2.128	2.62	3.046	2.9	1.629	2.046
T4-A2	0.404	0.216	0.78	0.510	0.59	0.339	0.71	0.419	0.807
T6-A2	1.778	1.814	2.6	2.171	2.4	2.26	2.18	1.354	1.459

Table 6. Alpha2 values at volleyball group for every studied moments

channel	**R1**	**A**	**R2**	**B**	**R3**	**C**	**R4**	**D**	**R5**
T5-A1	1.381	1.585	1.79	1.518	1.96	2.178	2.05	2.254	1.67
T3-A1	0.788	0.731	1.01	1.121	1.11	1.357	1.04	1.121	1.206
F7-A1	0.447	0.490	0.53	0.597	0.62	0.558	0.65	0.57	0.66

O1-A1	0.678	0.667	0.91	0.739	0.78	0.813	1.13	0.971	1.016
P3-A1	1.875	1.454	2.41	1.724	4.45	4.502	3.87	3.406	2.717
C3-A1	0.333	0.300	0.29	0.335	0.4	0.692	0.43	0.431	0.652
F3-A1	1.279	1.087	1.59	1.086	2.31	2.102	2.32	1.74	1.938
Fp1-A1	0.317	0.427	0.41	0.385	0.33	0.423	0.41	0.465	0.456
Fp2-A2	0.414	0.251	0.51	0.337	0.46	0.432	0.52	0.337	0.577
F4-A2	6.534	5.684	5.89	5.505	8.16	9.659	7.96	8.247	7.353
C4-A2	0.341	0.238	0.62	0.324	0.41	0.46	0.44	0.385	0.482
P4-A2	5.629	5.701	5.81	4.705	6.44	7.759	7.36	6.811	7.326
O2-A2	0.568	0.556	0.71	0.631	0.72	0.59	1.14	0.743	0.818
F8-A2	4.206	4.408	4.52	3.970	5.99	6.184	5.59	4.931	4.346
T4-A2	0.817	0.704	0.85	0.729	1.03	0.971	1.11	0.965	1.011
T6-A2	4.317	3.899	4.61	3.161	5.08	6.43	4.79	4.458	5.167

Discussions

Because our study aimed the identification of neurophysiologic patterns specific to a long sportive activity, the attention was directed towards athletes of whom the initial cerebral plasticity process stopped and the morphologic differences are born especially in M1 (primary motor) area.

Was suggested the importance of theta wave, in order to understand, evaluate and measure the motor memory processes, but especially, for improving the motor performances, in our case, the sportive ones [2], [3].

Thus, is considered that a decrease of alpha activity (non-synchronization) and an increase of theta one (synchronization), reflects a high capacity of memorization [4]. Following during our study, the electroencephalographic activity of each studied sportive discipline, we observed different response patterns, but constant for the same group of athletes, specific changes being reported by Pearce in 2000, by using magnetic stimulation [5]. At the beginning of the recordings, neither of the studied sportive disciplines presented theta power spectrum activity. The same moment of recording showed for handball group an alpha frontal-occipital activity, with a larger spreading but a smaller power, as for volleyball players, is recorded a frontal-occipital activity for alpha wave, but only for the non-dominant hemisphere, aspect described by Andrew and Pfurtscheller in 1997 [6]. The dominant hemisphere presented only an occipital activity at handball group, aspect reported by Klimesch in 1998 [7] and Babiloni in 2009 [3]. The right fist contraction moment produces spectacular EEG modifications in comparison with initial moment ones.

Volleyball players presented an increase of the theta band activity, so the theta band was very well represented in left frontal, parietal and occipital-temporal, well outline areas, while the theta band for the right hemisphere was not systematized, as was in the dominant hemisphere.

The handball group did not show the same theta activity during right fist contraction.

Group of volleyball athletes presented minor right frontal modifications for alpha2 bands. Is sustained the affirmation that for volleyball players, the changes during right fist contraction were mostly in theta band, having a long duration motor memory for the performed move [7].

For handball alpha1 and 2 decreases were obvious during this action, showing a high attention [7], so another EEG feature was outlined, that emphasize the difference between the two sports.

During relaxation moment R2, theta activity is constant or increases at volleyball group and alpha2 activity presents a slightly increase in parietal area, for handball, the frequencies bands had an increased activity in the areas where these frequencies already existed, characteristic for these is an alpha2 increase, more difficult to explain. The left fist contraction determined the same changes for alpha frequency bands as the right one, additionally appearing little left frontal-temporal-occipital areas that presented minimum increase of theta spectrum at handball players.

The changes find until now at the two sportive disciplines can not be totally explain by the literature, there are maybe the final result of an intermediary processes pointed out by other authors.

From this moment, the EEG characteristic patterns of the two sports, remain constant, being a small theta increase for handball in the left hemisphere and a alpha majority for both hemispheres at the same sport.
Alpha 1 activity is not higher in the right hemisphere at volleyball athletes, instead, alpha2 activity is higher in the left parietal area. The last recording moments are not so different from the initial moments at handball players, but for volleyball athletes the theta activity remains dominant for temporal and central areas.
Because of the particularities of each sportive discipline, is outlining the idea of some sportsmen presenting a performed movement imagination bigger than the one of other tested sport, which is produced by structural changes, signaled by Pearce in 2000 [5].
The whole EEG testing aimed to emphasize the classic rhythms power spectrums modifications, produced by different orders (fists successively contractions, movement thinking without perform it), in comparison with the relaxation moments between actions. The literature describes many observations regarding the motor memory, our objective study was to emphasize the differences inter-sports, an original aspect enough conspicuous outlined by the previous affirmations.

Conclusions

Emphasizing some neurophysiologic patterns specific to long period sportive activities through electrophysiological tests is imposed as a viable method and easy to use for cerebral electrogenesis appreciation, in presence of functional plastic changes determined by the training.
By processing the results recorded at handball group, was remarked the presence of classic rhythms specific to wakeful state at adult, both during relaxation moments and activity, with a diminution reaction characteristic to each rhythm, depending on relaxation-activity moment.
Volleyball players, unlike handball players, presented both during relaxation and movement thinking, theta band activity, aspect mentioned in literature as accompanying the motor memory process, which dominates at volleyball players.
EEG complex testing of professional sportsmen, as well as the outlining of an EEG pattern specific to studied sportive disciplines, handball and volleyball, represent an original aspect of this study.

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