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SELECTED QEEG RATIOS IN THE DISGNOSIS OF SPORTING ACHIEVEMENTS AMONGST BASKETBALL PLAYERS

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SUMMARY

Background: Ways are sought within sports science to determine competitors' potential achievements. One of the ways in which this may be tested is by examining the electrical activity of the sportsman's brain. The subject of research was an attempt to describe those neurophysiological parameters (Theta/Beta ratio, Theta/SMR ratio) which could have an impact in the obtaining of high levels of sporting success in basketball.

Material/ Methods: Two groups took part in the research: 1/ sportsmen who played basketball and 2/ students of the University of Physical Education and Sport in Gdansk. To determine the neurophysiological ratios of attention concentration and anxiety the QEEG method was applied. Registration of the EEG signal was conducted from the Cz point in accordance with the 10-20 system. Testing was conducted by means of a FlexComp-Infinity coder, with the use of an EEG-Z sensor with an inbuilt function for the measurement of impedance.

Results: In each testing condition (eyes open, closed and attention concentration) the basketball players display a lower Theta/Beta ratio and Theta/SMR ratio when compared to the student group.

Conclusions: The values of the Theta/Beta ratio and the Theta/SMR ratio may constitute an important source of information on the subject of QEEG markers used in the diagnosis of sporting achievements for those practising basketball.

Key words: basketball players, QEEG, Theta/Beta ratio, Theta/SMR ratio

INTRODUCTION

Researchers involved in sports sciences are looking for methods to determine the potential sporting achievements of competitors. They deliberate over how sportsmen concentration and attention may be strengthened as well as in what ways preventive treatment may be applied before overtraining in the discipline practiced.

One of the means for diagnosing the potential achievements of sportsmen may be a testing of the electrical activity of the brain. At present the registered EEG signal is, for scientific aims, subjected most often to so-called Quantitative EEG analysis, evaluating the electrical activity of the brain in the various frequency bands and areas of the brain. For the needs of the current work the following band ranges were adopted: Delta 1-4 Hz, Theta 4-8 Hz, Alfa 8-12 Hz, SMR 12-15 Hz, Beta 1 15-18 Hz, High Beta 18-30 Hz.

In the course of QEEG analysis there exists the possibility of calculating the so-called ratios or indexes, which determine the use of one wave to another. The Theta/Beta ratio is called an 'inattention index' because it negatively correlates with age and positively correlates with errors in continuous performance tasks (such a TOVA – Test of Variable Attention or IVA – The Integrated Visual Auditory). In ADHD patients this index is elevated in comparison to norms (Monastra et al., 1999). Depending on the assumptions adopted there is applied either a calculation of the ratio value or the power ratio. The value of the ratio is obtained as a result of the quotient of the amplitude of one band (μV) to the value of the amplitude of the other band (μV). The numerical result obtained is called the value of the ratio. For the needs of our work we have accepted that we will base our analysis on the ratio values.

It is worth emphasising that an analysis of Quantitative EEG provides descriptions of various aspects of cognitive functions (Klimesch, 1999; Klimesch, Pfurtscheller, Schilmke, 1992; Landers et al., 1991; Thompson and Thompson, 2012).

The effective working of an individual's attention is to a large extent dependant on the level of the brain's electrical activity in the particular frequency bands. Maurice B. Sterman (2000), lists certain EEG markers for attention disturbances in children, ones which may equally be observed in adults. These are, among others, increase in the activity of the Theta waves in the range of 4-8 Hz in the prefrontal cortex, frontal cortex, and sensorimotor cortex (Barabasz and Barabasz, 1996; Chabot and Serfontein, 1996; Chabotet al., 1996; Chabot et al., 1999; Dykman et al., 1982; Lazzaro et al., 1998; Mann et al., 1992; Matsuura et al., 1993; Monastra et al., 1999; Suffin and Emory, 1995). Another marker is the significant reduction of activity in the 12-20 Hz in the somatic sensory areas (the Sensorimotor Rhythm, or SMR) (Mann et al., 1992; Monastra et al., 1999). There is equally often observed a significant growth in the activity of the alpha rhythm mostly in anterior cortical areas (Chabot and Serfontein, 1996; Chabot et al., 1996; Cabot et al., 1999; Gittelmanet al., 1985; Pąchalska et al. 2014).

Having in mind the above information the authors of the research decided to conduct a registration of the QEEG signal from the Cz point, as a result of its positioning in the so-called central band, which covers the mentioned areas of the somatic sensory areas, in which, among other things, increased electrical activity in the Theta free bands (4-8 Hz) as well as Alfa (8-12) decreased activity in the SMR range (12-20 Hz), may be a marker of attention disorders.

Concentration strengthens the ability to focus attention and aids in the lowering of anxieties experienced during competitions (Gracz and Sankowski, 2007). We may use an evaluation of attention as an evaluation of the effectiveness in competitors' starts, changes in tactics as well as the effectiveness of the psychological interaction and the reception of the technical comments, advice and tips given. The information coming from many outstanding sportsmen points to a situation whereby a high level of attention concentration is closely connected with concentration on what they themselves are suppose to do and an ignoring of those factors upon which they have no direct influence (Pąchalska 2007; Pąchalska et al., 2012; Nęcka et al 2008).

Nideffer (1981) considered that elasticity in attention concentration is key to sport while the main question in psychological training in sport is the training of attention concentration. This is in accordance with the position held by Cox (1998) that talked of there being nothing more important than attention concentration in sport.

The aim of the present work is an attempt to show the connection between the value of the Theta/Beta ratio and the Theta/SMR ratio (so-called indicators of attention) with the sporting achievements of basketball players. The following research hypothesis has been adopted in the project herein described: basketball players obtaining a high level of results in their sport obtain lower values of the Theta/Beta ratio and Theta/SMR ratio, when compared to a control group of students.

MATERIALS AND METHOD

Participants

We examined 2 groups in this study: (1) sportsmen practising basketball and (2) students of the University of Physical Education and Sport in Gdansk.

The sportsmen group (men, N=30; average age 22.26) was composed of current players from the main two Gdansk clubs (Asseco Prokom and Start), playing in the Polish Premier Basketball League. Ten were either existing or former representatives of the Polish senior national team, while the remainder were players who had played internationally at junior levels. Nine of those tested had experience of playing in the Euro Basketball League, while seven had won in the past the Polish Championship at senior level. Tests were carried out on the first group for the period from February to May 2013.

The second, reference group was composed of students of the University of Physical Education and Sport in Gdansk, who at the time were not practicing

any highly qualified sport, had not achieved any spectacular successes in sport yet were individuals who actively participated in sport in general (men, N=52; average age 20.38). The tests were conducted in February 2013.

None of the research participants had suffered any head injuries resulting in a loss of consciousness or a hospital stay during the course of the previous year, equally they had not taken any drugs which could have had an impact on the modification of the brain's electrical activity.

Method

The tests were conducted by means of the Flex Comp Infinity coder produced by Thought Technology Ltd., with the use of an EEG-Z sensor with a built-in impedance function. During the tests resistance was maintained at under 5 kΩ. The data from the recordings was entered into the Biograph Infinity program (version 5.1.4). Before the commencement of reports an automatic correction of artefacts was equally conducted in this program through the application of a 50 Hz low-pass filter. The next stage was the drawing up of reports with the results of the individual patients, the results of which were utilised to create statistical analyses in the SPSS program (version 19).

An active (cup) electrode under which the recording of the EEG signal was conducted was placed at the Cz point in accordance with the international system for the localisation of 10-20 electrodes. On the earlobes were placed electrodes: referential (A1 – the left ear) and ground (A2 – the right ear).

The tests were conducted at the following ranges of frequency bands: Delta 1-4 Hz, Theta 4-8 Hz, Alfa 8-12 Hz, SMR-12-15, Beta 1 15-18 Hz and High Beta 18-30 Hz.

The measurements were conducted in 3 conditions: with open eyes, eyes closed as well as concentrating attention on a designated point, 3 times each for a minute for each test condition. The test participant sat straight on a comfortable chair looking from a distance of 1.5 metres at the centre of an empty, switched off screen of a 17-inch LCD monitor. Concentration took place on a black point of a 2 cm diameter printed in the middle of a white A4 piece of paper which was stuck to the centre of the screen of the same monitor.

All measurements were carried out by using the same coder and sensor.

The values of the Theta/Beta ratio and the Theta/SMR ratio were calculated as the result of the quotient amplitude of a single band (μV) to the value of the amplitude of the other band (μV). The numerical result obtained was called the ration value.

RESULTS

The distributions of the Theta/Beta ratio, Theta/SMR ratio analysed in the work in the basketball player and student groups are normal ratios. The "Z" Kołmogorow-Smirnow tests in each analysed case of the Theta/Beta ratio, Theta/SMR ratio value are not statistically significant (Tables1 and 2).

A comparison of the average results of the measured EEG ratios indicates an intergroup differentiation. Statistical analysis of the differences were conducted by means of the t-Student test taking into consideration the improvements of F-Lewene for the two types of variation (different and identical).

In each test condition (eyes open, closed, and attention concentration) the basketball players differ from the student group and there appear low Theta/Beta ratios. For the open eye test t(80)= 2.217; p=0.029; for the closed eye test t(80)= 3.235; p=0.002; while for the attention concentration test t(80)= 2.090; p=0.040 (Table 3).

Table 1. Analysis of result distribution normality within the basketball players group (n=30)

RESEARCH CONDITIONS	QEEG values	MEAN	SD	Test K-S	p-value
Eyes opened	Theta[a] (μV)	8.84	1.53	0.952	0.325
	SMR[b] (μV)	4.36	1.43	1.767	0.004*
	Beta1[c] (μV)	3.49	0.57	1.191	0.117
	Theta/Beta	2.46	0.65	1.067	0.205 (ni)
	Theta/SMR	2.15	0.56	0.661	0.774 (ni)
Eyes closed	Theta[a] (μV)	9.69	1.32	1.437	0.032*
	SMR[b] (μV)	5.57	2.42	1.522	0.019*
	Beta1[c] (μV)	4.42	0.84	0.868	0.439
	Theta/Beta	2.12	0.50	1.222	0.101 (ni)
	Theta/SMR	1.91	0.54	1.058	0.213 (ni)
Concentration on the point	Theta[a] (μV)	8.60	1.41	0.965	0.309
	SMR[b] (μV)	4.39	1.75	1.438	0.032*
	Beta1[c] (μV)	3.41	0.47	1.375	0.056
	Theta/Beta	2.40	0.63	1.120	0.163 (ni)
	Theta/SMR	2.14	0.65	0.953	0.324 (ni)

* The zero hypothesis has been rejected wherever the asymptotic relevance level is $p \leq 0.05$.
[a] Theta: 4-8 Hz; [b] SMR: 12-15 Hz; [c] Beta1: 15-18 Hz

Table 2. Analysis of result distribution normality within the students group (n=52)

RESEARCH CONDITIONS	QEEG values	MEAN	SD	Test K-S	p-value
Eyes opened	Theta[a] (μV)	10.45	1.67	0.627	0.827
	SMR[b] (μV)	4.28	0.83	0.861	0.448
	Beta1[c] (μV)	3.73	0.72	1.101	0.177
	Theta/Beta	2.75	0.52	0.415	0.995 (ni)
	Theta/SMR	2.50	0.53	0.791	0.558 (ni)
Eyes closed	Theta[a] (μV)	11.18	2.22	0.546	0.927
	SMR[b] (μV)	5.00	1.24	0.933	0.349
	Beta1[c] (μV)	4.35	1.16	0.989	0.282
	Theta/Beta	2.55	0.61	0.928	0.355 (ni)
	Theta/SMR	2.32	0.57	0.701	0.710 (ni)
Concentration on the point	Theta[a] (μV)	9.74	1.53	0.958	0.318
	SMR[b] (μV)	4.13	0.75	0.948	0.329
	Beta1[c] (μV)	3.56	0.68	1.161	0.135
	Theta/Beta	2.68	0.56	0.928	0.355 (ni)
	Theta/SMR	2.41	0.49	0.748	0.630 (ni)

* The zero hypothesis has been rejected wherever the asymptotic relevance level is $p \leq 0.05$.
[a] Theta: 4-8 Hz; [b] SMR: 12-15 Hz; [c] Beta1: 15-18 Hz

Table 3. A comparison of basketball players and students QEEG values

RESEARCH CONDITIONS	QEEG values	BASKET-BALL PLAYERS N=30 MEAN	STUDENTS N=52 MEAN	Test t-Student (df=80)	p-value
Eyes opened	Theta[a] (μV)	8.84	10.45	4.319	0.000*
	SMR[b] (μV)	4.36	4.28	-0.295	0.769
	Beta1[c] (μV)	3.49	3.73	1.555	0.124
	Theta/Beta	2.46	2.75	2.217	0,029*
	Theta/SMR	2.15	2.50	2.841	0.006*
Eyes closed	Theta[a] (μV)	9.69	11.18	3.797	0.000*
	SMR[b] (μV)	5.57	5.00	-1.204	0.236
	Beta1[c] (μV)	4.42	4.35	-0.302	0.763
	Theta/Beta	2.12	2.55	3.235	0.002*
	Theta/SMR	1.91	2.32	3.190	0.002*
Concentration on the point	Theta[a] (μV)	8.60	9.74	3.312	0.001*
	SMR[b] (μV)	4.39	4.13	-0.795	0.432
	Beta1[c] (μV)	3.41	3.56	1.100	0.275
	Theta/Beta	2.40	2.68	2.090	0.040*
	Theta/SMR	2.14	2.41	2.133	0.036*

* The zero hypothesis has been rejected wherever the asymptotic relevance level is $p \leq 0.05$
[a] Theta: 4-8Hz; [b] SMR: 12-15Hz; [c] Beta1: 15-18Hz

In each test condition (eyes open, closed, and attention concentration) the basketball players differ from the student group and there appear low Theta/SMR ratio. For the open eye test $t(80)= 2.841$; $p=0.006$; for the closed eye test $t(80)= 3.190$; $p=0.002$; while for the attention concentration test $t(80)= 2.133$; $p=0.036$ (Table 3).

The control values for the Theta/Beta ratio adopted in the current work are a value equal or less than 2.4, while for Theta/SMR equal or less than 2.0 (values recommended by the Centre for Cognitive Rehabilitation and Biomed Nature Therapy, a Polish company involved in the use of neurotechnology in diagnosis and therapy).

DISCUSSION

The authors of the present article wanted to show a simple and effective instrument designed for the diagnosing, monitoring and selection of sportsmen who practiced basketball. This instrument is based on selected QEEG ratios such as the Theta/beta ratio and the Theta/SMR ratio.

An important task for the authors was an attempt at transferring the research results into the daily practice of working with sportsmen. The authors often came across situations in their work in which they were dealing over an extremely short period of time with a group of several dozen competitors, and which as a result of the large number and complicated procedure they were unable to execute.

Hence also one point was selected for the diagnostic tests, in this case Cz, by means of which it is possible to conduct quick and frequent QEEG control tests.

The tests conducted are the subsequent piece of research within a whole series of tests planned by the authors investigating the brain electrical activity of EEG markers, which may be essential in the diagnostics of sporting achievements. The authors see the need and are consequently planning further tests in which there will be used other ratios reflecting an increase in the activity of free Alfa and Delta bands, in relation to faster frequencies e.g., Delta/Theta, Alfa/Theta or Alfa/SMR, which are often the markers of certain neurological problems.

It may be indirectly deduced from the tests that the application by neurotherapists of SMR/Theta training practices (Kropotov 2009; Thompson and Thompson, 2012; Ziółkowski et al. 2012; Pąchalska et al. 2014) may be extremely useful in the maintaining of an appropriate level of concentration, resistance to stress and a better realisation of tasks within the rivalry situations that we have in the case of basketball players.

CONCLUSIONS

1. In each test condition (eyes open, closed and attention concentration) basketball players display a lower Theta/Beta ratio and Theta/SMR ratio.
2. The Theta/Beta ratio and Theta/SMR ratio of the basketball players tested are much closer to those recommended in neurotherapy (the control values) when compared to the corresponding values obtained by the students.
3. The values of the Theta/Beta ratio and the Theta/SMR ratio may constitute an important source of information on the subject of QEEG markers, serving in the diagnosis of sporting achievements in basketball.

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