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Functional Changes of P300 Values among Young Football Players as a Measure of a Cognitive Function

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ABSTRACT

Numerous studies have shown that evaluation of evoked potentials (EP) is an excellent estimation tool for a cognitive function. During daily practices footballers are exposed to headers that can leave mild head traumas. In this study, young footballers were examined, while the control group included their coevals who don't practice contact sports. Results of the study have shown that footballers have longer latency value of the P300 wave when target stimulus is presented on N1, N2 and P3, but not on P2. Also, they have longer latency values when non-target stimulus is presented. Amplitude values of target stimulus are not different, but footballers have lower amplitudes of non-target stimulus. This study suggests that EP evaluation method can be used to detect first and mild changes of the brain function.

Key words: *young football players, evoked potentials, latency, amplitudes, cognitive changes*

Introduction

Football is definitely one of the most popular sports in the world. The International Federation of Association Football (FIFA) estimates that there are more than 40 million registered players in the world and that there is similar number of those who are not registered[1]. Football is a collective sport and its nature of game is unique. In other words, player is using unprotected head for controlling and advancing the ball which makes the head and neck vulnerable to injuries[2]. Apart from hitting the ball, very dangerous are the hits players receive from other players (head to head hit) or falling to the ground. Because of all the risks that are present while playing football, scientists of various disciplines have dedicated a big importance to exploring head injuries.

A concussion is a very common injury in contact sports such as football. Kirkendall et al.[1] reported about definition of concussion that was given by the Congress of Neurological Surgeons and it is 'a clinical syndrome characterized by immediate and transient post-traumatic impairment of neural function, such as alteration of consciousness, disturbance of vision, equilibrium, etc., due to mechanical forces'. Also, there are three grades of concussion: mild, where consciousness is preserved; moderate, where consciousness is lost followed by retrograde amnesia and severe, where unconsciousness lasts longer than 5 minutes[1]. Generally, when we talk about sports, the word contusion refers to changes in cognitive and also in neurological functions that occur as a result of mechanical forces accelerating the head and brain[3]. Terms that are seen as synonyms are contusion, concussion, mild brain injury, head injury, mild head injury and mild traumatic injury[4].

It is well known today that concussion can cause structural and functional changes to the brain in three different ways[1]. The first way is a consequence of the anatomical housing of the brain within its protective membranes hitting the skull which can cause the contusion. The second way is related to the interference within the white matter fiber tracts which connect the cortex to the midbrain and the brainstem. The third way in which trauma causes structural and functional changes is associated with neurochemical changes that begin within the first hours after trauma has occurred and may last for 10 days[1].

Impact frequencies and anatomic localization of the injury depend of the playing position, intensity of the game and tent to increase with age of the player. Furthermore, they are more frequent during the game than during the

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practice[5]. It is important to mention that head and neck are the second most common body areas at risk for injuries[6]. During the play player heads the ball approximately 6-7 times and the number of headers sum up to around 1440[5] during the season.

Repeated concussions and those that haven't been properly treated appear to impact cumulative damage and leave chronic neurological dysfunctions. Moreover, results of a study performed on the sample of the university football players show that the players with the history of contusions have significantly more deficits in the executive functioning and speed of information processing. However, such effects are present in the individuals that have suffered two or more contusions[7]. When we consider all mentioned facts, it is not hard to see why head injuries are subject of interest of many researches.

Consequences caused by a head trauma can be examined and notated in different ways, while one of the most effective ones is the method of evaluation of EP. EP is considered to be very sensitive and adequate for detecting fine changes of brain functions caused by head injuries that can be easily overlooked by classic neurological tests[8]. EP testing represents presentation of the electric activity of the brain provoked by presentation of an external stimulus. There are different types of EP that can be used for these types of research[9], like visual, motor, somatosensory and auditory.

Auditory EP are based on positive and negative waves that are provoked by auditory stimulus. There are two main parameters: amplitudes, measured in microvolts, and latency, measured in milliseconds. Auditory EP enable early diagnoses of the brain lesions and pathologies that can be located depending on the changes in latency and amplitude of each evoked response wave[10].

A wave P300 is a measurable brain response on a stimulus arisen in psychological tasks and processes when a participant pays attention and discriminates the stimulus different from the others. This type of discrimination creates a relatively big positive wave divergence (10-20 μV) with the latency of around 300 ms in auditory stimulus[12].

Materials and Methods

102 male participants at age of 16 were included in this study. Half of the participants are the football players and other half are their coevals who aren't players of any contact sport and don't have history of contusions. Participants of the control group are of the same age and sex and they are compatible in other relevant characteristics to other included participants. Additionally, the football players reported that they didn't suffer any head traumas outside of the football field (e.g. car accident).

This research was conducted in Department of Neurology, University Hospital Split. All participants were interviewed and clinical examination was performed. History of head brain injuries was recorded and candidates with brain injury were excluded. Not one participant had neurological disturbance. Data were collected individually. During the test, a person lies on a bed in a quiet room and being as relaxed as possible. The participant hears the sound stimuli through a pair of headphones. At the beginning of the test, the sound is being tuned until the sound is optimal for the person who is being tested**.** P300 components are easily induced with a simple discrimination task. The participant can hear two sounds that are randomly repeated, one of them is rare (target stimulus) while the other one is frequent (non-target stimulus). Their task is to count the frequent sounds.

The results were statistically analyzed by IBM SPSS Statistics 18 software package. T-test was used for the statistical analysis.

Results

Firstly, we analyzed wave latency of target stimulus measured in the football players and the control group. T- test for independent samples showed difference between groups in latency of wave P300 measured on N1 ($t=2.142$, $df1=100$, $df2=56.97$, $p<0.05$), N2 ($t=2.862$, $df1=100$, $df2=59.925$, $p<0.01$) and P3 ($t=4.439$, $df1=100$, $df2=62.572$), while a difference in the results measured on P2 ($t=0.892$, $df1=100$, $df2=62.572$, $p>0.05$) wasn't founded. It can be seen from the results in Table 1 that the football players had longer latency of target cognitive auditory response (Table 1).

The analysis of latency value P300 non-target stimulus showed statistically significant differences between the footballers and the control group on N1 ($t=4.723$, $df_1=100$, $df2=60.241$, $p<0.01$), N2 ($t=4.559$, $df_1=100$, $df_2=59.565$, $p<0.01$), P2 ($t=6.043$, $df_1=100$, $df_2=65.529$, $p<0.01$) and P3

TABLE 1
AVERAGE VALUES AND STANDARD DEVIATIONS OF P300 WAVE LATENCY

		Non-target stimulus				Target stimulus			
		N1	P2	N2	P3	N1	P2	N2	P3
X	Football	153.08	214.69	259.45	316.63	148.06	203.08	255.45	307.55
	Control	142.10	200.82	249.00	299.88	142.10	200.82	249.00	299.88
SD	Football	15.80	15.22	15.64	10.99	19.21	16.99	15.34	10.87
	Control	0.08	6.07	4.86	5.84	5.08	6.07	4.86	5.84

(t=9.607, df_1=100, df_2=76.108, p<0.01). In other words, the footballers have longer latency of non-target EP ($\overline{X}_{N1}$=153.08, $\overline{X}_{N2=}$214.69, $\overline{X}_{P2}$=259.45, $\overline{X}_{P3}$=316.63) than the control group.

Latency values of target and non-target EP measured on the footballers were compared. The difference between P300 wave latency value of target and non-target EP was obtained on P2 (t=4.122,df=50, p<0.01) and on P3 (t=4.643, df=50, p<0.01), while longer latency values were measured during non-target stimulus (X_{P2}=214.69, X_{P3}=316.63). No differences were obtained on N1 (t=1.804, df=50, p>0.05) and N2 (t=1.311, df=50, p>0.05).

Then, wave P300 amplitudes among the football players and the control group were analyzed. Amplitudes are described as normal, mild reduced, low and very low values. There are two analysis performed, one for target stimulus and one for non-target stimulus. T-test for independent samples shows that there is a differences in amplitudes of non-target stimulus between the football players and the control group (t=8.475, df=53.793, p<0.01). The results show (Table 2) that the football players have mild reduced amplitudes (45%).

Amplitude value analysis made on a target stimulus shows that there is no significant difference between the football players and the control group (t=1.896, df=68.610, p>0.05), as presented in Table 3.

TABLE 2
PROPORTIONS OF WAVE AMPLITUDE FOR NON-TARGET STIMULI

		Group		Total
		Football	Control	
Amplitude non-target	Normal	11 (22.5%)	49 (96%)	60
	Mild reduced	23 (45%)	2 (4%)	25
	Low	8 (15.7%)	0 (0%)	8
	Very low	9 (17.6%)	0 (0%)	9
		51 (100%)	51 (100%)	102

TABLE 3
PROPORTIONS OF WAVE AMPLITUDE FOR TARGET STIMULI

		Group		Total
		Football	Control	
Amplitude target	Normal	47 (92.2)	49 (96)	96
	Mild reduced	3 (5.8)	2 (4)	5
	Low	1 (2)	0 (0)	1
	Very low	0 (0)	0 (0)	0
		51 (100)	51 (100)	102

Discussion

The differences in latency between the football players and the control group were found for N1, N2 and P3, but not for P2 when stimulus is rare. Also, when stimulus is frequent, the differences in latency were found, which means that the footballers have longer latency of P300. Previous researches had shown inconsistency in findings about wave latency. In some researches significant differences between the control group and the football players weren't found, showing that latency is similar between the groups[12-15]. For example, Dupuis et al.[12] found similar latency for target and non-target stimulus between players of contact sports, the athletes who never sustained a contusion and those who suffered a contusion. The results of this study are confirmed with various studies that reported a prolonged latency in those participants that sustained a contusion[16-18]. Gosselin et al.[19] reported significant differences between control participants and athletes that suffered a concussion but measured only by central electrodes. Also, latency of the earlier component P2 wasn't differing from latency of the control group, which supports our findings.

The footballers have different amplitudes than the control group when stimulus is non-target and amplitudes mildly reduced. Differences are not found when stimulus is target. Those findings are supported by other studies. De Baeamount et al.[20] reported a significant amplitude attenuation in asymptomatic football players with a history of two and more head concussions. Moreover, asymptomatic concussed athletes show reduced amplitude when compared with athletes with no concussion history[21], which suggests that every concussion can make some deficits. Dupuis et al.[12] reported a decrease in amplitude of wave P300 when stimulus was frequent (non-target) but only in frontal and central regions. Authors explained the finding with a fact that head injuries mostly involve the front of the head. Also, this suggests that there might be a link between site of injury and abnormal measures of EP. The same study reported that the concussion group with symptoms tends to show smaller P300 amplitudes for both stimulus and on all electrodes, whereas the group with no concussions shows stronger amplitude for the rare stimulus than for a frequent one. The difference in this study was that the control group had the same amplitudes for rare and frequent stimuli.

The amplitude of the wave can vary because of the changes in the recoding electrode impedance, minor variations in electrode placement or alterations in stimulation parameters. Latency can also vary, but in general, the variability of amplitudes is usually greater than variability of latency. Therefore, latency is generally considered to be more reliable parameter when evaluating EP[22]. It is important to mention that latency values alone do not provide information on the nervous pathway function; however changes of latency in longitudinal observation tell us if nerve dysfunction severity is increasing[23].

Results suggest that young footballers have mild cognitive deficits that are seen in longer latency and mild re-

duced amplitude. Other authors also consider that EP abnormalities may detect traumas. In other words, cumulative small traumas can make abnormal EP findings[24] and it is well known that the football players are constantly exposed to brain injuries that can cause such traumas. Auditory evoked potentials can be useful for detecting a delay in the conduction of signals through nerve pathway and axonal loss in this pathway[23].

The aforementioned studies are affected by contradictory findings, methodological problems and with difficulties in interpreting findings. Also, there is a problem of finding adequate control groups[1]. It is necessary to choose the control group so the members are so much more similar to footballers in all aspects other than football participation and only then the effects of football headers can be obtained. A big effort has been made in this study to find the adequate control group and it can be considered as an advantage of the study. Moreover, studies like this are usually not conducted on the sample of the Croatian people. This research and similar ones are important because they are showing negative effects of contusions in contact sports. Studies of multiple sclerosis have shown that EP is a good method for detecting small traumas in early disease stages; therefore this method can be used to prevent further consequences. The research managed to prove that headers can leave a certain amount of deficits in electrophysiological activation even in such a young population.

Conclusion

This study measured auditory EP (P300) in the group of adolescent football players and was later compared to the group of their coevals who aren't players of any contact sport and don't have history of any previous head trauma. The study was focused on two measures: latency and amplitude of wave P300. The analysis has shown that the football players have longer latency in points N1, N2 and P3, but not P2. Furthermore, they have reduced amplitude of wave when non-target stimulus is presented. The same amplitude was found when stimulus is rare (target). Those findings suggest that the differences in EP can be clearly seen even at young players, which brings to conclusion that contact sports can make certain damage.

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FUNKCIONALNE PROMJENE P300 VRIJEDNOSTI KOD MLADIH NOGOMETAŠA KAO MJERA KOGNITIVNE FUNKCIJE

S A Ž E T A K

Brojne studije su pokazale da su evocirani potencijali (EP) odlična metoda za procjenu kognitivnih funkcija. Nogometaši su za vrijeme svakodnevnih treninga izloženi udarcima u glavu koji ostavljaju lagane traume glave. Ispitani su mladi nogometaši i njihovi vršnjaci koji se ne bave kontaktnim sportovima. Rezultati studije pokazuju da nogometaši imaju značajno duže latencije ciljnih EP mjerenih na N1, N2 i P3, ali ne i na P2. Također, imaju duže latencije vala P300 kod neciljnog podražaja. Nogometaši imaju jednake amplitude kao i kontrolna grupa na ciljnim podražajima, ali niže amplitude vala neciljnih podražaja. Ovi rezultati ukazuju da se koristeći vrijednostima dobivene mjerenjem EP mogu primjetiti početne i blage promjene funkcije mozga.