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# Aggression in Professional Female Defender Soccer Players

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## SUMMARY

**Background:** The goal of the present study was to investigate the effect of competition on brain activity representing aggression. Quantitative electroencephalograms (QEEGs) of Thai professional female soccer team players were analyzed in terms of aggression.

**Material/ Methods:** The QEEGs of 17 soccer players were recorded three times: twice before a competition (once per week) and one week after the competition.

**Results:** There was a significant increase in the beta frequency band associated with the $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions as the competition approached. The changes in brain activity were observed in two patterns: the first was an increase in the intensity level of brain processing (presented in terms of brain topographic maps as absolute power), and the second was the magnitude of the amplitude at each of the EEG channels between the hemispheres (presented in terms of brain connectivity as amplitude asymmetry).

**Conclusions:** Consequently, QEEG values were examined as they related to aggression. In the statistical analysis, paired-sample t tests confirmed that an aggressive phenomenon occurred as the competition approached. In addition, the aggressive phenomenon was found in the brain activity of players with defensive soccer positions.

**Key words:** Quantitative electroencephalography (QEEG), brain topographic map (absolute power), brain connectivity (amplitude asymmetry), aggression, Beta frequency band

# INTRODUCTION

Behavior analysis is widely used to enhance performance and in applications associated with competition, such as in athletic events. Therefore, behavior sport psychology is one method used for improving performance (Martin and Tkachuk 2000). Aggressive behavior can influence an athlete's performance. Both aggression and aggressive behavior illustrate inner strain. However, external factors, such as the environment and competitive situations, can induce aggressive forms of behavior (Lorenz 1969). These factors can induce personal frustration (Dollard et al. 1939), which can lead to an overt verbal and physical act or physical injury to oneself or another person (Husman and Silva 1984). The competitive situation is one factor that affects the level and duration of aggression. Some aggressive behaviors have been defined as rule-breaking behaviors in competitive sports, such as soccer (Coulomb and Pfister1998).

Humans can also experience defensive emotions, which are often evoked via stress and arousal and typically occur during competition. There are relationships among defensive emotions, anger, and aggression in induced confusion processes. Interestingly, several sports studies have reported an association between testosterone levels and assertiveness. Whether the competition was played at home or away, athletes fought harder to defend their perceived home territory, which might affect testosterone levels (Neave and Wolson 2003). In professional basketball players, testosterone levels have been associated with threats, fights, and attacks as measured by the score/time played ratio (Gonzalez-Bono 1999). Moreover, other studies have reported that increased testosterone could be associated with victorious tennis players (Booth et al. 1989, Mazur and Lamb 1980). Testosterone levels have been measured in male athletes before a competition, and they reflect the performance quality. Athletes with high-testosterone levels exhibit enhanced athletic performance compared to those who have low levels of testosterone (Mazur and Booth 1998). Salivary testosterone measured in male members of a professional team in the Italian Football League (Series A) was found to have a significant relationship with aggression (Perciavalle et al. 2013).

Laborde et al. 2011 proposed that another key factor affecting athletic performance is emotional intelligence, which can be investigated by using electroencephalography (EEG) (Mikolajczak et al. 2010). Emotional processes have been studied based on conceptual and empirical approaches of the role of asymmetrical frontal cortical activity (Harmon-Jones et al. 2010). However, analyses of EEG activity that have examined impulsiveness as a personality construct are likely confounded by a high incidence of aggressive and antisocial behavior (Houston and Stanford 2005). In addition, activity in the beta (12-30 Hz) frequency band could represent motivation-related incentives (Schutter et al. 2008). Therefore, EEGs should illustrate the manifestation of aggressive behavior. Asymmetrical patterns of frontal cortical activity have previously been measured to explain aggressive behavior. Aggression was associated with frontal alpha and beta asymmetry in violent offenders (Keune et al. 2012). The state-induced anger is associated with relative left-prefrontal activity and whether this prefrontal activity is also associated with aggression (Harmon-Jones and Sigelman 2001). Additionally, the study by Hofman and Schutter, 2012 concluded that the beta frequency band could establish individual differences, including an asymmetrical resting state, aggression traits, and response inhibition. There was a strong link between anger and aggressive behavior in relation to motivation. Interestingly, these associations were studied based on asymmetrical frontal EEG activity (Harmon-Jones and Allen 1998, Harmon-Jones 2007). In motivational and emotional studies, these associations were also evaluated via EEG activity, which was used to analyze the asymmetry of the frontal area (Harmon-Jones 2003, Davidson 2004).

In this context, the aim of this study was to examine the brain activity changes that are affected by competition events. The factor of interest was the aggression which arises in athletes due to concerns regarding the competition. Therefore, brain topographic maps (absolute power) and brain connectivity (amplitude asymmetry) were measured to reveal differences between defensive and offensive soccer players. The beta frequency band, which is associated with the $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions, was recorded for analysis. Furthermore, QEEG values were analyzed to confirm this phenomenon for describing brain activity changes affected by competition.

## MATERIAL AND METHODS

### Participants

The participants were 17 Thai professional female soccer players who participated in the 2014 AFC Women's Asian Cup. They were classified into 2 groups: the defensive and offensive groups. The defensive group had 8 players (center defenders, DC; full back, DL/DR; and defensive center midfielder, DMC), and the offensive group had 9 players (center forward, FC; left/right forward, FL/FR; and striker, SC). Following an explanation of the study process, all participants signed an informed consent form. The collected data were treated confidentially. The mean age of the participants was 23.71 ± 2.6638 years (range, 19-28 years), the mean height was 161.29 ± 4.740 cm (range, 153.0-173.0 cm), and the mean weight was 53.75 ± 4.322 kg (range, 44-63 kg). Fourteen participants were right leg and arm dominant, and three participants were left leg and arm dominant. None of the participants had any history of head injuries, neurological diseases, or cardiovascular conditions, and they were not using medications or drugs. All subjects had normal vision throughout the experiment. In addition, they all were instructed to avoid attending any intensive training sessions or examinations 24 hours before testing.

The experimental procedures were performed under the rules and regulations of the Center of Ethical Reinforcement for Human Research, Mahidol University (COA No. MU-CIRB 2015/143.2411).

## Instruments

A BrainMaster Discovery 24E system was used in this study. The measurements were separated into two parts for the brain topographic map and brain connectivity analyses. The collected data were analyzed using NeuroGuide software. The reliability percentages of the data were calculated using the split half and test retest methods, which corresponded to values greater than 90%. Moreover, the QEEG data were analyzed by using IBM SPSS statistical software, version 21, to determine the outcomes. The normal distribution of all the results was verified using the Kolmogorov-Smirnov (K-S) test. Then, the QEEG values were analyzed using paired-sample t tests to compare within groups, and unpaired t tests to compare between groups.

## Procedure

QEEG measurements were used to record the brain activity of the Thai professional female soccer team players at 3 time points, including 2 weeks before, 1 week before, and 1 week after the competition. For the QEEG measurements, the participants were asked to sit in a chair in a relaxed position, and the QEEG was recorded for 5 minutes with open eyes. Then, the QEEGs were analyzed in terms of the brain topographic maps (absolute power) and brain connectivity (amplitude asymmetry). Additionally, the behavior and performance of the athletes was observed and rated by staff coaches. The observed performance scores and brain activity were analyzed together.

## EEG recording

The study utilized the standardized international 10:20 system. Nineteen electrodes were placed on the surface of each participant’s scalp. All leads were referenced to linked earlobes (reference: A1 the right ear and ground: A2 the left ear). For EEG signal recordings, a sampling rate of 256 Hz/24 bit data and an EEG channel bandwidth of 0.43-80 Hz were used. The EEG electrode impedances were below 5 kΩ. During the QEEG measurements, the participants were instructed to keep their eyes open during the EEG recording.

## Data analysis

The data were analyzed using the Z-scored FFT method. The results were represented as the absolute power and amplitude asymmetry. The application of the mathematical Gaussian curve, i.e., the bell curve, via the estimation of probabilities using the auto- and cross-spectra of the EEGs is defined as the Z-scored FFT method (Thatcher et al. 2004-2007). This method was standardized to identify the brain regions that were de-regulated and departed from the expected values. The recorded EEG signals were described in terms of the selected frequency band and the calculated standard deviation and mean of the normative database (Collura et al. 2010), (Thatcher 1998).

Brain topographic map: Topographic EEGs present a spatial representation of raw EEG data, such as voltage amplitude, a derived parameter such as power for a given frequency band, or peak latency. In this study, the results are displayed as topographic maps based on calculations of absolute power. The absolute power represents activation of the brain corresponding to the magnitude of a specified frequency within the EEG signal. This method included 4 channels: $Fp_1$, $Fp_2$, $F_7$, and $F_8$. The QEEG value was calculated using equation (1).

$$X = \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right) \quad (1)$$

Where is the QEEG value of the brain topographic map (absolute power), and is one of the QEEG channels.

Brain connectivity: The objective of brain connectivity analysis is to aggregate the knowledge of computational neuroscience, neuroscience methodology and experimental neuroscience with a particular interest in understanding the tripartite relationship among anatomical connectivity, brain dynamics and cognitive function. In this study, brain connectivity was calculated based on amplitude asymmetry. Amplitude asymmetry is a statistical calculation that indicates the change in the magnitude of the signal between two electrode sites. This method includes 28 pairs of channels corresponding to $Fp_1$-$F_3$, $Fp_1$-$C_3$, $Fp_1$-$P_3$, $Fp_1$-$O_1$, $Fp_1$-$F_7$, $Fp_1$-$T_3$, $Fp_1$-$T_5$, $F_7$-$F_3$, $F_7$-$C_3$, $F_7$-$P_3$, $F_7$-$O_1$, $F_7$-$T_3$, $F_7$-$T_5$, $F_7$-$F_8$, $Fp_1$-$Fp_2$, $Fp_2$-$F_4$, $Fp_2$-$C_4$, $Fp_2$-$P_4$, $Fp_2$-$O_2$, $Fp_2$-$F_8$, $Fp_2$-$T_4$, $Fp_2$-$T_6$, $F_8$-$F_4$, $F_8$-$C_4$, $F_8$-$P_4$, $F_8$-$O_2$, $F_8$- $T_4$, and $F_8$-$T_6$. The QEEG value was calculated using equation (2).

$$X = \frac{1}{n}\left(\sum_{i=1}^{n} |x_i|\right) \quad (2)$$

Where is the QEEG value of brain connectivity (amplitude asymmetry), and is one pair of the QEEG channels.

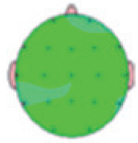
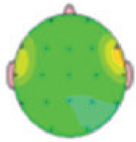
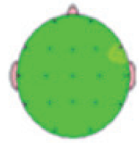
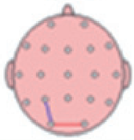
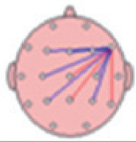
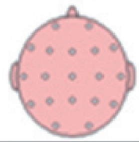
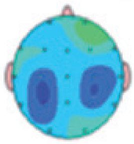
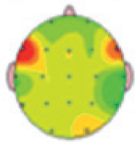
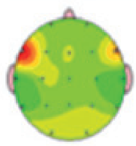
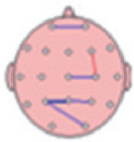
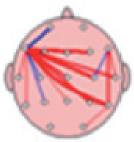
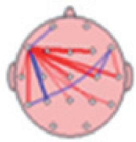
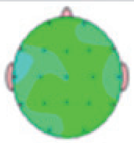
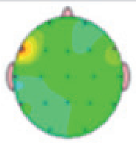
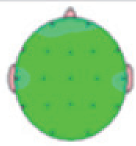
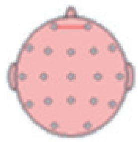
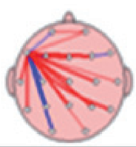
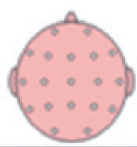
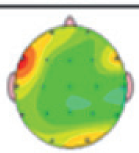
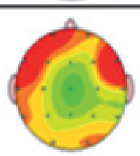
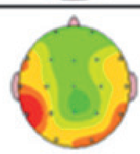
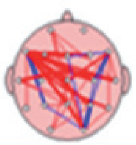
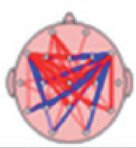
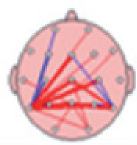
# RESULTS

Table 1 shows the results of the QEEG analysis representing aggression.

A. First recoding before the competition (Pre1), B. Second recording before the competition (Pre2), C. Recording after the competition (Post). $S_n$ is the subject number (1, 2, 3, …).

Two analyses of the beta frequency band were performed: the brain topographic map (absolute power) and brain connectivity (amplitude asymmetry). These results demonstrate the brain activity of athletes who exhibited aggressive phenomenon 1 week before the competition (Pre2, and column B in Table 1). This phenomenon was revealed in the brain activity associated with the $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions. The activity of these positions was related to logical attention, emotional attention, verbal expression, and emotional expression. Therefore, the results obtained in this study might be related to the aggression of ath-

Table 1. An example aggression result of the beta frequency band for the brain topographic (absolute power) and brain connectivity (amplitude asymmetry) analyses

| Name/Positions | Analysis | A | B | C |
|---|---|---|---|---|
| $S_1$ (DC) | Absolute Power (AP) |  |  |  |
| | Amplitude Asymmetry (AA) |  |  |  |
| $S_2$ (DC) | Absolute Power (AP) |  |  |  |
| | Amplitude Asymmetry (AA) |  |  |  |
| $S_3$ (DL, DML) | Absolute Power (AP) |  |  |  |
| | Amplitude Asymmetry (AA) |  |  |  |
| $S_4$ (DC, DMC) | Absolute Power (AP) |  |  |  |
| | Amplitude Asymmetry (AA) |  |  |  |


A. First recoding before the competition (Pre1), B. Second recording before the competition (Pre2), C. Recording after the competition (Post). Sn is the subject number (1, 2, 3, …).

letes. The brain topographic maps (absolute power) are presented in terms of colors as follows: blue indicates amplitudes lower than the normative database, red indicates amplitudes higher than the normative database, and green indicates normal conditions. The positions of $Fp_1$, $Fp_2$, $F_7$, and $F_8$ showed the results of the athletes' brains at the three time points: (A) 2 weeks before the competition, (B) 1 week before the competition, and (C) after the competition. These positions are displayed in red, and they tended to be more highly increased than were other positions. The brain connectivity analysis (amplitude asymmetry) demonstrated the differences in amplitude at each of the EEG channels between the hemispheres and was assessed at the 3 time points together with the brain topographic map. The blue lines refer to differences lower than the normative database, red lines indicate differences higher than the normative database, and no line indicates that the difference was equivalent to the normative database. The brain connectivity was recorded from the $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions. The results revealed changes in both directions, including changes lower and higher than the normal condition.

The average value of the brain activity of eight defensive players is shown in Figure 1 (Topographic map: Absolute Power) and Figure 2 (Brain connectivity: Amplitude Asymmetry).

The red lines in Figures 1 and 2 were recorded one week before the competition, which corresponded to higher values than those at the other time points. This brain activity phenomenon, which revealed higher activity than the normal state, could demonstrate aggression. This phenomenon distinctly appeared when the competition approached and returned to normal after the competition. Therefore, Figures 1 and 2 describe the brain activity level (in $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions) representing the aggression of the athletes.

The distributions of the brain topographic map (absolute power; AP) and brain connectivity (amplitude asymmetry; AA) data were normal distributions, which were recorded from the seventeen defensive and offensive players. The distri-

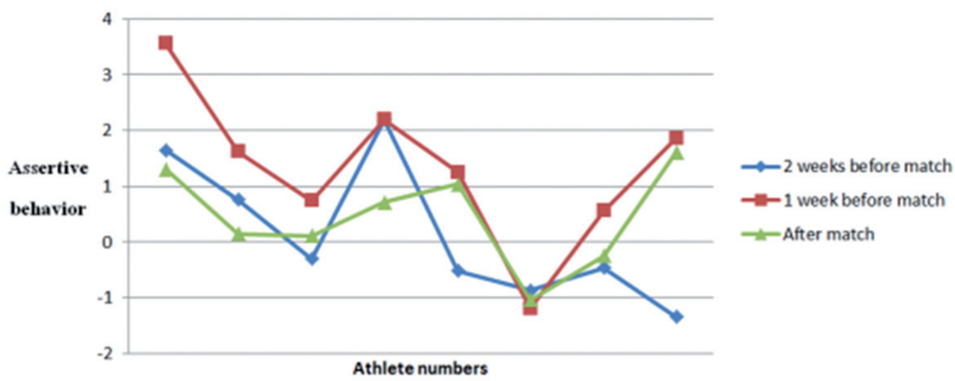



Fig. 1. Result of QEEG data (absolute power) of eight defensive players in terms of the beta frequency band

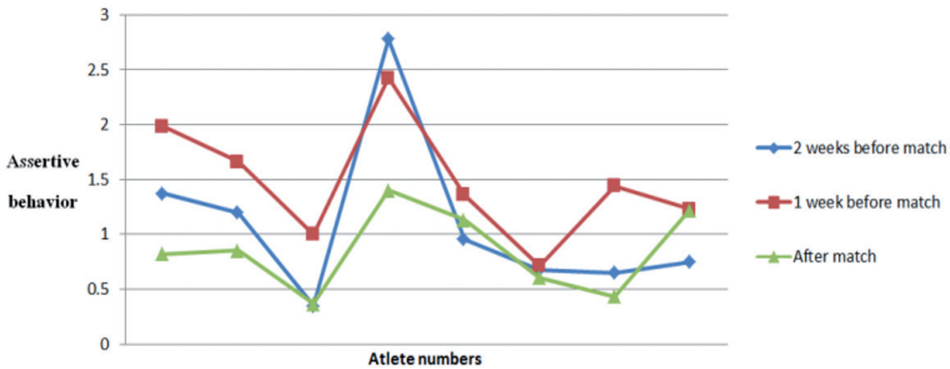



Fig. 2. Result of QEEG data (amplitude asymmetry) of eight defensive players in terms of the beta frequency band

butions of brain activity were tested using the Kolmogorov-Smirnov tests for both groups. There were no statistically significant differences between the groups, as shown in Table 2.

The comparison of the average brain activity among periods indicated differentiation of the brain activity. Paired-sample t tests were used to analyze the results of the defensive players. There were significant differences among the three time periods, as shown in Table 3.

For the average brain topographic map (absolute power; AP), the results were significantly different (p=.020) between 2 weeks before (Pre1) and 1 week before

Table 2. Results of the distribution normality analysis of the brain activity of the players (n=17)

| Research condition | QEEG values | Time condition | Mean | SD | Test K-S | p-value (2-tailed) |
|---|---|---|---|---|---|---|
| Eyes open | AP | Pre1 | .219 | 1.01 | .769 | .596[a] |
| | | Pre2 | .790 | 1.21 | .428 | .993[a] |
| | | Post | .397 | .851 | .574 | .897[a] |
| | AA | Pre1 | .913 | .597 | .732 | .658[a] |
| | | Pre2 | 1.14 | .544 | .578 | .892[a] |
| | | Post | .792 | .430 | .905 | .386[a] |

[a] = Test distribution is Normal

Table 3. Comparison of the brain activity of the defensive players in Pre1, Pre2, and Post conditions (n=8)

| Research condition | QEEG values | Time condition | Mean | SD | p-value (2-tailed) |
|---|---|---|---|---|---|
| Eyes open | AP | Pre1 – Pre 2 | -1.19 | 1.12 | .020* |
| | | Pre2 – Post | .873 | .809 | .019* |
| | | Pre 1 - Post | -.315 | 1.38 | .539 |
| | AA | Pre1 – Pre 2 | -.386 | .373 | .022* |
| | | Pre2 – Post | .622 | .453 | .006* |
| | | Pre 1 - Post | .236 | .559 | .270 |

*A lower bound of the true significance

Table 4. Comparison of the brain activity of the offensive players in Pre1, Pre2, and Post conditions (n=9)

| Research condition | QEEG values | Time condition | Mean | SD | p-value (2-tailed) |
|---|---|---|---|---|---|
| Eyes open | AP | Pre1 – Pre 2 | -.022 | .476 | .895 |
| | | Pre2 – Post | -.034 | .703 | .888 |
| | | Pre 1 - Post | -.056 | .710 | .819 |
| Eyes closed | AA | Pre1 – Pre 2 | -.092 | .402 | .512 |
| | | Pre2 – Post | -.111 | .434 | .466 |
| | | Pre 1 - Post | -.019 | .387 | .887 |

Table 5. Comparison of the QEEG values of the defensive (n=8) and offensive players (n=9) on the Thai professional female soccer team

| Research condition | QEEG values | Time condition | Defensive players MEAN | Offensive players MEAN | p-value |
|---|---|---|---|---|---|
| Eyes open | AP | Pre1 | .136 | .294 | .380 |
| | | Pre2 | 1.32 | .315 | .043* |
| | | Post | .451 | .349 | .407 |
| | AA | Pre1 | 1.09 | .756 | .131 |
| | | Pre2 | 1.48 | .847 | .006* |
| | | Post | .854 | .737 | .295 |

*A lower bound of the true significance

(Pre2) the competition. The brain topographic map results between Pre2 and after the competition (Post) were also significantly different (p=.019). In contrast, there was no significant difference (p=.539) between Pre1 and Post. The average values of brain connectivity (amplitude asymmetry; AA) between Pre1 and Pre2 (p=.022) and between Pre2 and Post (p=.006) were significantly different, while those between Pre1 and Post were not significantly different (p=.270).

However, statistical analysis of the nine offensive players did not reveal significant differences, as shown in Table 4.

For the brain topographic maps (absolute power; AP), there were no significant differences between Pre1 and Pre2, Pre1 and Post, or Pre2 and Post (p=.895, p=.819, and p=.888, respectively). Similarly, the results of brain connectivity (amplitude asymmetry; AA) revealed no significant differences between Pre1 and Pre2, Pre2 and Post, or Pre1 and Post (p=.512, p=.466, and p=.887, respectively).

Furthermore, the comparison of the QEEG values of the defensive and offensive players is shown in Table 5.

Statistical analysis was conducted using independent paired-sample t tests. It was confirmed that the aggression increased as the competition approached, with this being found only in defenders. Comparing the defensive and offensive players, the average brain topographic map values (absolute power; AP) for Pre1 and Post were not significantly different (p=.380 and p=.407), while Pre2 was significantly different (p=.043). Comparing the brain connectivity (amplitude asymmetry; AA) between defensive and offensive players revealed that there were no significant differences in Pre1 (p=.131) and Post (p=.295), although Pre2 was significantly different (p=.006).

# DISCUSSION

The present study aimed to explore aggression, which was observed as brain activity recorded in defensive soccer players. In addition, this study investigated the interrelations of brain activity changes among the phases associated with competition, including before and after the competition. There were two key parameters of aggression that were assessed via brain topographic maps (absolute power) and brain connectivity (amplitude asymmetry), which were revealed in the beta frequency band at the frontal area of the brain ($Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions). A previous study reported the association of beta band activity with cognitive means and motor control preservation (Engel and Fries 2010). In addition, several motor control studies using beta band activity have demonstrated similar results; this was particularly observed during steady contraction, attenuated during voluntary movement and highest during holding periods following movements (Baker 2007, Klostermann et al. 2007, Chakarov V et al. 2008). Furthermore, when there was an internal perceptual change, the beta band activities exhibited a specific relation. These suggest an association between human perceptions and beta band activities (Okazaki et al. 2008, Iversen et al. 2009). EEG can be used to evaluate the brain activity involved in human cognitive perceptions and emotions. Therefore, the locations of EEG activity could show individual differences that specifically depend on lobes and sides of the brain. Therefore, emotional processing was studied in terms of the relation between the left and right frontal lobes (Davidson 1988, 1992). Additionally, emotional control was also associated with the prefrontal areas (Davidson et al. 2000, Wager et al. 2008). Transcranial alternating current stimulation (tACS) has been used to explore the interconnections among asymmetrical beta activity, aggressive behaviors, and behavioral inhibition. The results revealed that the activity patterns of frontal areas were changed in the beta range (Kanai et al. 2008, Schutter and Hortensius 2010). One study evaluated psychological factors and aggressive behavior. The participants in this study were the Polish athletic national team who participated in the London Olympics in 2012. The neurophysiological and neuropsychological parameters were used to study measured and trained athletes to control aggressive behavior, which could have resulted in  a gold medal in London (Ziolkowski et al. 2012). Consequently, aggressive behavior could affect athlete performances. Aggressive behavior, the trait of aggression, and inhibited responses could represent the brain activity measuring the resting state asymmetry of frontal beta activity (Hofman and Schutter 2011, and Peterson et al. 2008). Other factors that relate to athletes' potential are hormone levels. Pokrywka et al. 2005 stated that there might be a positive correlation between athletic potential and the dominant side in females. They found that elite female athletes had significantly lower left hand 2D:4D ratios (correlated with androgen concentration) than non-elite female athletes. Several studies have indicated associations of testosterone changes and aggression. This relation might be necessary in athletes as an enhancement of the positive aspects of aggressive behavior such as vigor and energy (Zitzmann 2006). In a study by Salvador et al. 1999, the authors proposed that the role of hormones could be linked to the expression of human behavior including competitive aggression. Furthermore, Gonzalez-Bono et al. 2000 found testosterone changes in a strongly chance-independent competition of 17 professional basketball players. A correlation between aggressive behavior and testosterone was found. Here, aggression was studied in soccer players using EEG. The results showed that the beta frequency band was affected by testosterone in a manner similar to an adrenergic stimulant. EEG could be used to demonstrate adrenergic stimulation. Adrenergic stimulation increased the EEG resistance to photic stimulation and enhanced performance in simple repetitive tasks (Stenn et al. 1972, and Vogel et al. 1969). Therefore, an association between testosterone levels and EEG topography was proposed. Another study suggested that the increased salivary testosterone concentration associated with the relative delta power was decreased and that the alpha relative power was increased in male children (Poblano et al. 2003). In elite athletes and healthy non-athletic controls, the interaction between EEG coherence in alpha and beta frequency domains with salivary cortisol levels differed (Schmikli et al. 2010). Therefore, aggressive behavior could affect hormone levels, which can be demonstrated in EEG frequency bands.

Statistical analysis of aggressive brain activity data presented differences among soccer players one week before the competition (Pre2), as shown in Table 3. This finding indicated an offset in the brain activity of defensive soccer players one week before the competition (Pre2), which was interpreted as aggression (in absolute power; $p=.020$, $p=.019$; in amplitude asymmetry; $p=.022$, $p=.006$). Therefore, the aggression exhibited by the soccer players was related to emotion or assertiveness, and human aggression can appear in several forms including defensive behavior (Coccaro 1996). In athletics, aggressive defense was studied in the Spanish professional men's basketball league (ACB League; 2004-2005 seasons). The basketball players' characteristics were identified as free throws (successful and unsuccessful), 2- and 3-point field goals (successful and unsuccessful), and offensive and defensive rebounds, blocks, assists, fouls, steals, and turnovers. Then, the characteristics were statistically analyzed in relation to the game. At home games, the key characteristics for winning were rebounds and steals. The results demonstrated that these 2 behaviors aroused the home team, enabling them to secure the ball with an aggressive defense (Gomez et al. 2008). However, in some types of sports, such as basketball, ice hockey, rugby, and volleyball, athletes must assume roles as both offensive and defensive players, which differ from soccer players. This study showed that the results of the offensive soccer players' brain activities did not exhibit significantly different patterns, as shown in Table 4. This finding shows that offensive soccer players did not indicate aggression via their brain activity (absolute power and amplitude asymmetry in the beta frequency band). Furthermore, comparison of the brain activity among defensive and offensive soccer players confirmed that aggression arose in athletes who performed the defensive positions. Moreover, as the competition approached (1 week before the competition; Pre2), the aggression also increased as shown in Table 5 (in absolute power; p=.043, in amplitude asymmetry; p=.006). Consequently, an aggressive defense was an important feature for sports performance, especially during the competitive game. In fact, aggressive behavior has been shown to be positively associated with performance in athletes (Widmeyer 1984). Additionally, emotions are dynamic in nature and influence behavior. In sports, the players' behavior and emotions are directly associated with (Campo et al. 2016) and exert powerful effects on performance (Lazarus 2000). Consequently, these behaviors might be better explained in terms of learning responses and could be modeled and reinforced to facilitate behavior that enhances performance (Gee and Leith 2007). Microgenetic model of perception might be usuful in this procedure (Pachalska et al. 2018). It is of interest in future research to investigate the role of aggression in brain activity responses in relation to the performance of athletes.

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## CONCLUSION

In this study, our data indicated that the brain activity of defensive soccer players revealed aggression that arises before the competition. This phenomenon was demonstrated in the beta frequency band at the $Fp_1$, $Fp_2$, $F_7$, and $F_8$ positions. Compared with the normal condition, the brain topographic map (absolute power) indicated increased activity of brain processing. For brain connectivity (amplitude asymmetry), there was a larger differentiation between amplitudes that were recorded from EEG channels in opposite hemispheres compared with the normal condition. However, this finding might be related to the performance of the athletes during the competition, which may illustrate defensive soccer positions. The aggression may be executed to provide optimal anxiety, good decision-making, and forcefulness or self-confidence during the competition. Moreover, statistical analysis of the QEEG values confirmed that aggression occurred and increased as the competition approached. This manifestation was found only in players representing defensive soccer positions.

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