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Evaluation and comparison of Brain Waves by neurofeedback in People with Obsessive-Compulsive Disorder and normal persons

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Abstract

The main objective of the present study was to evaluate the brain waves using neurofeedback in patients with OCD. This is a comparative case-control study. A number of 30 patients were selected from those referring to Ardebil Sepand Consulting Center, and and 30 healthy individuals. Neurofeedback evaluating was done for the patients for diagnosis after performing a clinical interview by using the Yale - Brown Obsessive Compulsive Scale questionnaire. Evaluation of waves was conducted through taking EEG from alpha, beta and theta rhythms in five regions of Pz, Oz, Fz, F3 and F4. The results of Multivariate analysis of variance (MANOVA) showed that a significant difference between the two groups in areas of θ F3, α F3, β F3, θ F4, β F4, θ Fz, β Fz, θ Oz, θ Pz and **β** Pz. In other words, it can be said that the brain waves of θ F3, α F3, β F3, θ F4, β F4, θ Fz, β Fz, **θ** Oz, **θ** Pz and **β** Pz in people with OCD are higher than normal people. Also, the results showed that in the brain waves of α F4, α Fz, α Oz, **β** Oz and **α** Pz there is no significant difference in two groups. The present study results indicated the effectiveness of neurofeedback as an instrument in diagnosis of abnormal waves in patients with obsessive-compulsive disorder in comparison with the normal group .Also, these results have important implications in the field of diagnosis and treatment planning for OCD.

Keywords: Brainwaves, Neurofeedback, Obsessive-compulsive disorder

Introduction

Obsessive–compulsive disorder (OCD) is a debilitating disorder. It is previously classified as an anxiety disorder in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (American Psychiatric Association, 2000), OCD is presently listed in a new chapter in DSM-5 under obsessive–compulsive and related disorders. Disorders in this category included OCD, body dimorphic disorder, trichotillomania, hoarding disorder and excoriation. It is also determined that the nature of obsessive preoccupation and repetitive behaviours are the common main features among the symptomatology of these disorders (American Psychiatric Association, 2013). According to DSM-5 (American Psychiatric Association, 2013), OCD is characterized by: Obsessions–recurrent and persistent thoughts, urges or images that cause noticeable distress and

compulsions–repetitive and time-consuming behaviours or mental rituals that individuals feel compelled to perform to reduce the anxiety which are caused by the obsessions. The prevalence rate of OCD is estimated about 2–3% (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012; Ruscio, Stein, Chiu, & Kessler, 2010; Subramaniam, Abdin, Vaingankar, & Chong, 2012), and OCD has been recognized by the World Health Organization as the top 20 causes of years of life lived with disability for 15 to 44 year olds (World Health Organization, 2001). It is also reported that the prevalence of health anxiety has been shown a range from 5.7% in community samples (Sunderland, Newby, & Andrews, 2013), to 17.5% to 24.7% in medical settings (Tyrer, Cooper, Crawford, Dupont, Green, & et al, 2011). Discoveries on the prevalence of the extreme form of health anxiety i.e. hypochon driasis in obsessive–compulsive disorder (OCD) are supposed to be inconclusive, but a prevalence level of 10–17%, significantly higher than in controls is recommend by the most recent and methodological robust revisions (Bienvenu, Samuels, Riddle, Hoehn Saric, Liang, & et al, 2000; Fallon, Qureshi, Laje, & Klein, 2000; Jaisoorya, Janardhan Reddy, & Srinath, 2003).there is The quiet high prevalence rate reluctance to accept referral to psychiatric clinics. It is also reported that the health anxiety is made as a social concern by the excessive health care utilization both from a public health and also cost-effectiveness perspective (Greeven, vanBalkom, Visser, Merkelback, van Rood, & et al, 2007). In the past two decades, it has been carried out a substantial advance in the understanding of the biological underpinnings of obsessive-compulsive disorder (OCD) with emergence of various hypothetical models. It is noticeable that there is little confusion over a significant neurobiological basis of OCD. Certain consistent abnormalities in OCD have been shown by genetic, neurochemical, neuropsychological and neuroimaging studies. After frequent failures of structural neuroimaging methods in finding consistent structural abnormalities in psychiatric disorders, evolving functional brain-imaging techniques nowadays represent the most powerful tools for characterizing in vivo human anatomy, neurophysiology and neurochemistry at modest temporal and spatial resolution. It is reported obviously that the recent functional neuroimaging studies in OCD population have reliably found abnormalities the frontal cortex and basal ganglia structures (Saxena & Rauch, 2000). Quantitative EEG (QEEG) being a physiological imaging technique can be used to delineate abnormal functioning of brain regions with notable temporal precision. The findings of the quantitative EEG power-spectral studies in OCD population have been mostly inconsistent. Power- spectral analysis on 10 patients with OCD with a limited montage is used in one of the first quantitative EEG studies. Decreasing variability in the temporal region is also reported by Flor-Henry, Venudall, Koles, & Howarth (1979). Moreover in this study, no frontal lead was used which is not in agreement with the findings of some researchers like Khanna (1988) who found out decreasing in log power in the non-dominant frontal-midline and posterior temporal regions. This study suggested right temporo-frontal hyper functioning to be associated with OCD and stressed the importance of the non-dominant fronto-temporal regions in this connection, with regards to both the localization by changes and by the nature of the activity observed (beta activity). Bennasar, Plannells, Gearcia-Mas, & Izard (1991),

in their study of power spectrum on OCD patients, found increased beta power in the frontal region. However, Perros, Young, Ritson, Price, & Mann (1992) found that relative power in the theta-2 band in the left temporal and central regions was significantly increased and the variability in frontal and temporal regions was significantly reduced. Kuskowsky, Malone, Kim, Dysken, Okaya & et al (1993) demonstrated EEG from 13 unmedicated and no depressed patients with DSM-III-R obsessive compulsive disorder (OCD) and from 10 age-matched controls. Quantitative analysis of the EEG revealed lower log absolute power in the delta, beta 1, and beta 2 bandwidths for OCD patients at frontal and right-hemisphere locations. Moreover, OCD patients displayed greater hemispheric asymmetries in EEG activity based on difference measures of EEG power from homologous electrode pairs, indicative of severe right hemisphere EEG hyperactivity. Drake, Pakalnis, & Newell (1996) compared EEG spectral measures in 20 patients meeting DSM-III-R criteria for obsessions and compulsions and 12 neurologically intact unmedicated controls. The EEG was documented from 11 electrodes. The results showed that both left frontal and right frontal variability was significantly reduced in OCD patients in compared with controls. Consistent with literatures suggesting neurophysiological disturbances in OCD, this study has supported it by showing frontal lone dysfunction in OCD patients in comparison to neurologically intact controls. Tot, Ozge, Comelekoglu, Yazici, & Bal (2002) had a recent study on OCD patients using quantitative EEG methods. The study contained within 22 right handed OCD subjects as the study group and 20 rights handed pair-wise matched healthy subjects as control group. The authors have also used 12-channels for analysis of alpha, beta, delta and theta bands. Hemispheric asymmetry and regional differences for 3 brain regions: frontal, Temporal and parietal were evaluated with frequency analysis. The analysis presented a considerable increase in delta and theta activity and a decrease in alpha activity of left fronto-temporal regions. A left temporal decrease in beta activity was significant. The study found that patients with OCD showed important fronto-temporal dysfunction, predominantly in the left hemisphere. Hammond (2003) showed that Theta waves are abnormal in people with OCD. In another recent study, Karadag, Oguzhanoglu, Kurt, Oguzhanoglu, Atesci, & et al. (2003) obtained quantitative analysis of the EEG in patients with OCD. The study revealed a decreased beta and an increased theta power at fronto-temporal regions. It was also shown that the patients who had higher scores in doubting test (Maudsley Obsessive Compulsive Questionnaire) and more severely ill patients shared similar q-EEG features. The relative theta powers were significantly increased and alpha powers were significantly decreased in these patients, particularly in the fronto-temporal region. It was suggested that the q-EEG could be useful in investigating the OCD patients with heterogeneous characteristics. Also Desarkar, Sinha, Jagadheesan & Nizamie (2007) showed that OCD patients had significantly advanced power in comparison to controls which was widespread in the theta frequency, predominantly left sided fronto-temporo-parietal in delta and alpha and only left frontal in beta2 bands. In summary, the results of different quantitative EEG studies in OCD patients have been mostly so far inconsistent except the finding of an increase in theta power, which has come up more or less

consistently across studies. Thus, the aim of this study was to determine whether it is possible to achieve a global pattern on brain waves of OCD patients?

Methods

This is a comparative case-control study. All patients with OCD disorder referred to the Sepand Counseling Center, Ardebil or those had been referred to the center by other specialists formed the study statistical population. The subjects were selected from the clinical population by an available approach. The sample were selected of 30 patients with OCD that after doing clinical interview and completing Yale Brown Inventory and 30 healthy individuals. The subjects of two groups were matched in terms of age, gender and education, and had no concurrent disorders. The subjects' age range was between 14 and 39 years.

Data collection instrument:

Yale-Brown Obsessive-Compulsive Scale

This measure, developed by Goodman, Rasmussen, Price, Heninger and Charney (1986), has 10 statements, including 5 to assess the obsessive thoughts and5 to assess compulsive actions. The test scoring is done on a five-degree scale (0-4), and each item is scored with a 5-point scale from zero (no symptoms) to 4 (very severe). Data relating to the validity and reliability of the scale implies that the reliability among assessors in 40 patients was equal to 98%, and the coefficient of internal consistency (Cronbach's alpha) was as 0.89.) (Van Kim, Diskin and Katz, 1989). Convergent validity of this test with the general determining test of obsessive-compulsive syndrome at the baseline was obtained as 0.97. The scale reliability was reported as 0.84 by test-retest method in a 2-week period, while its discriminant validity was obtained as 0.64 and 0.59 by using Beck Depression Inventory and Hamilton Anxiety Rating Scale (HRSA), respectively (Abolqasemi and Narimani, 2006).

Methodology:

In the present study was used the Procomp Infiniti-2 software (Thought Technology Company, Canada). First, a quantitative EEG was taken from each patient; the patient was placed in front of the computer screen, and the electrodes were installed according to the International 10-20 Standard Location System at the desired location using the specific gels. At the beginning of the session with basic EEG was recorded for 2 minutes and ten seconds in Pz, Oz, Fz, F3 and F4 areas to determine the patient's progress. In the alpha / theta / beta program, first,a base line without feedback and with eyes closed is recorded for the patient, by which, the references dominant frequency will be determined. One and a half Hz higher or lower than these frequencies obtained, whatever they are, would be the individual's alpha / theta / beta range. In this research, through taking EEG, alpha, beta and theta rhythms in five regions of Pz (parietal), Oz (occipital), Fz (frontal), F3 (left temporal) and F4 (right temporal) were used.

Results

the mean and standard deviation of scores obtained by the groups in OCD and the normal in the brain waves of Pz, Oz, Fz, F3 and F4 areas are shown in table 1.

Table 1: The mean and SD of scores of waves in Pz, Oz, Fz, F3 and F4 regions

Variable	OCD		Normal	
	Mean	SD	Mean	SD
θ F3	9.46	1.11	8.62	1.15
α F3	9.03	0.72	8.49	0.91
β F3	8.78	1.32	6.03	1.52
θ F4	9.29	1.16	8.71	0.86
α F4	8.08	1.54	8.53	1.43
β F4	9.37	1.25	8.66	1.23
θ Fz	10.7	1.36	9.83	1.29
α Fz	8.29	1.66	8.86	1.59
β Fz	8.71	0.66	8.24	0.9
θ Oz	9.71	1.78	8.6	1.05
α Oz	10.37	1.51	9.94	1.07
β Oz	8.39	1.36	7.78	1.11
θ Pz	10.56	1.19	7.35	1.67
α Pz	8.53	1.91	9.09	1.12
β Pz	9.82	1.19	5.38	0.79

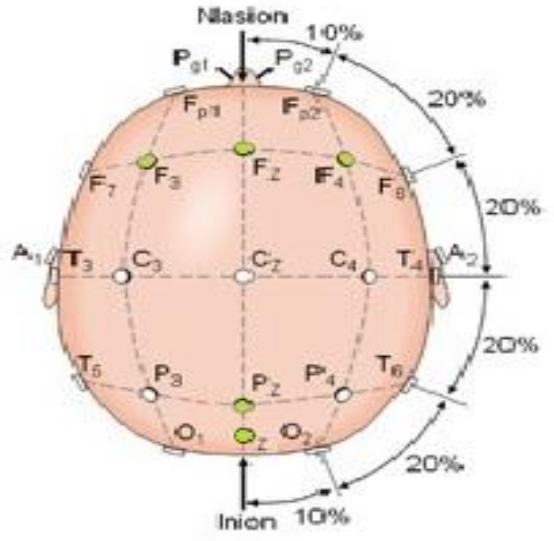

Figure 1: The five regions of taking EEG; Pz, Oz, Fz, F3 and F4 regions are shown in green

As can be seen, Table (1) shows the mean and standard deviation of scores obtained by the groups in OCD and the normal in the brain waves of Pz, Oz, Fz, F3 and F4 areas.for example mean scores in β F3 OCD and normal persons are 8.78 and 6.03 respectively. Box and Levin tests were used before using multivariate analysis of variance parametric test to comply with its assumptions. According to Box test, which was not significant for any of the variables, the condition of homogeneity of variance / covariance matrices is properly observed (P = 0.21, F = 1.16 and BOX = 62.68). Also, based on Levin test and its insignificance for all the variables, the equality condition of variances of the groups studied is respected (θ F3, α F3, β F3, θ F4, α F4, β F4, θ Fz, α Fz, β Fz, θ Oz, α Oz, β Oz, θ Pz, α Pz and β Pz respectively as 0.703, 0.118, 0.354, 0.054, 0.831, 0.952, 0.364, 0.98, 0.61, 0.096, 0.093, 0.125, 0.144, 0.071 and 0.127).

Table 2: Results of MANOVA significance tests for the main effect of dependent variables

	Effect	**Value**	**F**	**df**	**Error df**	**Sig**	**Partial Eta Squared**	**Observed Power**
Group	pillai's Trace	0.897	25.464	15	44	0.001	0.897	1
	Wilk's Lambda	0.103	25.464	15	44	0.001	0.897	1
	Hotelling Trace	8.681	25.464	15	44	0.001	0.897	1
	Roy's Largest Root	8.681	25.464	15	44	0.001	0.897	1

According to Table 2, the effect of group on the linear combination of dependent variables is significant (P< 0.001 and Wilk's Lambda = 0.103). These results indicate that in the groups studied, there is a significant difference regarding at least one of the dependent variables. The above tests allowed the capability of using the multivariate covariance analysis.

Table 3: The difference between multivariate analysis of variance to investigate changes in brain waves

Dependent Variable	Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared	Observed Power
θ F3	10.576	1	10.576	8.273	0.006	0.125	0.807
α F3	4.347	1	4.347	6.403	0.014	0.099	0.701
β F3	112.998	1	112.998	55.823	0.001	0.49	1
θ F4	5.058	1	5.058	4.875	0.031	0.078	0.584
α F4	3.179	1	3.179	1.437	0.236	0.024	0.218
β F4	7.562	1	7.562	4.894	0.031	0.078	0.585
θ Fz	11.353	1	11.353	6.477	0.014	1	0.706
α Fz	4.862	1	4.862	1.846	0.179	0.031	0.267
β Fz	3.342	1	3.342	5.363	0.024	0.085	0.625
θ Oz	18.637	1	18.637	8.673	0.005	0.13	0.825
α Oz	2.765	1	2.765	1.605	0.21	0.027	0.238
β Oz	5.563	1	5.563	3.612	0.062	0.059	0.464
θ Pz	154.273	1	154.273	73.046	0.001	0.557	1
α Pz	4.593	1	4.593	1.874	0.176	0.031	0.27
β Pz	295.349	1	295.349	288.175	0.001	0.832	1

Table 3 shows the results of the analysis of covariance on the brain waves areas. The results revealed a significant difference between the two groups in areas of θ F3 ($p < 0.01$, $F = 8.273$), α F3 ($p < 0.05$, $F = 6.403$), β F3 ($p < 0.001$, $F = 55.823$), θ F4 ($p < 0.05$, $F = 4.875$), β F4 ($p < 0.05$, $F = 4.894$), θ Fz ($p < 0.05$, $F = 6.477$), β Fz ($p < 0.05$, $F = 5.363$), θ Oz ($p < 0.01$, $F = 8.673$), θ Pz ($p < 0.001$, $F = 73.046$) and β Pz ($p < 0.001$, $F = 288.175$), In other words, by looking at the means of the groups, it can be seen that the brain waves of θ F3, α F3, β F3, θ F4, β F4, θ Fz, β Fz, θ Oz, θ Pz and β Pz in people with OCD higher than normal. Also, the results showed in the

brain waves of α F4, α Fz, α Oz, β Oz and α Pz there is no significant difference in any of the four groups of students.

Discussion

This study aimed to evaluate the brain waves using neurofeedback in OCD patients. Gevins, Le, Martin, Brickett, Desmond & Reutter (1995) believed that better spatial sampling is the first requirement for extracting more detailed information about cognitive processes from scalp recorded EEGs. In recent years, due to the observed abnormalities of brain waves in patients with OCD, the evaluate of the disorder by using neurofeedback method has been considered. Neurofeedback is a approach based on biofeedback in which EEG of person is used for evaluation of brain waves. In this research, the approach of obtaining the EEG from the rhythms of alpha, beta and theta in five regions of Pz (parietal), Oz (occipital), Fz (frontal), F3 (left temporal) and F4 (right temporal) was used to using neurofeedback can detect abnormal waves. The results showed a significant difference between the two groups of OCD and normal in some areas of the brain waves. The results revealed a significant difference between the two groups in areas of θ F3 ($p < 0.01$, $F = 8.273$), θ F4 ($p < 0.05$, $F = 4.875$), θ Fz ($p < 0.05$, $F = 6.477$), θ Oz ($p < 0.01$, $F = 8.673$) and θ Pz ($p < 0.001$, $F = 73.046$), In other words, by looking at the means of the groups, it can be seen that the brain waves of θ F3, θ F4, θ Fz, θ Oz and θ Pz in people with OCD higher than normal. The results obtained are consistent with Perros et al (1992), Tot et al (2002), Hammond (2003), Karadag et al (2003) and Desarkar et al (2007) studies that anomalies and increases beta waves in individuals with OCD. In explaining this finding, the importance of increase or decrease in the range of theta brain waves (4-8 Hz) in brain's functions should be mentioned. Demos studies of (2002) have shown that increase in slow brain waves (less than 10 Hz) in different areas of the brain is associated with misty thinking and arousal in people with OCD. Also, the results showed a significant difference between the two groups in areas of β F3 ($p < 0.001$, $F = 55.823$), β F4 ($p < 0.05$, $F = 4.894$), β Fz ($p < 0.05$, $F = 5.363$), and β Pz ($p < 0.001$, $F = 288.175$), In other words, by looking at the means of the groups, it can be seen that the brain waves of β F3, β F4, β Fz, and β Pz in people with OCD higher than normal. The results obtained are consistent with Khanna (1988), Bennasar et al (1991), Kuskowski et al (1993), Tot et al (2002), Karadag et al (2003) and Desarkar et al (2007) studies that anomalies and higher beta waves in individuals with OCD. Also, the studies have shown the importance of beta rhythm (12-20 Hz) with the state of alertness and attention (demos, 2005). The results revealed a significant difference between the two groups in area of α F3 ($p < 0.05$, $F = 6.403$), In other words, by looking at the means of the groups, it can be seen that the brain wave of α F3 in people with OCD higher than normal. The results obtained are consistent with Tot et al (2002), Karadag et al (2003) and Desarkar et al (2007) studies that anomalies and higher beta waves in individuals with OCD. Also, the results showed in the brain waves of α F4, α Fz, α Oz, β Oz and α Pz there is no significant difference in any of the four groups of students. The small sample

size and lack of follow-up courses for re-registration of patients with OCD and normal brain waves were as limitations of this study.

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