

# Quantitative electroencephalogram (QEEG) Spectrum Analysis of Patients with Schizoaffective Disorder Compared to Normal Subjects

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**Objective:** The aim of this study was to achieve a better understanding of schizoaffective disorder. Therefore, we obtained electroencephalogram (EEG) signals from patients with schizoaffective disorder and analyzed them in comparison to normal subjects.

**Method:** Forty patients with schizoaffective disorder and 40 normal subjects were selected randomly and their electroencephalogram signals were recorded based on 10-20 international system by 23 electrodes in open- and closed-eyes while they were sitting on a chair comfortably. After pre-processing for noise removal and artifact reduction, we took 60- second segments from each recorded signals. Then, the absolute and relative powers of these segments were evaluated in all channels and in 4 frequency bands (i.e., delta, theta, alpha and beta waves). Finally, Data were analyzed by independent t-test using SPSS software.

**Results:** A significant decrease in relative power in the alpha band, a significant decrease in power spectra in the alpha band and a significant increase in power spectra in the beta band were found in patients compared to normal subjects ( $P < 0.05$ ). The predominant wave in the centro-parietal region was the beta wave in patients, but it was the alpha band in normal subjects ( $P = 0.048$ ). Also, the predominant wave of the occipital region in patients was the delta wave, while it was the alpha wave in normal subjects ( $P = 0.038$ ).

**Conclusion:** Considering the findings, particularly based on the significant decrease of the alpha waves in schizoaffective patients, it can be concluded that schizoaffective disorder can be seen in schizophrenia spectrum.

**Keywords:** *Predominant wave, Power spectra, Quantitative electroencephalogram (QEEG), Relative power, schizoaffective*

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Schizoaffective disorder is a psychotic disorder that affects 0.5% to 0.8% of the general population in their lifetime period (1). The disorder has presentation of schizophrenia as well as mood disorder. According to the prominence of mood symptom, this disorder has two subtypes: bipolar type and depressive type (2). Whether schizoaffective disorder originally is a psychotic disorder with mood presentation or mood disorder with psychotic presentation or distinct entity is unclear. In general, the prognosis of the disorder lies between schizophrenia and mood disorder (e.g., better prognosis than schizophrenia and worse prognosis than mood disorder). Also, as a group, compared to patients with schizophrenia, patients with this disorder often have a non-deteriorating course and better response to lithium (a mood stabilizing drug) (1, 2). Available data suggest that patients with schizoaffective disorder are a

heterogeneous group, and some of whom may have schizophrenia with mood disorder, some others may have mood disorder with schizophrenia symptoms, or they may have distinct psychiatric syndrome. This confusing and uncertain data show the complexity of this disorder and the need for the further study of the disorder from different aspects (1, 2).

Many studies perused brain waves and QEEG for various psychiatric disorders including psychotic and mood disorders. Schellenberg and Schwarz (3) investigated the brain signals in patients with schizophrenia and concluded that the alpha wave power was reduced in these patients at the occipital region. In 1993, Locatteli et al. reported the increase of delta and theta power and the decrease of alpha power in patients with schizophrenia compared to normal subjects (4).

Khan et al. (5) suggested that the frequency of the alpha and delta waves is increased in the frontal

region which is contrary to most studies on these patients. In the Clementz et al. study on patients with schizophrenia and bipolar disorder compared with normal subjects, the increase of the delta and theta waves and the decrease of the alpha wave were found in both patient groups compared to normal subjects (6).

In another work by Koles et al. (7), they analyzed the EEG signals in patients with schizophrenia, depression and bipolar disorder. They observed the left hemisphere hyperactivity in schizophrenia, the right hemisphere hyperactivity in depression and both hemispheres hyperactivity in bipolar disorder. Winterer et al. conducted a study on patients with depression compared to normal subjects. They reported a significant decrease of brain waves power in these patients compared to normal subjects (8). Ramos et al. performed a study on refractory patients with schizophrenia and patients who react to treatment compared with normal subjects. Patients responding to treatment had major alpha wave and minor delta wave, while refractory patients had major beta wave compared with normal subjects (9). Knott et al. also reported overall power rising of the brain waves compared to normal subjects (10). The evaluation of quantitative EEG (QEEG) signals in patients with schizophrenia by Kirino (2004) revealed that the delta and theta waves power in patients is more than normal subjects statistically (11). Harris et al. investigated patients with chronic schizophrenia and achieved the same results with Kirino (12). In a recent study, Zaytseva et al. (2013) assessed spectral power and coherence from the EEG signals of 32 patients with schizophrenia, 32 patients with schizoaffective and 40 normal subjects. Their results in patients with schizophrenia compared to healthy subjects revealed that the power spectral of theta and gamma frequency bands was higher, and power spectral of alpha band was lower in the patients significantly. Also, the schizoaffective group had a higher power spectral than normal group in part of the beta band (13).

To our knowledge, just a few studies have analyzed the QEEG in patients with schizoaffective disorder. Therefore, the aim of this study was to investigate the brain functions by QEEG analysis in these patients, especially in the chronic episode of the disorder. Given that the diagnosis of this disorder is uncertain in the first episode, we examined it in the chronic episode.

## Material and Methods

### *Participants*

In this study, 25 men aged 23 to 66 years and 15 women aged 22 to 57 years who were diagnosed to have schizoaffective disorder (according to Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) criteria) by two psychiatrists were eligible for the study (with mean age  $44.7 \pm 14.0$  years). Thirty seven

patients with schizoaffective disorder had the bipolar type and 3 patients had the depressed type. Also, 23 normal men aged 18 to 55 years and 17 normal women aged 18 to 53 years were selected randomly as the control group (with the mean age of  $42.4 \pm 12.6$  years). The subjects in the control group were selected from healthy individuals who referred to the EEG department in Razi hospital for checkup. They were matched by age, and no significant difference was found between the participants with respect to age ( $P = 0.13$ ). The exclusion criteria were as follows for both groups: history of neurologic diseases (such as seizure) or head trauma; being diagnosed with other disorders; schizoaffective patients treated with benzodiazepines or barbiturates and normal subjects who took them; individuals with a history of substance abuse; family's unwillingness to participate in the study.

### *Experiment*

EEG signals of both groups (i.e., 40 patients with schizoaffective disorder and 40 normal subjects) were recorded by Micromed Brain Quick 98 QEEG device in Razi psychiatric Hospital. Their EEG signals were recorded based on 10-20 international system by 23 electrodes in open- and closed-eyes for 8-10 minutes. During EEG recording, subjects were sitting on a chair comfortably in a quiet room and were asked to minimize their movement. The channels were located on these positions on the scalp: Fz, Cz, Pz, Fpz, Oz, C3, T3, C4, T4, Fp1, Fp2, F3, F4, F7, F8, P3, P4, T5, T6, O1, O2, A1 and A2. The average of A1 and A2 channels was used as a reference value in the focal montage. The signals were filtered real-time with a band-pass filter between 0.4 and 70 Hz and a notch filter.

After pre-processing of noise removal and artifact reduction, 30 epochs of 2s with minimal artifacts were selected by visual inspection so that the length of the final segment of EEG under analysis was 60 seconds on average. Also, 15 epochs (i.e., 30 seconds) belonged to open eyes and 15 epochs belonged to close eyes situation.

Next, a digital FFT-based power spectrum analysis (Welch technique) computed power spectrum density (PSD) of the EEG frequency bands. The following standard band frequencies were studied: delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-12 Hz) and beta (14-34 Hz) bands. Then, the absolute power and relative power features were extracted from all 21 channels and in 4 frequency bands using power spectrum density (PSD). Power spectra indicate signals or waves power distribution in various frequencies.

Predominant wave represents the superiority of a wave (delta, theta, alpha and beta) in each topographical regions of the brain (frontal, parietal, temporal and occipital) and we obtained it as a feature.

Therefore, schizoaffective disorder and health were independent variables, and power spectra, relative power and predominant wave were dependent variables.

*Statistical Analysis*

Kolmogorov-Smirnov test showed that our data had normal distribution. Hence, to assess the statistical significance of the differences between the brain waves of patients and normal subjects, independent t-test was used. Statistical analysis was done using SPSS version 21 and differences were considered significant with  $P < 0.05$ .

**Results**

The relative power of alpha band in all brain regions except F7, F8, Fp2, T3 and T4 in the patients compared with normal subjects showed a significant decrease ( $P < 0.05$ ) (see Fig. 1). The relative power of delta band

in focal comparison was significant only in the right occipital electrode or O2, and contrary to the results of other studies (4, 6, 10-12) which found significant increases in many other regions in the psychotic patients, in our study, this difference was not statistically significant. The relative power of theta band in patients was more than normal subjects, but this difference was not significant. The relative power of the beta band had a significant increase in the frontal and central regions (F3, Fz, F4, C3, Cz). Figures 1 and 2 demonstrate the relative power and power spectra of the alpha wave for each channel in patients and healthy persons, respectively.

**Table 1: Features with Significant Differences ( $P < 0.05$ ) between schizoaffective Group and controls based on Statistical Analysis**

Features	Patient (Mean $\pm$ S.D)	Control (Mean $\pm$ S.D)	P-value
FP1-alpha-absolute	0.272 $\pm$ 0.201	0.542 $\pm$ 0.241	0.003
FP1-alpha-relative	0.231 $\pm$ 0.148	0.406 $\pm$ 0.257	0.035
FP2-alpha-absolute	0.256 $\pm$ 0.193	0.540 $\pm$ 0.246	0.002
F3-alpha-absolute	0.295 $\pm$ 0.235	0.521 $\pm$ 0.256	0.020
F3-beta-absolute	0.284 $\pm$ 0.283	0.121 $\pm$ 0.117	0.049
F3-beta-relative	0.440 $\pm$ 0.264	0.237 $\pm$ 0.157	0.018
F4-alpha-absolute	0.195 $\pm$ 0.181	0.409 $\pm$ 0.260	0.016
F4-beta-absolute	0.162 $\pm$ 0.472	0.110 $\pm$ 0.296	0.013
F4-alpha-relative	0.328 $\pm$ 0.215	0.576 $\pm$ 0.285	0.027
F4-beta-relative	0.433 $\pm$ 0.251	0.237 $\pm$ 0.157	0.021
F7-alpha-absolute	0.234 $\pm$ 0.208	0.455 $\pm$ 0.245	0.048
F8-alpha-absolute	0.264 $\pm$ 0.244	0.513 $\pm$ 0.255	0.013
Fz-alpha-absolute	0.234 $\pm$ 0.208	0.455 $\pm$ 0.245	0.015
Fz-beta-absolute	0.645 $\pm$ 0.207	0.483 $\pm$ 0.225	0.027
Fz-alpha-relative	0.252 $\pm$ 0.171	0.576 $\pm$ 0.294	0.001
Fz-beta-relative	0.485 $\pm$ 0.305	0.264 $\pm$ 0.151	0.019
Fpz-alpha-absolute	0.220 $\pm$ 0.180	0.476 $\pm$ 0.243	0.004
Fpz-alpha-relative	0.232 $\pm$ 0.150	0.540 $\pm$ 0.273	0.001
C3-alpha-relative	0.419 $\pm$ 0.232	0.687 $\pm$ 0.265	0.008
C3-beta-relative	0.398 $\pm$ 0.253	0.220 $\pm$ 0.138	0.025
C4-alpha-relative	0.308 $\pm$ 0.158	0.535 $\pm$ 0.216	0.003
Cz-beta-absolute	0.223 $\pm$ 0.389	0.103 $\pm$ 0.193	0.031
Cz-alpha-relative	0.171 $\pm$ 0.500	0.180 $\pm$ 0.297	0.017
Cz-beta-relative	0.388 $\pm$ 0.321	0.160 $\pm$ 0.124	0.017
P3-alpha-relative	0.335 $\pm$ 0.229	0.571 $\pm$ 0.249	0.013
P4-alpha-relative	0.276 $\pm$ 0.198	0.552 $\pm$ 0.264	0.004
Pz-alpha-relative	0.270 $\pm$ 0.209	0.523 $\pm$ 0.284	0.012
T3-delta-absolute	0.125 $\pm$ 0.707	0.139 $\pm$ 0.580	0.041
T4-delta-absolute	0.118 $\pm$ 0.525	0.176 $\pm$ 0.385	0.036
T5-alpha-relative	0.373 $\pm$ 0.238	0.623 $\pm$ 0.283	0.016
T6-alpha-relative	0.313 $\pm$ 0.174	0.517 $\pm$ 0.262	0.022
O1-alpha-relative	0.358 $\pm$ 0.275	0.570 $\pm$ 0.247	0.038
O2-alpha-absolute	0.146 $\pm$ 0.153	0.326 $\pm$ 0.259	0.033
O2-alpha-relative	0.331 $\pm$ 0.210	0.580 $\pm$ 0.234	0.006
O2-delta-relative	0.210 $\pm$ 0.415	0.118 $\pm$ 0.227	0.032
Oz-alpha-absolute	0.209 $\pm$ 0.226	0.410 $\pm$ 0.289	0.048
Oz-alpha-relative	0.304 $\pm$ 0.226	0.522 $\pm$ 0.270	0.027

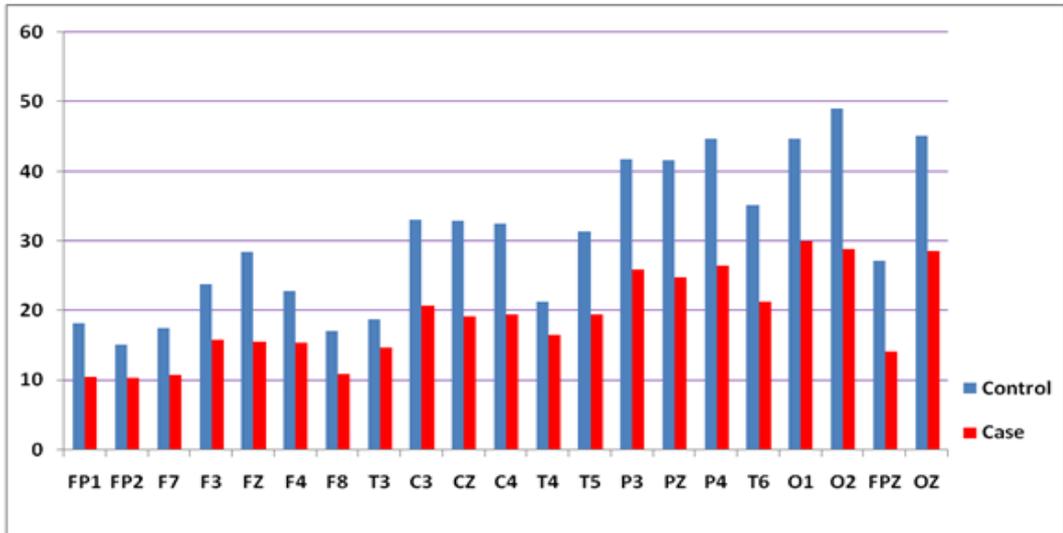


Figure 1: Alpha Band Relative Power in all Channels in schizoaffective group and control. All differences are significant except Fp2, F7, F8, T3, and T4.

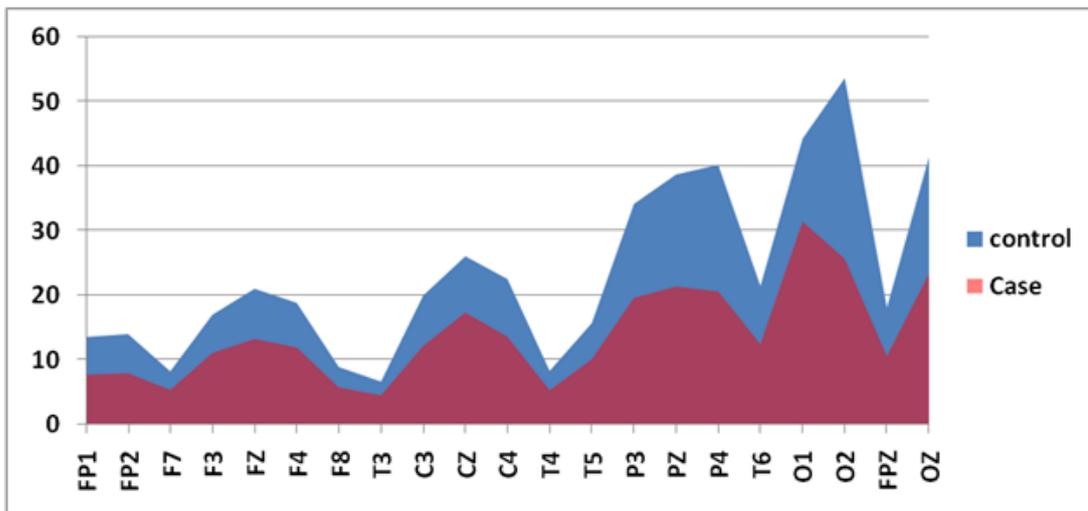
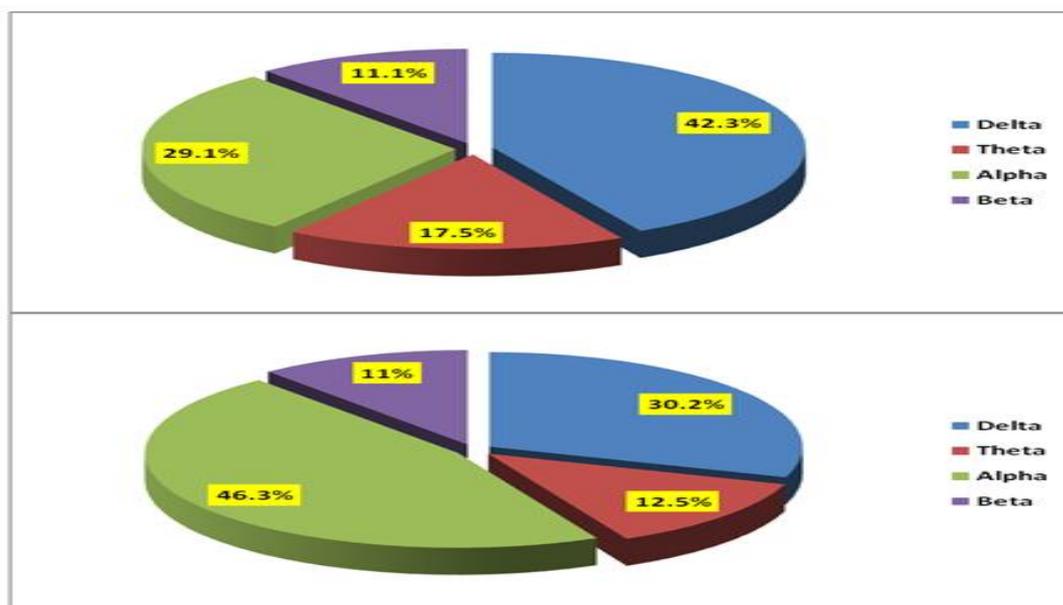


Figure 2: Overlapping Plot for Power Spectra of the Alpha Band in all Channels in schizoaffective Group and control (P = 0.040)



**Figure 3: Distribution of the Brain Waves and the Predominant Wave in the Occipital Region for the schizoaffective (top) and the Normal subjects (bottom)**

The power spectra of the alpha band showed significant differences in frontal, mid-sagittal and right hemisphere. Alpha band had less power spectra in patients compared with normal subjects in the aforesaid regions (Fig. 2). A significant increase was observed in frontal and mid-sagittal regions for beta band power spectra in the patients. This significant difference was found in Fz, F3, F4 and Cz locations. Delta band power spectra had a significant decrease in temporal region. This difference was found in T3 and T4 channels. The power spectra of the theta band in any of the brain regions and channels did not show a significant difference between patients and normal subjects. Although the theta power spectra increase was observed in many brain regions, the difference was not statistically significant. Table 1 demonstrates the mean and standard deviation of all the significant features between patients with schizoaffective disorder and normal subjects. The predominant waves were also studied in various regions of the brain in patients and normal subjects. The predominant wave in the centro-parietal in the patients was delta, while it was the alpha wave in the normal subjects at the same region, and this difference was statistically significant ( $P = 0.048$ ). In the occipital region, the predominant wave was delta in the patients and it was alpha for the normal group significantly ( $P = 0.038$ ). In other regions, despite the differences between the predominant waves in the patients group and the control group, these differences were not significant. Figure 3 shows the distribution of the brain waves in the occipital region for both groups.

## Discussion

A comprehensive study on 53 previous studies of QEEG analysis in the patients with schizophrenia was

performed by meta-analysis in 2008. The results of the mentioned study indicated that QEEG can be used as a diagnostic tool in these patients and emphasized that findings from QEEG analysis is independent from taking drugs in schizophrenia (14). The overall results obtained in our study confirmed the diagnostic power of QEEG in spite of the fact that all the patients in this study have a history of hospitalization and medication. As stated before, schizoaffective disorder has many common symptoms with schizophrenia and mood disorders like bipolar disorder and major depressive disorder. One goal of this study was to find evidences to show whether there is similarity between schizoaffective disorder and the two aforesaid disorders or whether schizoaffective disorder is entirely separable from them and can it be considered a separate disorder.

In general, it can be suggested that findings and results obtained from previous studies on patients with mood disorder and schizophrenia are roughly different although the outcome of these studies indicate the alpha wave reduction and the increase of delta and theta bands in patients with schizophrenia (3, 4, 6, 10-13).

Although increase the beta power and decrease in the alpha power in the patients is consistent with (13), these observations can be due to the different episodes in the patients under investigation.

Our results showed a significant decrease in the alpha waves and a slight increase in the delta waves and theta waves in the patients with schizoaffective disorder compared to healthy individuals. Indeed, we observed the slowing of EEG activity in schizoaffective disorder, which it cab consider as a neuropathology affecting the brain function and causing some symptoms, such as hallucinations, in this disorder.

## Limitation

One of the limitations of current study is that our patients were not in a drug-free period before EEG recording. As we know, psychiatric drugs can affect the pattern of brain functions and cause bias in the results.

## Conclusions

In this research, we assessed the abnormalities of brain function in the patients with schizoaffective using QEEG analysis. Considering our findings, particularly based on the significant decrease of the alpha waves in schizoaffective patients, we can conclude that schizoaffective disorder can be seen in schizophrenia spectrum.

In addition to quantitative EEG investigations, cognitive evaluation tests or positive and negative psychotic symptoms can be used simultaneously to assess the correlation between them and QEEG findings in patients with schizoaffective disorder and schizophrenia.

In our future study, we intend to evaluate and analyze the brain function and QEEG in schizoaffective patients compared to patients with mood disorders such as bipolar disorder to understand the overlap and differences between them.

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