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Examining EEG Signals with Spectral Analyses Methods in Migrain Patients during Pregnancy

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ABSTRACT

The EEG data belonging to three different experiment groups consisting of 17 healthy women, 9 women patient diagnosed with migraine and 8 migraine patients in pregnancy period, whose ages change between 18 and 35, has been analyzed in this study by using parametric and non-parametric spectral analysis methods. Amongst the parametric methods; Burg, Covariance and Modified Covariance methods and Welch method, which gives better results compared to one of the non-parametric spectral analysis methods which is periodogram, have been used for analysis. For describing spectral components in EEG analyses, it has been compared statistically by using independent variables test (t-test) with self-reliant performance of parametric and non-parametric spectral analysis methods. Also, for three groups, EEG channels with the same statistical results of all parametric and nonparametric methods and frequency bands have been determined; thereby it has been attempted to put forth the change of the EEG signals in women, whom are in pregnancy period, with migraine. In this study, EEG frequency bands and signals of migraine patients in pregnancy period giving close results to the characteristics those of healthy people are the most crucial findings.

Key words:EEG, Migraine, Spectral Analysis, Welch, Burg, Covariance, Modified Covariance.

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1. INTRODUCTION

The most important factor in migraine diagnosis is to clearly define all the facts with a careful and detailed story according to the time. Based on these factors, medical history of the patients, age of onset of the pain, settling and features of the pain, course of the pain, coexisting symptoms and questioning the neurological disorders are very important for the diagnosis [1]. In order to question the neurological functions and establish a final diagnosis, the examination tools such as Magnetic Resonance (MR), Computed Tomography (CT) and electroencephalography (EEG) in parallel with the advancing technology are widely used in neurology clinics [2].

EEG potentials that are measured via the electrodes on the head surface consist of the total of the potentials coming from various points below and from a quite vast area of cerebral cortex. EEG signals have a very complex structure and it is very hard to interpret them [3, 4]. The amplitude of EEG signals taken on the head is 1-100 µV peak to peak and the frequency band is 0-100 Hz. Although EEG signals have a wide frequency range between 0-100 Hz, the frequency range of 0-30 Hz is very important in interpreting and analyzing EEG signals. The frequency range of 0-30 Hz includes four basic frequency band range arranged for EEG. These frequency band ranges are respectively 0.5-4 Hz (Delta), 4-8 Hz (Theta), 8-13 Hz (Alfa), and 13-30 Hz (Beta) frequency ranges [5, 6 and 7].

Alfa waves are the brainwaves between 8-13 Hz. They are observed in awake and calm people. Their amplitude is up to 5 µV and they intensely appear in the occipital area [8]. Beta waves are the brainwaves, the frequency rate of which is generally over 12 Hz. They extend up to 25 Hz and rarely 50 Hz. They are obviously observed in the parietal and frontal areas on the scalp. They are separated on the Beta I and Beta II defined frequency band, but the main frequency range for Beta waves is accepted as 13-30 Hz. Theta waves generally appear in the parietal and temporal areas and their amplitude is generally below 100 µV. Theta waves are the brainwaves below 4 Hz and they are observed in serious organic brain disorders and their amplitude rate is below 100 µV.

EEG signals are not periodical signals and their amplitude, phase and frequency continuously change. When EEG signals are interpreted by the specialists, the visual analysis of these signals is inadequate as they are long-term registries and examined within the timescale axis. In order to overcome this inadequacy and to obtain significant results from EEG signals, different signal processing techniques and statistical analysis methods have been developed in parallel with the advancing technology. In the literature, there is not any EEG symptom specific to migraine. Migraine is mainly classified in two groups as migraine with aura and without aura. The seizures of migraine without aura last 4-72 hours and cause mild or intense shooting pain localized on a certain part of the head. Migraine with aura generally develops slowly in 5-20 minutes and lasts up to 60 minutes, appears with neurological symptom seizures localized on cerebral cortex or brain stem, and causes recurrent pains, which last up to 1 hour, from time to time [9].

In this study, EEG signals of three groups composing of healthy people, migraine patients and pregnant women with migraine have been analyzed. In the second section, in describing spectral components in the EEG data and the analyses of the data, parametric and nonparametric spectral analyses methods have been identified. In the third section, spectral component values acquired by parametric and non-parametric methods have been compared statistically by using independent variables test (t-test). By attempting to identify differential channels and frequency bands in diagnosing the migraine with EEG, the changes of the EEG signals in women with migraine in pregnancy periods have been investigated.

2. MATERIAL AND METHODS

2.1. Collecting of the EEG Data

The used EEG data in this study was provided from Training and Research Hospital Neurology Polyclinic of Medical Faculty in Cumhuriyet University between the dates of 2008-2009. In this study, The EEG data belonging to three different groups consisting of 17 healthy women, 9 women patient diagnosed with migraine and 8 migraine patients in pregnancy period, whose ages are between 18-35, has been recorded by using all channels that are monopolar with regards to the international 10-20 electrode standards and by using Nihon Kohden brand EEG device with 200 Hz sampling frequency and with 10 minute durations. The EEG data belonging to migraine patients are migraines without **auras** and they have been acquired by patients consulting to clinics with complaints of headache. The women in pregnancy periods are the same women diagnosed with migraine previously in the same clinic and the EEG data has been recorded while them consulting to clinics for checkouts. International 10-20 electrode standards and the placement of the monopolar electrodes are shown in the Figure 1. In this study, the data collected from the three groups has been analyzed with both parametric and non-parametric spectral analysis methods. These methods, respectively, are: Welch (nonparametric), Burg, Covariance, and Modified Covariance (parametric). The theories of used methods are introduced briefly in the below:

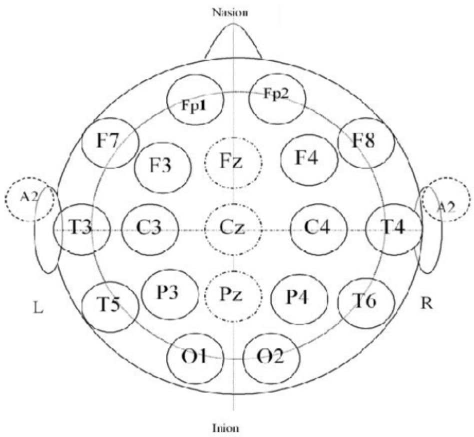


Figure 1.International 10-20 electrode system.

2.2. Preprocessing Methods

2.2.1. Non-Parametric Welch Method

Welch spectral prediction is a method based on fast Fourier transform. Welch spectral prediction is based on periodogram definition and explained as the following [10]:

$$P_{ref} = \left| \frac{1}{N} \sum_{n=1}^{N} x(n) \exp(-2\pi f n) \right|^2 \qquad (1)$$

In Welch method, the signal is divided into overlapping gaps and the periodograms are measured by windowing the signal in these divided gaps. Finally, these measured periodograms are averaged [9].

In conclusion, the prediction of power spectral density with Welch method is expressed as follows:

$$\hat{P}welch(f)" = \frac{1}{L} \sum_{t=0}^{L-1} \hat{S}\,xx(f) \qquad (2)$$

Here, L is the length of the time series. Examining the short data registries with conjoint and nonrectangular window reduces the predictive resolution. Welch method allows obtaining a better resolution than periodogram if the signal noise level is low [7, 8].

2.2.2. Parametric Spectral Analysis Methods

Auto Regressive (AR) method is a commonly used method. The most important advantage of AR model parameter provides stable statistical estimates with high frequency resolution. For this reason, in the analysis have been used Burg, Covariance and Modified Covariance methods. Estimated accuracy of parameters in AR signal models is a suggested matter and estimations are found by solving linear equations. The magnitude of the signal in the period given in the AR method is acquired by the total number of the magnitudes of previous samples and, in addition, it minimizes the errors. Model sequence is connected to AR factors. Selection of the degree of AR model is very important and is defined by different criteria. Though a number of methods are used to determine the degree of the model, Akaike Information Criteria-AIC is used most commonly. Selection of this model degree is done by minimizing the statement in the below.

$$AIC(p) = ln\sigma^2 + \frac{2p}{N} \qquad (3)$$

Here, σ^2 is the estimated variance of linear estimating error and N is the length of the data. With the increase in the AR model parameter, σ^2 diminishes and therefore, $1n\sigma^2$ diminishes as well. On the other hand, with the increase of the p value, comes the increase in the value of 2p/N. In this case, p must be valued as minimum. When selected degree is low, apparent hillocks doesn't form in the spectrum; that said, context of the frequency can't be determined precisely. But when the selected degree is too high, deceptive and inaccurate peaks occur and spectrum fails.

In this study, AIC is used and to reduce the value of 2p/N to minimum, p is accepted as 20. [4, 10, 11]

2.2.2.1. Burg Method

By using Burg Method, AR parameter estimation aims to minimize the estimating of reflection factors and the seesaw estimation of errors. Seesaw estimation of errors for model sequence of p is defined with equation 4.

$$\hat{e}_f, p(n) = x(n) + \sum_{n=1}^{p} \hat{a}_{p,i} x(n-1) \ldots\ldots n = p+1, \ldots\ldots\ldots N$$

$$\hat{e}_b, p(n) = x(n-p) + \sum_{n=1}^{p} \hat{a} *_{p,i} x(n-p+i) \ldots\ldots n = p+1, \ldots\ldots\ldots N \qquad (4)$$

Here, $\hat{e}_f, p(n)$ and $\hat{e}_b, p(n)$ are estimation of errors for p. sequence. AR parameters related to reflection factors are:

$$\hat{a}_{p,i} = \begin{cases} \hat{a}_{p-1,i} + \hat{k}_p \hat{a} *_{p-1,p-1}, & i = 1, \ldots\ldots, p-1 \\ \hat{k}_p, & i = p \end{cases} \qquad (5)$$

Based upon this statement, display made up by repeating the estimation of errors that are formed from the estimation of reflection coefficients is shown in equation 6.

$$\hat{e}_f, p(n) = \hat{e}_{f,p-1}(n) + \hat{k}_p \hat{e}_{b,p-1}(n-1)$$
$$\hat{e}_b, p(n) = \hat{e}_{b,p-1}(n-1) + \hat{k}_p * \hat{e}_{f,p-1}(n) \qquad (6)$$

These equations are used for furthering sequence algorithm for estimation of the AR factors. Power spectral density statement acquired by the estimation of AR parameters is defined by equation 7.

$$\hat{P}_{Burg}(f) = \frac{\hat{e}_p^2}{\left|1 + \sum_{i=1}^{p} \hat{a}_p(i) e^{-2\pi i f}\right|^2} \quad (7)$$

Here, $\hat{e}p = \hat{e}f, p + \hat{e}b, p$ defines the total error of Least Squares. [12, 13]

2.2.2.2. Covariance Method

The only difference between Yule-Walker method and Covariance method is the accumulation of estimation of errors in a sequence. In Covariance method, all datum points are necessary for calculating the estimation of error in power estimation. In the present case, solution of estimations of AR parameter as an equation is defined by this statement

$$\begin{bmatrix} C(1,0) \\ \dots\dots \\ C(P,0) \end{bmatrix} + \begin{bmatrix} C(1,1) & \dots & C(1,p) \\ \dots & \dots & \dots \\ C(p,1) & \dots & C(p,p) \end{bmatrix} \begin{bmatrix} \hat{a}(1) \\ \dots \\ \hat{a}(p) \end{bmatrix} = \begin{bmatrix} 0 \\ \dots \\ 0 \end{bmatrix} \quad (8)$$

Based upon this,

$$C(j,k) = \frac{1}{N-p} \sum_{n=p}^{N-1} x^*(n-j) x(n-k) \quad (9)$$

This statement is acquired and white noise variance is,

$$\sigma^2 = C(0,0) + \sum_{k=1}^{p} \hat{a}(k) C[0,k] \quad (10)$$

Based on this statement, power spectral density statement of AR parameter estimation is,

$$\hat{P}_{cov} = \frac{\sigma^2}{\left|1 + \sum_{k=1}^{p} \hat{a}(k). e^{-j2\pi f k}\right|^2} \quad (11)$$

2.2.2.3. Modified Covariance Method

Modified Covariance method used in estimating of autoregressive parameters of p sequence s (AR (p)) bases upon Least Squares method, which grounds on minimizing seesaw estimation of errors in linear estimations. When we take notice of seesaw linear estimations in order to obtain the estimation, depending on the sample number, hologram h(x) statement can be acquired with the figure in the below[14]:

$$\hat{h}(n) = -\sum_{k=1}^{p} a(k) h(n-k) \quad (12)$$

$$\hat{h}(n) = -\sum_{k=1}^{p} a^*(k) h(n+k) \quad (13)$$

Here, a(k) is the autoregressive(AR) filter parameter. In both scenarios, the only minimum power estimation error is the τ^2 white noise variance. Modified Covariance, by minimizing the average of the seesaw power estimations, estimates the AR parameters [15].

$$\hat{p} = \frac{1}{2}\left(\hat{p}^f + \hat{p}^b\right) \quad (14)$$

Here, N is the exemplification number:

$$\hat{p}^f = \frac{1}{N-p} \sum_{n=0}^{N-1} \left| h(n) + \sum_{k=1}^{p} a(k) h(n-k) \right|^2 \quad (15)$$

$$\hat{p}^b = \frac{1}{N-p} \sum_{n=0}^{N-1-p} \left| h(n) + \sum_{k=1}^{p} a^*(k) h(n+k) \right|^2 \quad (16)$$

It is achieved with this statement. From this statement, we obtain the statement in the below if we use Least Square solution for minimization.

$$\left[\begin{pmatrix} Chh(1,1) & \cdots & Chh(1,p) \\ \vdots & \ddots & \vdots \\ Chh(p,1) & \cdots & Chh(p,p) \end{pmatrix}\right] \begin{bmatrix} \hat{a}(1) \\ \dots \\ \hat{a}(p) \end{bmatrix} = -\begin{bmatrix} Chh(1,0) \\ \dots \\ Chh(p,0) \end{bmatrix} \quad (17)$$

Here,

$$Chh(i,j) = \frac{1}{2(N-p)} \left(\begin{array}{c} \sum_{n=p}^{N-1} h^*(n-i) h(n-j) + \\ \sum_{n=0}^{N-p-1} h(n+i) h^*(n+j) \end{array} \right) \quad (18)$$

Solution of the matrix gives us the values of a(k), in between k=1,2…..p. So, power spectral density can be acquired by using values of a(k), in between k=1,2…..p. Estimation of white noise variance is acquired with this statement:

$$\hat{\tau}^2 = Chh(0,0) + \sum_{k=1}^{p} \hat{a}(k) Chh(0,k) \quad (19)$$

Power spectral density is acquired with the mathematical statement in the below [16].

$$Phh(f) = \frac{\tau^2}{\left|1 + \sum_{k=1}^{p} \hat{a}(k). e^{-j2\pi f k}\right|^2} \quad (20)$$

3. RESULTS AND DISCUSSION

Because of the reason of EEG signals having a complicated structure and being long-term records, it is pretty hard to comment and evaluate these signs in a time-scale. For this reason, both the time info and frequency info of EEG signs, whose analysis is tough to do, are needed. The alteration of EEG signals in a time scale is shown in Figure 2.

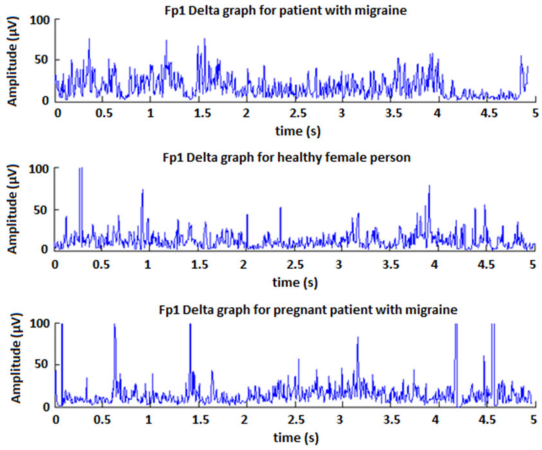


Figure 2.For FP1 Delta band obtained from the patients with migraine, pregnant women with migraine and healthy people, Time-Amplitude graphic (200 sample equals to 1 second in x axis. The total time is 5 seconds).

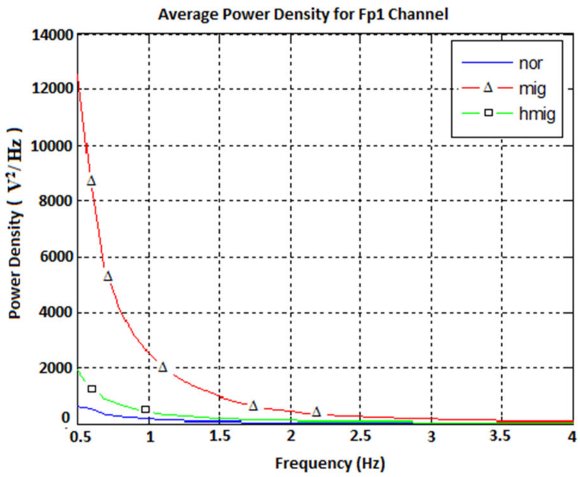
In this study, by separating into four fundamental frequency domains (Delta, Theta, Alpha, Beta) that are significant for EEG, power spectral densities of 19 channels of EEG signals acquired as monopolar in equal 10 minute periods with regards to international 10-20 electrode system belonging to migraine patients, migraine patients in pregnancy period and healthy women, whose ages change between 18-35 and who're from Training and Research Hospital Neurology Clinic of the Medical Faculty in Cumhuriyet University, are calculated. Calculations are made by using Matlab 7.0 (Mathworks NA) program. The analyses are realized by using non-parametric Welch method and all of the following parametric methods: Burg, Covariance and Modified Covariance. 3 experiment groups are compared statistically with power spectral densities obtained from the results of calculations for all used methods. Respectively, these comparisons are: (a) migraine patients- healthy people, (b) migraine patients who're pregnant- healthy people, (c) migraine patients who're pregnant- migraine patients.

Table 1. Calculation parameters used in the analysis.

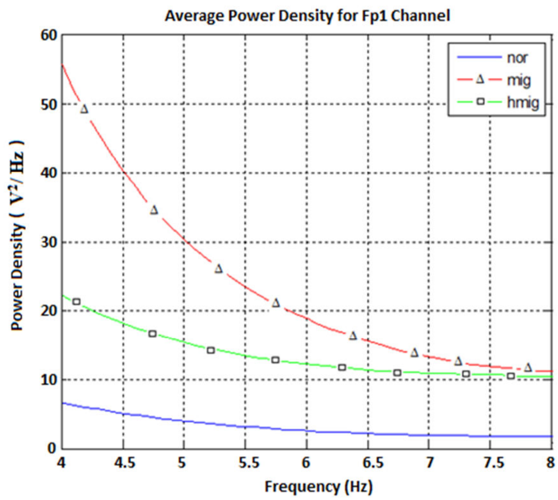
Method	Parameters
Welch	window size=64 nfft=2048 noverlap=empty[ ] sampling frequency=200 Hz
Burg	model order=20 sampling frequency =200Hz
Covariance	model order=20 Sampling frequency =200Hz
Modified Covariance	model order=20 sampling frequency =200Hz

In evaluating statistics, statistical t-test is used and p is accepted as $p<0.05$ for statistical significance. Power spectral density curves for four fundamental frequency bands, which belong to the three experiment groups, comprising of calculations that are acquired from Modified Covariance method and Welch method are shown in Figure 3 and Figure 4 respectively.

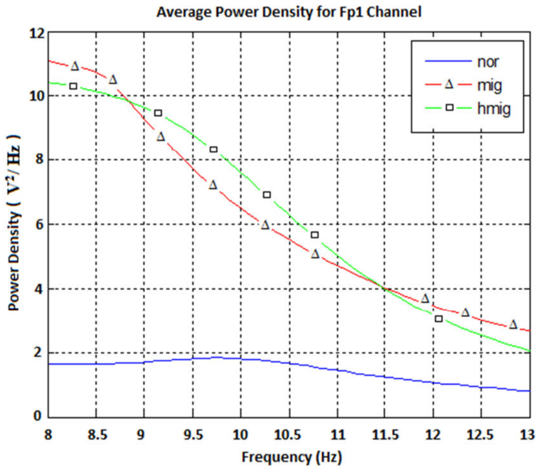
Power density of Welch's method is illustrated graphically for usednon-parametric Welch method which is more stable than other non-parametric methods.Power density of Modified Covariance Method are shown graphically because of Modified Covariance Method is more usuful than other parametric analysis methods (According to istatistical results in table 3).



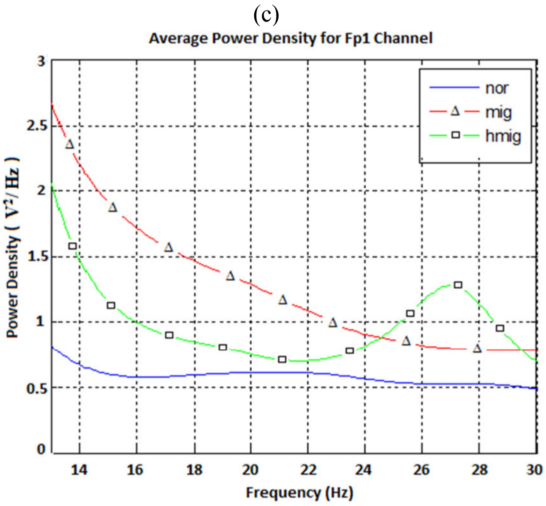
(a)



(b)

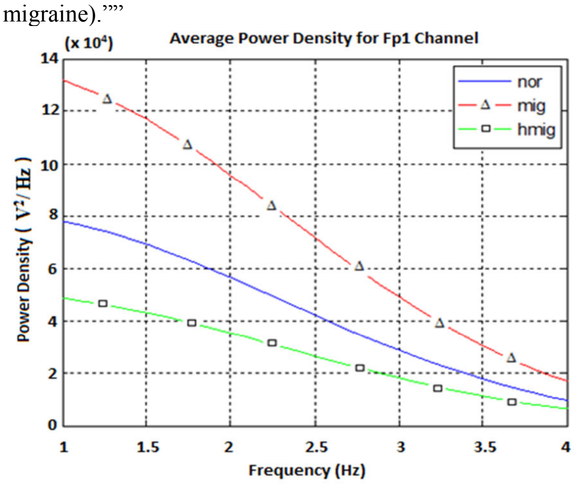


(c)



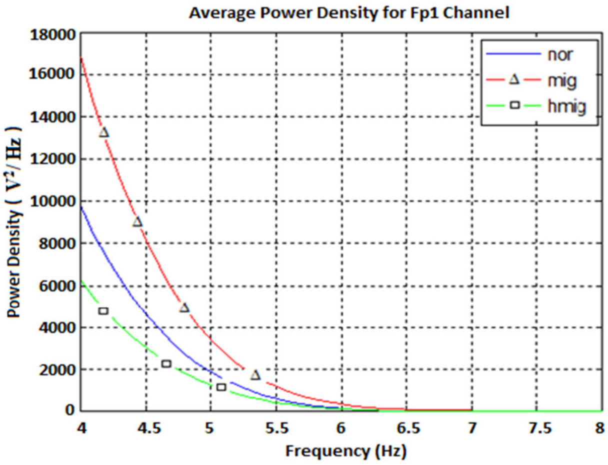
(d)

Figure 3.Power Spectral Density (PSD) graphics created with Modified Covariance method in (a) Delta, (b) Theta, (c) Alfa, and (d) Beta frequency range (nor: healthy, mig: with migraine and hmig: pregnant with migraine).””

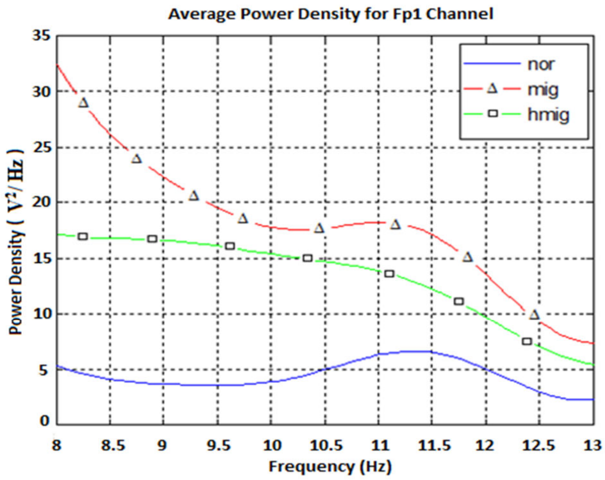


(a)

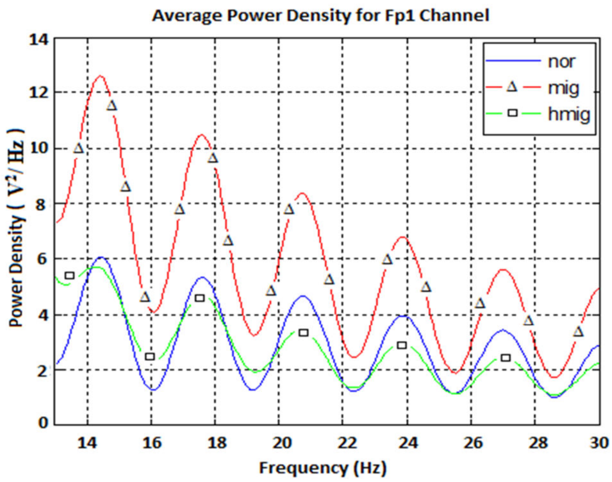
(a)



(b)



(c)



(d)

Figure 4.Power Spectral Density (PSD) graphics created with Welch method in (a) Delta, (b) Theta, (c) Alfa, and (d) Beta frequency range (nor: healthy, mig: with migraine and hmig: pregnant with migraine).

Statistical results belonging to three experiment groups (migraine patients- healthy people, migraine patients who're pregnant- healthy people, women migraine patients who're pregnant- migraine patients) are given in the Table 2 by using power spectral density curves obtained from Modified Covariance method.

Statistical values are compared with t-test by calculating power spectral densities with nonparametric Welch method that is used in analysis in a similar way with Burg and Covariance parametric methods and $p<0.05$ values, which belong to the four used methods, accepted as significant in statistical meaning are stated in only one table and that is table 3.

In this study, because the statistical significance can not established at the end of the calculations made by Yule-Walker, which is one of the parametric methods, analysis results with this method are not included. When results acquired from Table 3 are examined:

-In general, the results of Covariance and Modified Covariance methods appear to be very close to each other.

-Parametric methods gave much better efficient results in the first group (migraine patients- healthy people). On the other hand, non-parametric Welch method shows much more distinguishing features in the second Group (migraine patients who're pregnant - healthy people). According to the results, which are commonly accepted as significant in all used methods, alpha and beta waves of EEG signal of the first Group (between migraine patients and healthy people) carry distinctive features.

Table 2.The statistical values acquired by using Modified Covariance method in evaluating the 4 frequency bands (delta, theta, alpha and beta) of EEG signals for three groups (Patients with migraine -Healthy subjects - Pregnant women with migraine) ($p<0.05$ values are shown in bold).

EEG	Patients with migraine -Healthy subjects				Pregnant women with migraine- Healthy subjects				Pregnant women with migraine- Patients with migraine			
Channel	Delta	Teta	Alfa	Beta	Delta	Teta	Alfa	Beta	Delta	Teta	Alfa	Beta
Fp1	**0.0136**	**0.0114**	**0.0019**	**0.0240**	**0.0013**	**0.0068**	**0.0390**	0.2017	0.2436	0.5367	0.9697	0.6149
Fp2	**0.0145**	**0.0068**	**0.0011**	0.2133	0.6963	0.3036	0.5289	0.6439	0.2076	0.2028	0.1071	0.0672
F3	**0.0122**	**0.0003**	**0.0195**	0.8960	**0.0295**	**0.0025**	0.7581	0.7017	0.6168	0.3641	0.1156	0.2961
F4	0.6434	**0.0015**	**0.0186**	0.6668	0.0504	**0.0475**	0.9671	0.7660	0.4382	0.3607	0.1429	0.2022
C3	0.0882	**0.0003**	**0.0039**	**0.0245**	0.3403	0.2374	0.4203	0.4952	0.8399	0.0813	0.0518	0.0519
C4	0.0572	**0.0003**	**0.0040**	**0.0257**	0.3381	0.2511	0.4143	0.4846	0.7546	0.0805	0.0527	0.0518
P3	0.7630	**0.0091**	0.0687	**0.0147**	0.9903	0.6391	0.7098	0.9024	0.7623	0.1782	0.0690	0.0836
P4	0.1326	**0.0010**	**0.0029**	**0.0099**	0.1516	0.0607	0.9836	0.8858	0.6921	0.2275	0.0683	0.1344
O1	**0.0215**	**0.0064**	0.8174	0.1610	**0.0399**	0.1302	0.9009	0.8201	0.5152	0.2276	0.7936	0.4768
O2	**0.0219**	**0.0049**	0.4774	0.4579	0.0563	0.1432	0.9139	0.9403	0.4201	0.2650	0.5828	0.5523
F7	**0.0311**	**0.0012**	**0.0125**	0.5972	0.0777	0.1481	0.9960	0.7932	0.4635	0.1809	0.1250	0.3982
F8	**0.0006**	**0.0009**	**0.0194**	0.0887	0.0934	0.5414	0.9801	0.7731	0.9117	0.0694	0.1451	0.1623
T3	0.0760	**0.0008**	**0.0016**	0.0760	0.1964	0.1342	0.4571	0.7390	0.8563	0.1455	0.1351	0.1148
T4	**0.0392**	**0.0003**	**0.0093**	**0.0030**	**0.0208**	0.0913	0.7183	0.6255	0.2905	0.1466	0.1463	0.0573
T5	0.0970	**0.0069**	0.7949	0.1689	0.0861	0.1465	0.8149	0.8484	0.4431	0.3125	0.9434	0.3907
T6	**0.0064**	**0.0009**	0.4757	0.0666	0.0929	0.2914	0.9016	0.8256	0.7635	0.1232	0.6949	0.0991
Fz	**0.0369**	**0.0005**	**0.0183**	**0.0329**	**0.0341**	**0.0116**	0.8961	0.7573	0.7996	0.2971	0.1503	0.1762
Cz	0.6918	0.8259	**0.0108**	**0.0441**	0.5380	0.4887	0.3607	0.3216	0.4152	0.1280	0.0692	**0.0292**
Tz	0.1125	**0.0017**	**0.0222**	**0.0052**	0.4033	0.2162	0.7643	0.8384	0.7252	0.1502	0.1955	0.1174

Table 3.Whole assessment table of the statistical comparison results of analysis methods (Burg, Covariance, Modified Covariance, and Welch) used in evaluating the 4 frequency bands (delta, theta, alpha and beta) of EEG signals for three groups (Patients with migraine -Healthy subjects - Pregnant women with migraine) ($p<0.05$ values are shown in the table).

EEG	Patients with migraine -Healthy subjects				Pregnant women with migraine-Healthy subjects				Pregnant women with migraine-Patients with migraine			
Channel	Delta	Teta	Alfa	Beta	Delta	Teta	Alfa	Beta	Delta	Teta	Alfa	Beta
Fp1	CM	BCM	**BCM***	M	BCM	BCM	CM*	*				
Fp2	M	CM	**BCM***	*			*	*				
F3	CM	BCM	M*	B	CM	CM						
F4		BCM	**BCM***		CM	CM						
C3	B	BCM	M*	**BCM***							**BCM***	**BCM***
C4	B	BCM	CM*	**BCM***							**BCM***	**BCM***
P3	B	CM	B*	**BCM***	*	*						
P4		BCM	**BCM***	**BCM***								
O1	M	CM			M*	*		*				
O2	CM	CM			CM*							
F7	CM	BCM	CM*									
F8	CM	BCM	**BCM***									
T3	C	BCM	**BCM***	*								
T4	CM	BCM	CM*	**BCM***	CM*	*		*				
T5	BC	CM										
T6	CM	BCM		*								
Fz	CM	BCM	CM*	M	BCM	BCM						
Cz			**BCM***	**BCM***								**BCM***
Tz		BCM	**BCM***	**BCM***								

B: Burg, C: Covariance, M: Modified Covariance (Parametric Methods),*: Welch Method (Non-Parametric Methods)

(a) When took notice of the beta frequency domain of the first group, a significant difference is acquired from all lobes (7 channels comprising of, consecutively, C3, C4, P3, P4, T4, Cz, and Tz) expect from the frontal lobe. This result means that frontal lobe with migraine doesn't get affected from this situation for beta wave and it doesn't change; and it means that central and parietal lobes show high levels of distinguishing features and temporal lobe shows distinguishing features in fractional level.

(b) When took notice of the alpha frequency domain of the first group, It is seen that frontal lobe has more distinctive features. For alpha frequency, a significant difference is acquired in 8 channels comprising of Fp1, Fp2, F4, P4, F8, T3, Cz and Pz. This result means that parietal, central and temporal lobes, from which frontal lobe is most affected

When alpha wave is affected with migraine; carry distinctive features in fractional level.

According to results, which commonly seem as significant, of all performed methods; in no frequency domain of EEG signal of second group (migraine patients who're pregnanthealthy people), a significant difference is obtained. From this point, it can be established that migraine patients who are pregnant can show the same behavior resembling those of healthy people. That is, pregnancy period can be said to create a positive effect on migraine patients.

- In the third group (migraine patients who're pregnant- migraine patients) comparison results, even though all methods gave little result, they all point out the same thing. And that shows that signals, which are in central channels (C3, C4 and Cz) in between migraine patients in pregnancy period and migraine patients, carry a distinctive feature in between two groups.

4. CONCLUSION

In this paper, 19 channels of EEG signals, as 10 minute periods, in between migraine patients, migraine pregnant patients and healthy people and four frequency domains (delta, theta, alpha and beta) are calculated in terms of power spectral density and they are compared statistically in between each other. These comparisons are, respectively: (a) migraine patients- healthy people, (b) migraine patients who're pregnant- healthy people, (c) migraine patients who're pregnant- migraine patients.

Here, before doing a statistical comparison; power distribution is reviewed by both parametric and non-parametric methods. The obtained data is calculated from these four following methods, in an order: Burg, Covariance, Modified Covariance (parametric methods) and Welch (non-parametric method). The statistical values of the results are evaluated by t-test. $p<0.05$ is accepted for statistical significance. When looked at the values that show common significance in all used methods, most important results can be summarized as this:

- Alpha and Beta waves of EEG signal carry distinctive feature between migraine patients and healthy people.
- Because no significance distinctness is shown in any frequency domain of EEG signal between migraine patients in pregnancy and healthy people, it can be seen that pregnant migraine patients carry a similar type of characteristics of EEG signal to those of healthy people. This result can be said to create a positive effect on pregnant migraine patients.
- In the analyses made between pregnant migraine patients and migraine patients, all of the used methods showed significance in the same channels and it is established that signals in central channels (C3, C4 and Cz) carry a distinctive feature in between two groups.

In the future, as this study may very well be able to reach more significant statistics by increasing subject number, also an automatic diagnostic system for detecting migraine by using wavelet transform and fuzzy logic algorithms can be developed and besides, by evaluating the effects of pregnancy hormones that reduce the efficiency of migraine, development of methods like hormone therapy can be contributed to.

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