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Title: The effect of a prostration (Sajdeh) on the prefrontal brain activity, a pilot study

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Abstract

Background: **Sajdeh is a prostration position** that being part of Muslim daily prayers, has several effects on the brain and heart activity. The aim of this study was to investigate the prefrontal brain activity after ten seconds of Sajdeh in the direction of Qiblah while putting the forehead on the ground.

Methods: Three women and two men participated in this pilot study. Linear (absolute and relative power of Theta (4-8Hz), Alpha1 (8-10 Hz), Alpha2 (10-12 Hz), Beta1 (12-16 Hz), Beta2 (16-20 Hz), Beta3 (20-30 Hz), Gamma1 (30-40 Hz), Gamma2 (40-50 Hz) and non-linear features (approximate entropy, Katz fractal dimension, petrosian fractal dimension, spectral entropy and Sample entropy) from Fps channel were calculated.

Results: relative beta to Gamma band, approximate and Sample entropy, petrosian fractal dimension and mean of amplitude decreased in open eye state in women. While theta to Gamma bands in the closed eye state, decreased after the Sajdeh in women. The absolute Gamma bands in closed eye state and relative beta band in open eye state increase after Sajdeh in men.

Conclusion: the pilot study showed that 10 seconds of Sajdeh has effects on brain activity and sometimes showed opposite effect on genders.

Keywords: Sajdeh, EEG, non-linear analysis, brain activity, gender

Introduction

Namaz, being the most important daily duty of Muslims, has several parts and positions. During Sajdeh the subject is in prostrating position in the direction of Qiblah and some groups of muslim community put their forehead on Mohr, which is made of dried clay. Rare studies showed the effect of Namaz on bio-signals like EEG and ECG. Doufesh et al. showed significant decrease of heart rate and sympathetic activity during Namaz and especially during Sajdeh in comparison with before and after namaz time, especially in actual form^{1, 2}. They also presented the increase of relative alpha activity regardless of recitation in comparison with the rest position^{2, 3}. It is possible that the increase of alpha activity and absence of the alpha blocking in open eye is due to the higher state of calmness and focus as the head touches the ground. Amplitude of Gamma band increased after Namaz and this effect was significantly higher after listening to music⁴. The Gamma power during actual Namaz was statistically higher than during mimic Namaz in the frontal and parietal regions in all stages especially in the left hemisphere. Increased Gamma power during Namaz, is possibly related to an increase in cognitive and attentional processing⁵.

Usually Namaz is compared with meditation. Many studies showed than some meditations had beneficial effects on the brain^{6, 7}. During the meditation, the increase of alpha band frequency primarily in the frontal region was demonstrated⁶. On the other hand, some studies reported adverse effects during and after meditation⁸. It must be noted that meditation techniques are often done in static posture such as sitting or lying supine, while Namaz involves active physical movements.

EEG frequencies have been linked to specific functions of brain as an “electrophysiological signature”. Gamma oscillations have been related to sensory processing, attention, action selection, conscious awareness and memory and integrative function⁹. Delta oscillations has been correlated to motivation, reward processing, memory encoding and retrieval and learning. The activity of theta-band associated with emotional arousal, fear conditioning and recognition memory¹⁰. The alpha-band has been associated with working memory functions and short-term memory. Beta oscillations might be associated to control of cognition^{11, 12}.

Studies using local field potentials, scalp or cortical EEG recordings systematically revealed positive correlations between the power of the Gamma power band (>30 Hz) and the BOLD fluctuations at the same location. They reported same correlation during cognitive, sensory and motor function at brain regions expected to be activated. The negative correlations between the power of the low-frequency ranges (alpha, beta and theta) and BOLD signals of those regions¹³.

The limited studies about Namaz showed that the brain activity changed during the Sajdeh more than other position. Then the aim of the pilot study is whether only 10 seconds Sajdeh as a part of namaz in the Qiblah direction was done, it could induce any remained changes in the prefrontal activity that contact with ground or not. On the other hand the biological signals also had complex and chaotic pattern¹⁴ and the non-linear analysis of biological signals were high reliable than linear ones ¹⁵. Then the brain activity was evaluated by non-linear analysis

in addition to frequency and amplitude analysis. We hypothesize that a Sajdeh could change brain activity but it was not significant in the pilot study.

Methods

Subjects

2 men (aged between 40 to 55) and 3 women (aged between 25 to 50) participated in the pilot study. They were clearly informed about the procedure of the study and signing approval forms given by the Baqiyatallah University of Medical Sciences. All of the participants had the following characteristics: 1) No history of psychological disorder based on DSM-5 guideline 2) No surgery or trauma in the cranium and spine regions; 3) No history of taking regular neuropsychological medication and 4) they are always saying their prayers (Namaz) regularly on time. They are right hand dominant expect one of the male subjects.

Data acquisition

EEG signals were obtained from BioMed EEG system 32 channels (made in Iran). Fp1 and Fp2 electrodes are based on the international 10/20 system attached to scalp. The reference electrode was put in the Cz position and ground electrode was attached to the right hand. The skin was cleaned with alcohol before electrode placing to reduce the skin impedance to 20 kilo Ohm or less. 40 seconds of EEG were recorded with eye open and eye closed in the rest sitting position before and after 10 second of a Sajdeh in the Qiblah direction. Test was done at 6 to 8 AM.

Data processing

EEG data were analyzed offline using MATLAB version R2014b. The data was filtered from 0.2-48 Hz to remove any unwanted artefacts including EOG and EMG. After artefact removal, data were transformed to the average reference. Twenty two linear features were extracted from signals in both states before and after the Sajdeh. The linear features were the absolute and relative power of frequency bands consist of Theta (4-8Hz), Alpha1 (8-10 Hz), Alpha2 (10-12 Hz), Beta1 (12-16 Hz), Beta2 (16-20 Hz), Beta3 (20-30 Hz), Gamma1 (30-40 Hz), Gamma2 (40-50 Hz) and mean and variance of signal amplitude. The relative features were calculated using the various band powers divided by total power of the signal. The non-linear features were approximate entropy, Katz fractal dimension, petrosian fractal dimension and Sample entropy and spectral entropy. **The Fp channels were preferred to study because the frontal region is contacted with ground during a Sajdeh.**

Statistics analysis

The Non-parametric Mann-Whitney test was used to compare the EEG features before and after the Sajdeh in separate groups in two different. As a result of the small sample and similar behavior in Fp1 and Fp2, they were considered together **and mean of them reported.**

Results

The linear features of EEG

The linear EEG feature based on Mann-Whitney test before and after a Sajdeh in open and closed eye state were shown in table 1. The absolute power of band frequency did not show significant difference except significant increase of the Gama1 and 2 after sajdeh in the state of closed eyes in men (figure 1). Relative power showed a significant decrease in both states in women. The relative power from Beta 2 to Gama2 band frequency in the opened eye and from Theta to Gama 1 band frequency in the closed eye state decreased after Sajdeh in women. In contrast women?, The relative power band frequency tended to increase after the Sajdeh in men in the closed eye state that was significant only in the Beta 1 band (figure 2).

Table 1: the P-value of Mann-Whitney test of EEG features between before and after Sajdeh in men and women, in the open and closed eye state.

features	Men(N=2)		Women(N=3)	
	Opened eyes	Closed eyes	Opened eyes	Closed eyes
Absolute Theta	0.68	0.2	0.093	0.39
Absolute Alpha 1	0.68	0.68	0.065	0.24
Absolute Alpha 2	0.68	0.88	0.065	0.24
Absolute Beta 1	0.68	0.68	0.065	0.24
Absolute Beta 2	0.68	0.68	0.13	0.18
Absolute Beta 3	0.88	0.34	0.13	0.24
Absolute Gamma1	0.34	0.029	0.13	0.13
Absolute Gamma 2	0.14	0.029	0.13	0.31
Relative Theta	0.68	0.68	0.58	0.004
Relative Alpha 1	0.2	0.34	0.58	0.041
Relative Alpha 2	0.11	0.11	0.065	0.041
Relative Beta 1	0.02	0.057	0.093	0.041
Relative Beta 2	0.11	0.057	0.004	0.041
Relative Beta 3	0.34	0.057	0.004	0.041
Relative Gamma1	0.34	0.057	0.004	0.041

Relative Gamma 2	0.48	0.057	0.004	0.13
Mean of amplitude	0.057	0.2	0.026	0.81
Variation of amplitude	0.34	0.34	0.065	0.58
Approximate entropy	0.68	0.48	0.002	0.041
Katz fractal dimension,	0.2	0.68	0.093	0.48
Petrosian fractal dimension	0.48	0.48	0.041	0.065
Sample entropy	0.88	0.48	0.002	0.093

The significant data were showed as bold text

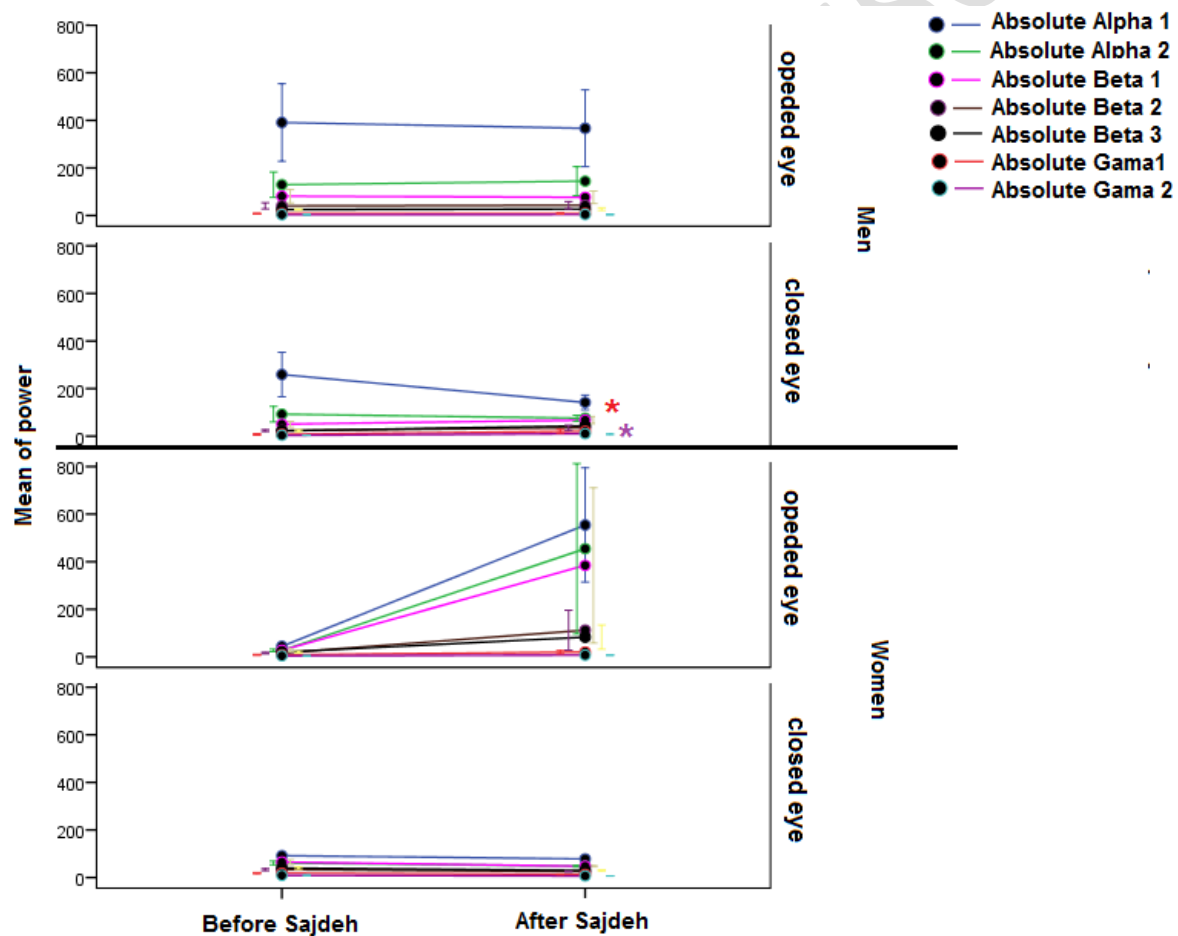


Figure 1: the plot shows the mean of absolute power of EEG with one standard error of alpha 1 to gama2 in both men (N=2) and women (N=3) and in the opened and closed eye recording. The gama1 and 2 band were significantly increase in men in the closed eye state. Significant change

(p -value < 0.05) was detected as star sign with same color of that power band. Theta band was deleted because of the high power and standard error

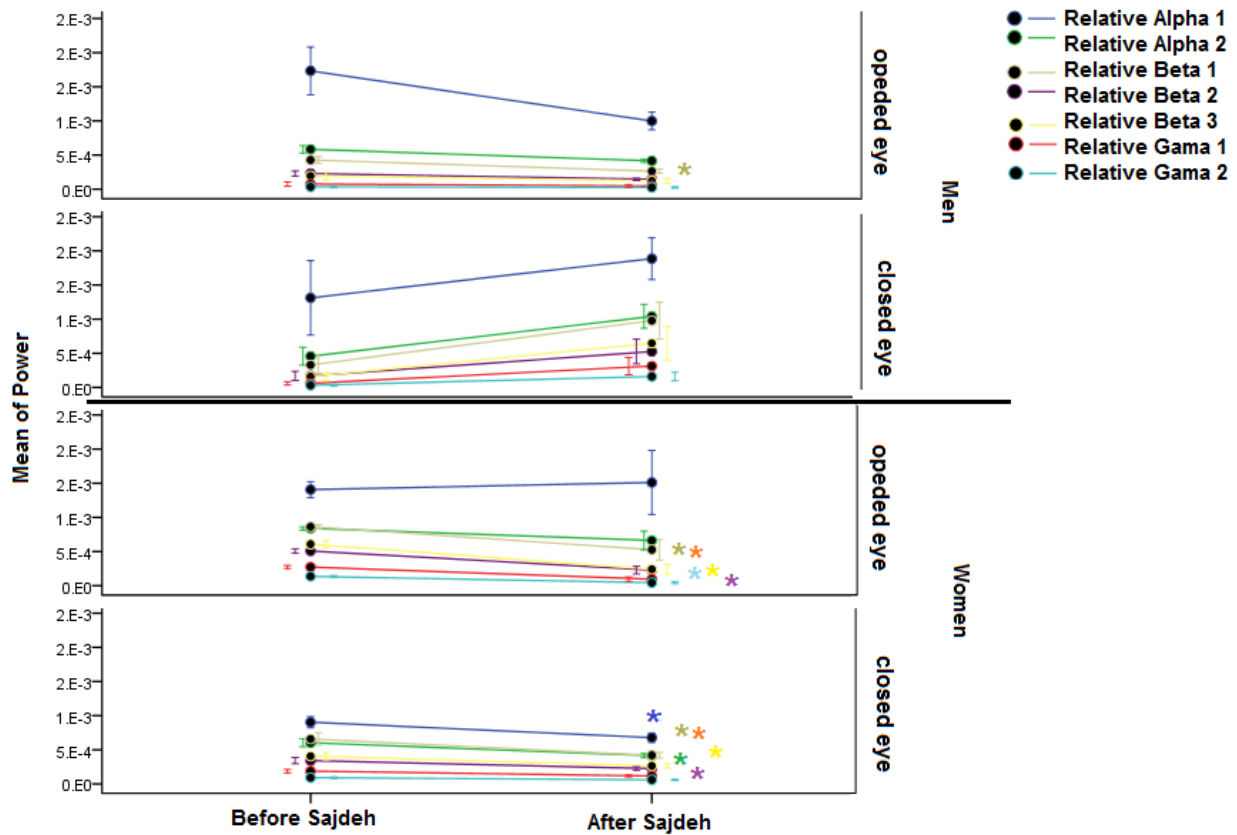


Figure 2: the plot shows the mean of relative power of EEG with one standard error of alpha 1 to gama2 in both men ($N=2$) and women ($N=3$) and in the opened and closed eye recording. The significant decrease was seen in the almost band in the Beta 2 to Gama2 band frequency in the opened eye recording and in the Theta to Gama 1 band frequency in the closed eye recording in the women. Theta band was deleted because of the high standard error. Significant change was detected as star sign with the same color of that power band.

The mean of EEG Amplitude changed after the Sajdeh in women in the open eye recordings. But the variation of EEG amplitude did not show significant difference although there was an increasing trend in the women, especially in the open eye recording (table 2, figure 3).

Table 3: the mean (standard error) of the mean of EEG amplitude in the open and closed eye recording in men and women, before and after the Sajdeh

	Opened eye				Closed eye			
	Men (N=2)		Women(N=3)		Men (N=2)		Women(N=3)	
	Before	After	Before	After	Before	After	Before	After
Mean of amplitude	-4.2	-0.45	0.73	-0.84	1.7	-1.5	-1.7	-0.22
	(0.3)	(1.4)	(0.2)	(0.4)*	(1)	(2)	(2.4)	(0.9)

*: significant different showed the effect of a Sajdeh on it in women in the open eye recording (P-value< 0.003)

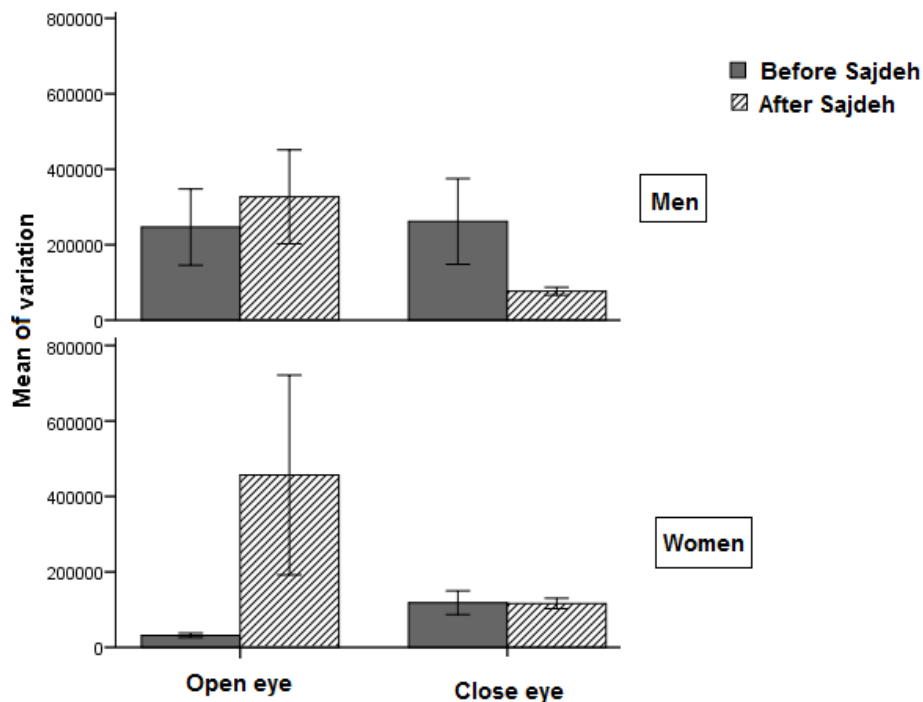


Figure 3: The plot showed the mean (standard error) of variation of EEG amplitude in the open and closed eye recording in men (N=2) and women (N=3), before and after the Sajdeh. No significant difference was seen.

The non-linear features of EEG

The fractal non-linear features of EEG such as katz fractal dimension and petrosian fractal dimension showed that the Sajdeh decreased significantly the fractal dimension of EEG signals in prefrontal region in women in open eye state. Approximate entropy and Sample entropy decreased significantly in the open eye state in women.

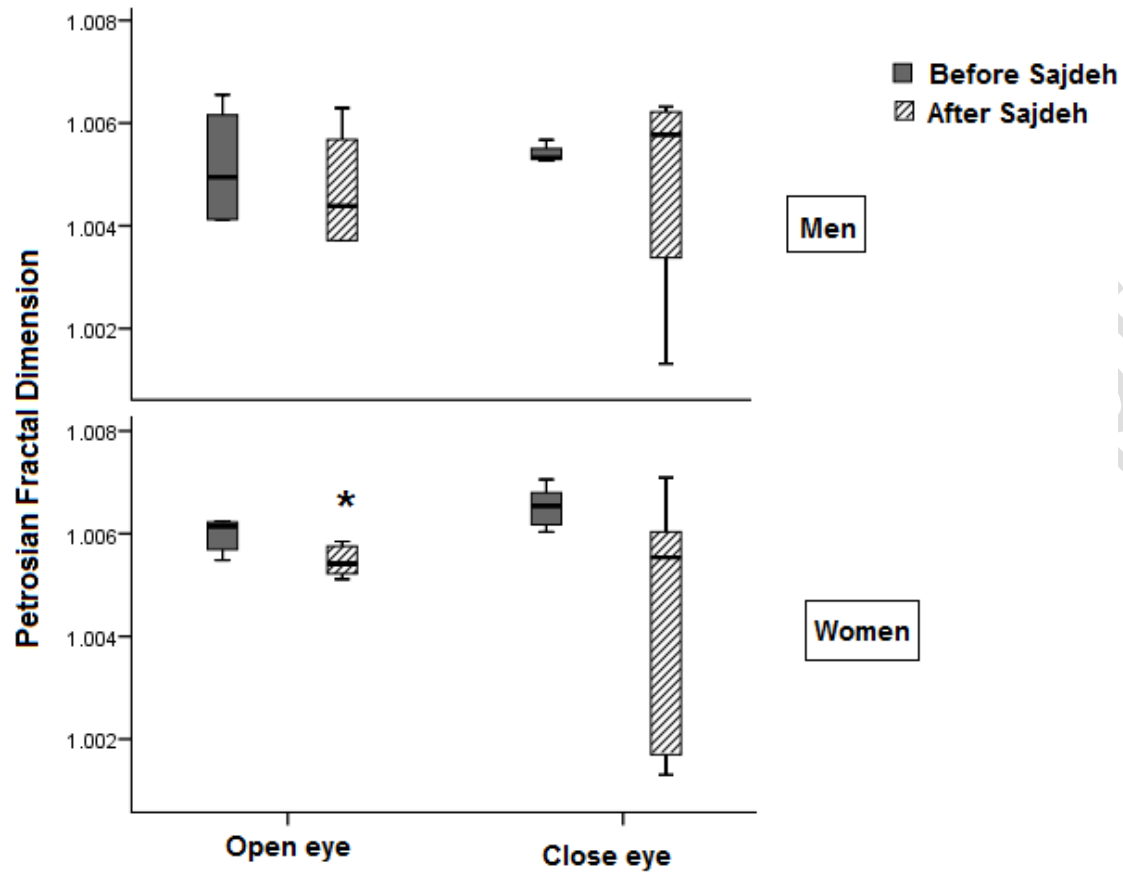


Figure 4: The plot showed the petrosian fractal dimension was affected by Sajdeh especially in women (N=3) and in the eye open recording (*: p-value< 0.05).

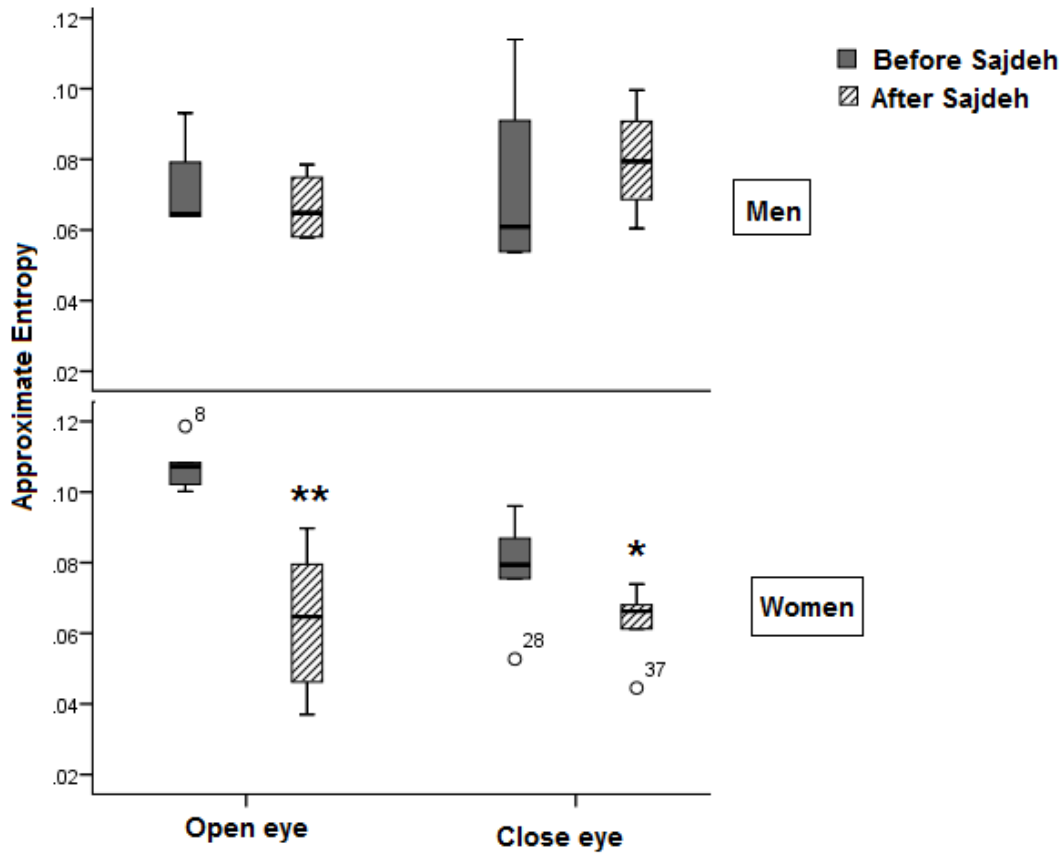


Figure 5: the plot showed that approximate entropy was decreased after Sajdeh in the women (N=3). (*: P-value<0.05, **: p-value <0.003)

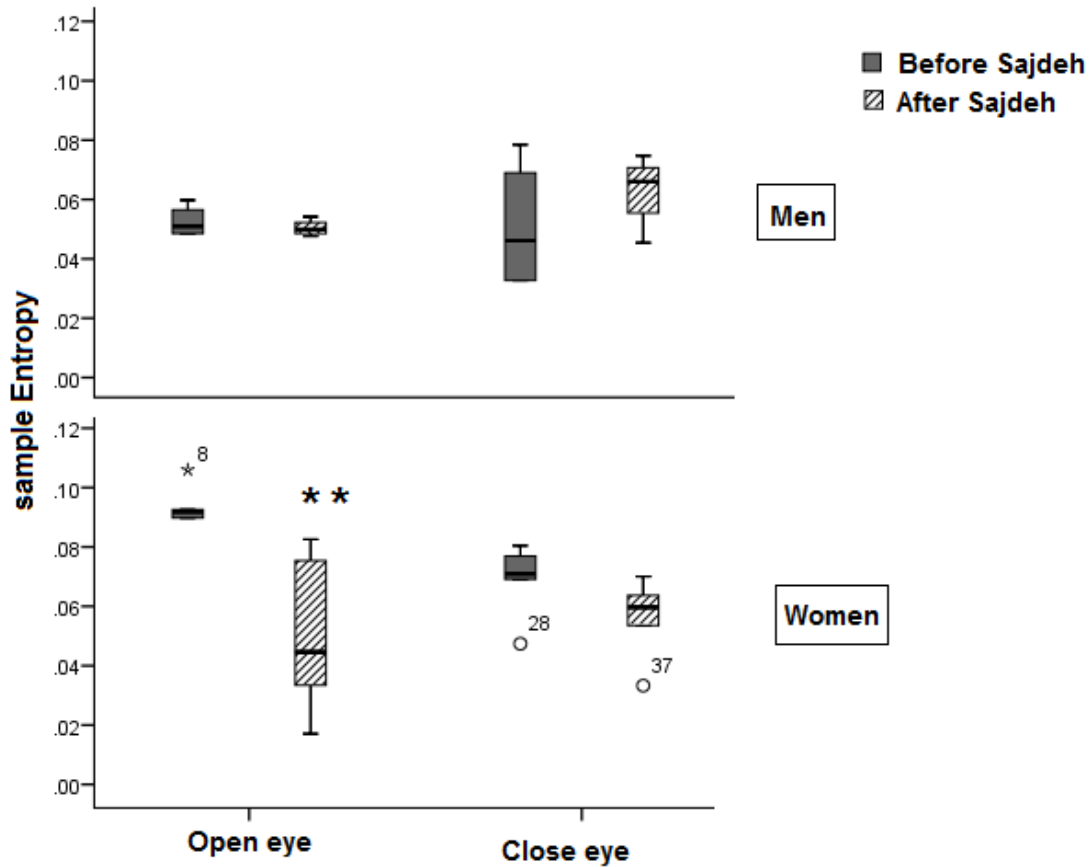


Figure 6: the plot showed that sample entropy was decreased after Sajdeh in women significantly in the open eye recording. (**: p-value<0.003).

The Mann-Whitney test was also used to compare the EEG features between men and women before and after Sajdeh. The results showed that gender differences in the EEG features were diminished after Sajdeh in the open eye state and in the non-linear features in the both state of eyes. It means the trend of changes in two genders were in contrast after the Sajdeh that were significantly evident in the open eye recording (table 4).

Table 4: the P-value of mann-whitney test between men and women before and after the Sajdeh in the open and closed eye

features	Opened eyes		Closed eyes	
	Before Sajdeh	After Sajdeh	Before Sajdeh	After Sajdeh
Absolute Theta	0.11	0.76	0.14	0.038
Absolute Alpha 1	0.067	0.91	0.25	0.17

Absolute Alpha 2	0.067	1	0.76	0.17
Absolute Beta 1	0.11	1	0.35	0.17
Absolute Beta 2	0.11	1	0.11	0.25
Absolute Beta 3	0.47	0.27	0.11	0.47
Absolute Gamma1	0.47	0.27	0.01	0.61
Absolute Gamma 2	0.47	0.35	0.01	1
Relative Theta	0.76	0.91	0.01	0.01
Relative Alpha 1	0.47	0.76	0.91	0.01
Relative Alpha 2	0.01	0.11	0.25	0.01
Relative Beta 1	0.01	0.61	0.11	0.01
Relative Beta 2	0.01	0.61	0.11	0.038
Relative Beta 3	0.01	0.25	0.03	0.038
Relative Gamma1	0.01	0.35	0.03	0.17
Relative Gamma 2	0.01	0.61	0.03	0.25
Mean of amplitude	0.01	0.91	0.35	0.61
Variation of amplitude	0.01	0.91	.76	0.067
Approximate entropy	0.01	1	0.61	0.17
Katz fractal dimension,	0.01	0.47	0.11	0.11
Petrosian fractal dimension	0.47	0.25	0.01	0.76
Sample entropy	0.01	0.76	0.25	0.35

Discussion

The aim of this pilot study was to measure the linear and non-linear features of brain activity in the prefrontal region before and after one Sajdeh, as a part of Namaz. In spite of small sample size, some clearly significant effects of the Sajdeh were seen especially in women at the open eye recording. The results showed the decrease of the relative power of bands, especially beta and

Gamma oscillations in both open and closed eye recording and decrease of entropy and Petrosian fractal dimension as a non-linear feature of EEG in the open eye state after the Sajdeh in women.

Increase of the Gama power during and after Namaz had been demonstrated before. But the participants were men^{4, 5}. Our study evaluated the women too and showed the opposite effect of one Sajdeh to relative Gamma band in women but not in men. **On the other hand the brain activity after a Sajdeh did not covered the effect of Namaz and they could be different and not comparable.** Therefore the current results confirmed the previous results in men in the absolute power of Gamma band. The non-linear features showed that the entropy and fractal dimension of EEG signals as indices of signal complexity^{16, 17} were decreased in women. Ten seconds of Sajdeh like any other cognitive tasks^{18, 19} or exposure to electromagnetic field²⁰ has inverse effect in brain activity of men and women which could be the result of gender structural differences^{16, 18, 19, 21}. The effects of sex steroids in the human brain may play some role mediating these differences. The sex steroids interact with neurotransmitters and other hormones such as oxytocin-vasopressin System in the brain that regulates the brain function²². Several studies showed that some cognitive abilities were higher in women and some of them were advanced in men^{21, 23, 24}. The interesting finding shown in table 4 indicated that the significant baseline different of linear and non-linear features of EEG between genders decreased or changed after the Sajdeh.

The increase of Gamma power that was seen after the Sajdeh has been related to increased activity of the frontal node of the default mode network (DMN), the medial prefrontal cortex²⁵ and the cognitive activity⁹. The increase of alpha oscillation that related to working memory¹² and theta oscillation that related to emotional processing¹⁰. The event-related potentials studies concluded that meditation can increase attention and enhance emotional control that matched with increase of theta and alpha oscillations in meditation²⁶. The results of studies in meditation or Namaz were reported in the men or mixed gender group^{2, 3, 5, 6, 26} and there was no study that measured the effect of meditation or Namaz in the brain activity with interaction gender. **Whenever the Sajdeh that was studied as a part of real namaz and our findings confirmed some changes after Namaz but it could not to be referred to effect of the completed Namaz.**

Some researchers believe that Namaz is a type of meditation. But there are significant difference between them in term of the action and effects. The Namaz has a physical movement with specific and fixed mentions and pattern but meditation often involves static position without mention in the several patterns. The meditation Researches with expanding the methodological paradigm of cultural setting as the place of meditator, the particular practice and the state of consciousness of mediators showed several state and trait effects on brain activity especially increased of the power of low frequency such as theta and alpha band and decrease of Gamma oscillations over the frontal and midline regions^{6, 25, 27, 28}. Whereas Namaz increased both the power of alpha and Gamma bands^{2, 3, 5}. **Therefore the comparison of them are always not appropriate.**

There is no study to measure non-linear features of EEG in the whole of Namaz or meditation or a part of them. Whereas our results showed the Sajdeh had significant effect on the complexity of EEG signal. The decrease of sample and approximate entropy and petrosian fractal dimension were seen after the Sajdeh in the women especially in the open eyes state. The signal complexity of EEG is correlated to high frequency oscillations specially Gamma band.^{13, 17, 29} But on the other hand the decrease of complexity was shown in inhibition control as an adaptive ability of brain³⁰. Less neural complexity not always indicate the declines of information processing and cognitive function³¹. The decrease of Gamma power and signal complexity in women might be the result of shifting of the cognitive processing from sensory and motor processing to inhibition control dominance and decreased activity of the frontal node of DMN. The limitations of the study were the small sample size, limited recorded electrodes and did not recording during Sajdeh or in the real Namaz and assessment whole of Namaz.

Conclusion

The pilot study showed that 10 seconds of Sajdeh in the direction of Qiblah while putting the forehead on Mohr significantly influenced the brain activity on the prefrontal region. Sajdeh had opposite effects on different genders . Women showed that the power bands especially Gamma and beta oscillation and the complexity of signal were decreased, especially in open eye recording. Whereas the effect of Sajdeh showed increase the absolute power of Beta or Gamma frequency band of EEG in men. The genders indicated significant baseline difference in the linear and non-linear features of brain activity in the prefrontal region after Sajdeh. The findings of the pilot study need to be improved by the study with enough sample size and real Namaz. The Sajdeh is only one part of Namaz which showed significant improvement on brain activity. The Muslim are supposed to do it five times a day. Thus the effect of Namaz to maintain and improve brain activity and mental health is critical and needs to be studied more in future.

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