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Research Article

Correlation between Cognition and Quantitative EEG Changes in Patients with Migraine

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Abstract:

Background: Migraine is a common debilitating disorder characterized by attacks of mostly unilateral, moderate to severe, throbbing headaches. The diagnosis of migraine is made according to the third edition of the International Classification of Headache Disorders developed by the International Headache Society. There are several types of migraine, the most common of which are migraine without aura and migraine with aura.

Objectives: This study aims to find the correlations between quantitative EEG changes and cognition in migraine patients.

Methods: The study included 20 migraine patients,10 during pain attack (ictal phase) and 10 during pain-free period (inter-ictal), in addition to 18 healthy controls. Montreal cognitive assessment and 20 minutes' scalp EEG were done. After that, four seconds epochs were taken from the EEG record to find the power spectral density (PSD) for each of the waves in the range of [delta δ(0.5-4)Hz, theta θ(4-8)Hz, alpha α (8-12)Hz, and beta β (12-30)Hz]. The study was conducted in Al-Shaheed Ghazi Al-Hariri Hospital in Baghdad from October 1, 2022, to May 1, 2023.

Results: Quantitative EEG analysis revealed that there is a significant decrease in theta and beta waves in descending pattern from control to inter-ictal and then to ictal migraine patients while alpha wave increased in ascending pattern from control to inter-ictal to ictal migraine patients. In cognition, there was a significant difference between controls and migraine patients in recall memory, language, and abstraction domains.

Conclusions: Quantitative EEG findings suggest that alpha waves correlate negatively with cognition, while both theta and beta waves correlate positively with cognitive level.

Keywords: Cognition; Electroencephalography; Migraine; Montreal cognitive assessment. Power spectral density;

Introduction:

Migraine is a common debilitating illness of the brain that results in attacks of moderate to severe headaches, that are mostly unilateral, throbbing in nature, and has particular symptoms including nausea and light and sound sensitivity. It is also characterized by a global dysfunction in multisensory information processing (1). It is considered the second-highest cause of disability, affecting about 12% of the population. Migraines are 2-3 times more common in females than males. It is the most common cause of disability in females aged between 15 and 49 years (2). Migraine is considered a neuro-vascular disease in which neural events lead to pain and activation of the nerve. The dysfunction of the brain involves both the central and peripheral constituents of the trigeminal-vascular system and the inflammatory mediators will be released, which will accordingly lead to the propagation and prolongation of pain (3). There are several types of migraine, but the most common are migraine without aura, which represents about 75% of all migraine patients, and migraine with aura, which is about 20%. The diagnosis of migraine is made according to the third edition of the ICHD (ICHD-3), developed by the International Headache Society (HIS) (4).

Cognition is a mental process involved in information acquisition and understanding the surrounding environment. It includes a variety of high-level processes and intellectual functions such as visuospatial function, language, perceptual comprehension, decision-making, planning, reasoning, judgment, memory, and attention. (5) Cognitive deficit is the impairment of different cognitive domains. It might be a short-term (transient) condition or a long-term (permanent) entity. (6).

Pathophysiology: Normal cognitive function depends on a regulated and continuous blood supply, and any pathology that causes a reduction in the blood perfusion to the brain, in addition to ageing, may cause damage to the brain's vulnerable neurons (7). Glucose plays a major role as a main source of energy for the brain, and brain function will be affected by any disturbance in its circulating level.

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There are various cognitive assessment screens, and the physician should choose the test that is preferred for the patient's mental and physical state. (8) Montreal cognitive assessment (MoCA) is the most widely used test for general screening because it covers a broad array of cognitive functions (9), including language, executive function, abstract reasoning, memory, attention and concentration, and visuospatial skills (10). These are the neurophysiological domains used to evaluate for cognitive impairment.

Electroencephalogram: It is the recording of the brain's spontaneous electrical activity by electrodes placed on certain scalp positions. It is a non-invasive test that is safe and easy to perform. Digital EEG data is mathematically processed in quantitative EEG to extract relevant information for further analysis or comparison with other forms of data (11). Quantitative EEG helps us identify regions of the brain that are too active or underactive, as well as regions that are not properly coordinating their activity as they should normally do. Derivative parameters are provided by q EEG, which results from analyzing EEG raw data.

The goal of our study is to correlate quantitative EEG changes with cognition in migraine patients.

Patients and Methods:

This is a case-control study carried out at the Department of Neurophysiology in Al-Shaheed Ghazi Al-Hariri Hospital in Baghdad during the interval from October 1, 2022, to May 1, 2023.

Controls: Eighteen healthy individuals(12 females, and 6 males), who visited the neurophysiology department of the hospital for the Nerve Conduction Study (NCS) and Electromyography (EMG) agreed to be included in the study as controls. A consultation neurologist examined them to exclude any history of chronic headaches or neurological diseases.

Patients: The study group included 20 patients with migraine who presented to the Department of Neurophysiology as referrals from the neurology unit in Baghdad Teaching Hospital. Inclusion criteria involved male and female patients diagnosed as migraine patients according to the 3rd edition of the classification of headache disorders by the International Headache Society. Exclusion criteria involved patients with other acute or chronic neurophysiological disorders, malignancy, previous craniotomies, or the use of neuroactive substances as anti-depressants or anti-epileptic drugs.

All patients and controls verbally agreed to participate in the study after being given a detailed explanation of the study plan. The study was approved by the ethics committee of the University of Baghdad's Coll ege of Medicine.

Methods: The Arabic version of the standard MoCA was used to perform cognitive assessments. These tests are available in Arabic from the MoCA website, and permission to use the test in our research was obtained from http://mocatest.org. (12)

Scores below 26 indicate cognitive impairment on the scale, which ranges from 0 to 30, and lower scores indicate worse cognitive function. Multiple domains, including visuospatial/executive, naming, memory, attention, language, abstract delayed recall, and orientation, are used for the assessment of cognitive function. The test was administered in a quiet section of the department. The assessments were carried out within 10–15 minutes.

A detailed history was taken from the patient about the severity of pain, history of pain onset, duration of pain, and if the patient had a migraine headache at the time of the EEG recording. Accordingly, the patients were grouped into ictal and inter-ictal groups.

ANatus EEG device was used along with Nicoletone N EEG software version v5.95.1.17, and 21 EEG electrodes were applied to the scalp; the electrode names and locations are specified by the international 10-20 system). Twenty minutes of EEG recording—10 minutes with the eye opened and 10 minutes with the eye closed—were done.

For quantitative analysis, artifact-free four-second epoch segments were selected. An EEG frequency spectrum was obtained with Fast Fourier Transformation (FFT), and the power spectral density (PSD) values (uV2) of each wave were calculated by summing power across all the bins in this frequency spectrum (0.5–3.9) for delta, (4–7.9) for theta, (8–12.5) for alpha, and (13–30) for beta.

The average values for the occipito-parietal (P3-O1, P4-O2), temporal (T3-T5, T4-T6), and fronto-central (F3-C3, F4-C4) regions were calculated.

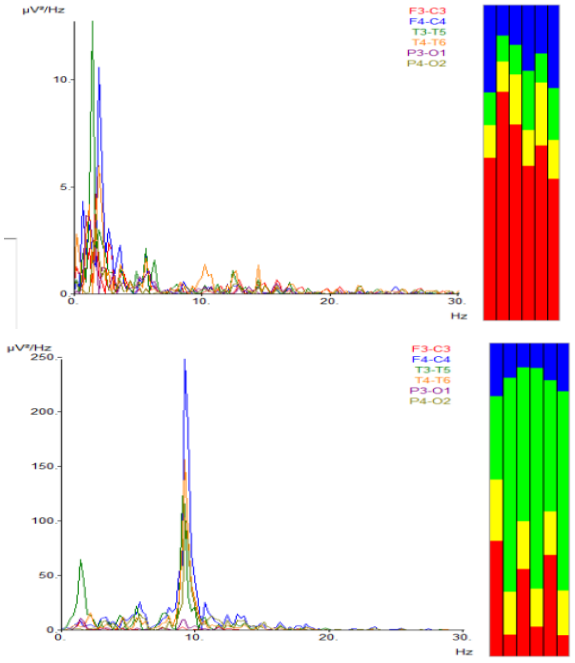

Figure (1): Power range density (UV²) calculated by taking 4 seconds artefact free epochs from (F3-C3) (F4-C4) (T3-T5)(T4-T6) (P3-O1)(P4-O2) channels and Fast Fourier Transform analysis was selected from the toolbar of Natus Software. (a) For healthy control (b) For migraine patient

Statistics: Data analysis was done using the Matlab statistical tool. Numerical and normally distributed data were analyzed using the Kruskal-Wallis test, with a P-value of 0.05 being considered statistically significant.

Results:

Table 1 shows the description of demographic and clinical data (mean±SD and ratios) for the two study groups and controls, where appropriate.

Table (1): Demographic and clinical data of the study groups

Variables	Ictal (mean±SD)	Interictal (mean±SD)	Control (mean±SD)
Age (years)	31.7±10.47	27.2±7.37	26.8±3.66
Gender (male/female)	4/6	3/7	6/12
Years of education	10.3±388	11.2±3.29	16.00**
MWA/MWO*	2/8	3/7	-
Headache history(years)	7.2±7.92	3.9±3.88	-
Headache frequency(per month)	8.8±3.49	7.5±3.77	-
Headache duration(hours)	3.8±0.83	3.2±1.47	-
Pain severity(0-10)	7.8±1.09	8.1±1.28	-

*MWA (Migraine with Aura) /MWO (Migraine without Aura)
** All those in the control group had 16 years of education and therefore, there was no variation in their means to calculate the standard deviation.

Power Spectral Density (PSD): EEG test when the eyes were open showed that both of delta and theta waves higher in the control group than the inter-ictal and then the ictal phase which has the lowest PSD (*0* = 0.06,0.02respectively), which is significant in the theta wave. The alpha wave was significantly lower in the control group than the inter-ictal and then the ictal phase (*p*= 0.001). The beta wave was significantly higher in the control group than the inter-ictal and then the ictal group (*p* = 0.005), figure (2)

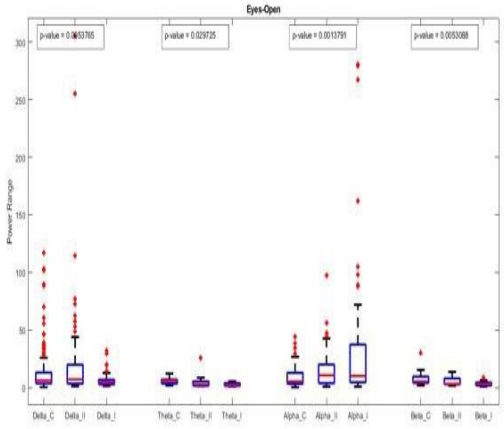

Figure (2): PSD of Delta, Theta, alpha, and beta waves for the ictal (I), interictal (II), and controls(C) during eye opened EEG test

EEG test when the eyes were closed showed a significant decrease in PSD of the delta wave in migraine patients than in the control group (*p*<0.001). For the theta wave the PSD also decreased significantly in a descending pattern from the control to the interictal and then the ictal migraine patient(*p* = 0.023). The PDS of the alpha wave was significantly higher in both ictal and interictal migraine patients than controls (P <0.001). In the beta wave, the PDS significantly decreased in a descending pattern from control to interictal and ictal patients (*p*= 0.01), figure (3)

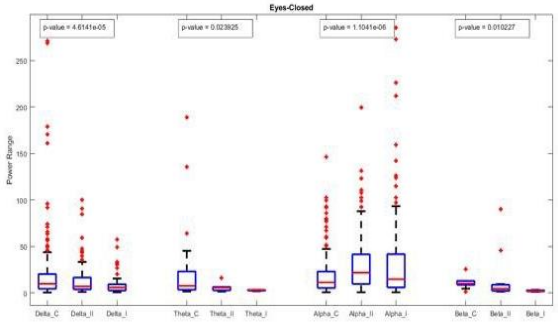

Figure (3): PSD of the delta, theta, alpha, and beta waves for the ictal (I), interictal(II), and controls (C) during the eyes closed EEG test

Cognition:

Table 2 shows that the mean scores of language, memory, and abstraction were significantly lower in migraine patients (ictal and interictal) than in the controls (*p-values* of 0.004, 0.001, and 0.049)

Cognitive Functions	Ictal (mean ±SD)	Interictal (mean ±SD)	Control (mean ±SD)	*p*
MoCA total score	21.0 ± 4.1	21.14 ± 2.6	25 ± 2.4	0.73
Visuospatial	4.2 ± 0.99	4 ± 1.2	4.7 ± 0.79	0.45
Naming	2.5 ± 0.53	2.2 ± 0.75	2.9 ± 0.24	0.06
Attention	4.7 ± 0.9	3.4 ± 1.7	5.1 ± 0.8	0.059
Language	1.0 ± 0.75	1.2 ± 0.75	2.1 ± 0.7	0.004
Abstraction	1.1 ± 0.6	1.2 ± 0.75	1.7 ± 0.4	0.049
Memory	1.7 ± 1.1	2.4 ± 1.3	3.5 ± 0.7	0.001
14231	5.3 ± 1	5.7 ± 0.48	5.6 ± 0.5	0.87

respectively. Other MoCA subtests (visuospatial, naming, attention, and orientation) were found to be non-significant (*p* values = 0.45, 0.06, 0.059, and 0.87) respectively as in figure 4,5 &6).

Table (2): Mean±SD of cognitive function scores in the study groups (subtests of MoCA)

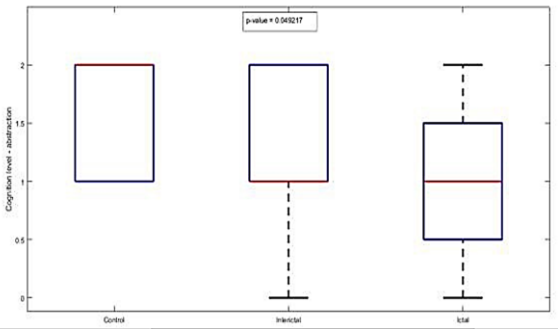

Figure (6): Scores of the abstraction domain for the control, ictal, and inter-ictal patients

Discussion:

Migraine is the second most common disabling disorder, affecting about 12% of the population and characterized by moderate to severe headaches, throbbing in nature, mostly unilateral, and certain features such as nausea and light and sound sensitivity.

In this study, we tried to explore the correlation between quantitative EEG changes in patients with migraine and cognition by using the Montreal cognitive assessment.

The study revealed that the PSD of the slow-wave theta and beta were significantly higher in controls than interictal and ictal migraine patients. The opposite was true for the alpha waves. Many studies were done to quantify EEG changes in patients with migraine. One study measured the relative power of the four EEG frequency bands [delta, theta, alpha, and beta] to compare various groups of transient neurological deficit disorders, including migraine, and discovered a marked increase in the alpha relative power and a marked decrease in the beta relative power (13). EEG spectral analysis was performed in 20 untreated migraine patients without aura. The alpha power was found to be higher than that of the control group, except front to central, but only in the right occipital region (O4) where spectral differences were statistically significant (14). Different results have been documented by other studies. The researchers discovered that migraines had generally higher relative theta activity when they analyzed the absolute power, relative power, and asymmetry of the delta, theta, and alpha frequency bands in parieto-occipital, temporal, and frontocentral areas. (15)

Regarding cognition, in our study, we found a significant difference in MoCA subtests (language, recall-memory, and abstraction) between controls and migraine patients (during ictal and inter-ictal periods). Quadros et al found that there is no objective decline in cognitive performance between the interictal phase and the ictal or peri-ictal periods when 142 migraine patients were evaluated in different phases of migraine with cognitive tests, which can be due to patients' and attack variability (16). Santangelo et al found problems with attention, memory, language, visuospatial processing, and executive functions (17). Wen et al discovered that migraineurs, especially those with aura, often do better on tests of cognition than do those without (18). Another study found no significant difference in the cognition level between migraine patients and controls (19).

When trying to link quantitative EEG changes in patients with migraine with cognition, we found that when theta (4–8) Hz and beta (12–30) Hz decrease, cognition level becomes worse, and when alpha waves (8–12) Hz increase, cognition levels decline. Lithfous et al reported that cognitive achievement was generally positively correlated with relative Delta and relative Theta and inversely correlated with relative Alpha (20). Wang et al observed no correlation between the EEG power of each frequency band and scores of specific domains of MoCA (21).

The limitation of this study is that the sample size was too small to draw any firm conclusions.

Conclusion: Quantitative EEG findings suggest that alpha waves correlate negatively with cognition, while both theta and beta waves correlate positively with cognitive level.

Authors' declaration:

Conflicts of interest: None.

All of the figures and tables in the text are original works by myself or my collaborators. In addition, the non-original figures and photographs included with the article have been licensed for reuse. Authors sign off based on their acceptance of ethical considerations. Meeting Ethical Requirements: Ghazi Al-Hariri Hospital's local ethics committee in Medical City gave their stamp of approval to the study, according to the code number. (88.4.6.2023)

Author's contributions:

Study conception & design: Raghad A. Abdul-Kareem, Hanan L. Al-Omary. Literature search: Raghad A. Abdul-kareem, Hanan L. Al-Omary. Data acquisition: Raghad A. Abdul-kareem. Data analysis& interpretation: Raghad A. Abdul-kareem. Manuscript preparation: Raghad A. Abdul-kareem. Manuscript editing & review: Raghad A. -Kareem, Hanan L. Al-Omary

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العلاقة بين القدرة الإدراكية والتغيرات الحاصلة في تخطيط الدماغ الكمي لدى مرضى الصداع النصفي

رغد علاء عبد الكريم[1]، حنان لؤي العمري[1]
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الخلاصة:
خلفية البحث: الصداع النصفي هو اضطراب إعاقة شائع يتميز بنوبات من الصداعغالبا ما تكون في جانب واحد من الرأس، متوسط إلى شديد، يتم تشخيص الصداع النصفي وفقًا للإصدار الثالث من(ICHD-3) الذي طورته جمعية الصداع الدولية. هناك عدة أنواع الصداع النصفي، والأكثر شيوعًا هو الصداع النصفي بدون هالةأو نسمة(MOA) والصداع النصفي المصحوب ب هالةأو نسمة(MWA).
الأهداف: هدفت هذه الدراسة إلى إيجاد العلاقات المتبادلة بين التغيرات الكمية في مخطط كهربية الدماغ مع القدرة الإدراكيةلدى مرضى الصداع النصفي.
المنهجية: اشتملت الدراسة على 20مريضًا بالصداع النصفي،10 أثناء نوبة الألم و 10أثناء فترة خالية من الألم (بين النوبات)، و 18شخص سليم، وقد تم تقييم القدرة الادراكيةمن خلال فحص Montreal cognitive assessment(MoCA)، وتم إجراء تخطيط كهربية الدماغ لفروة الرأس لمدة 20 دقيقة بعد ذلكتم اخذ أربعة ثوان فحص تخطيط الدماغ لإيجاد كثافة القدرة الطيفية لكل من دلتا (0.5-4) هرتز، ثيتا (4-8)هرتز- ألفا (8-12) هرتز و بيتا (12-30) هرتز.
النتائج: وجد التحليل الكمي لـ EEG أن هناك انخفاضًا كبيرًا في موجات ثيتا، وموجات بيتا في النمط التنازلي من من الاشخاص السليمين إلى مرضى الصداع النصفي خلال الفترةبدون الم الى مرضى الصداع خلال فترة الصداعمع زيادة موجات ألفا في النمط التصاعدي من الاشخاص السليمين إلى مرضى الصداع النصفي خلال الفترةبدون الم الى مرضى الصداع خلال فترة الصداع. اما فحص ألقدرة الإدراكية فقد تبين انهناك فرق كبير بين مرضى الشقيقة ومرضى الصداع النصفي في مجالات الذاكرة واللغة والتجريد.
الاستنتاجات: انخفاض الأداء المعرفي لدى مرضى الصداع النصفي خلال كل من مرحلتي (النوبات وبين النوبات) عند مقارنتها الاشخاص السليمين وتشير إلى أن موجات ثيتا وبيتا ترتبط بشكل إيجابي بالإدراك بينما موجة ألفا ترتبط سلبًا بالإدراك.
مفتاح الكلمات: الصداع النصفي، الإدراك، تخطيط كهربائية الدماغ، كثافة القدرة الطيفية.