Neuropsychological Trends

32
November 2022

Rajyoga meditation: effects on visual evoked potentials in migraine patients

Sudhanshu Kacker[1] - Anshul Sharma[2] - Sheshav Somani[3] - Shailesh K Kawale[2] - Amit Tak[3]

[1] Department of Physiology, RUHS College of Medical Sciences, Jaipur, Rajasthan, India

[2] Government Medical College, Bharatpur, Rajasthan, India

[3] Department of Physiology, Rajmata Vijaya Raje Scindia Medical College, Bhilwara, Rajasthan, India

DOI: https://dx.doi.org/10.7358/neur-2022-032-kack

shaileshkawle@gmail.com

ABSTRACT

Light can precipitate migraine attacks, suggesting the visual system's role in migraine pathophysiology. The present study hypothesized the positive effects of Rajyoga meditation on visual evoked potentials (VEPs) in migraineurs. This repeated-measures study included 185 migraine patients (Group A) and 51 age-matched controls (Group B). Initially, the VEPs of both groups were recorded and compared using the Mann-Whitney U test. Subsequently, group A patients followed weekly sessions of Rajyoga meditation for three months. Then, VEPs were re-recorded and compared with pre-intervention measurements using the Wilcoxon signed-rank test at a 5% significance level. Before the intervention, P100 latency was significantly delayed, and the P100 amplitude was significantly lower in migraine patients compared to the control group. After performing Rajyoga meditation, migraineurs showed a significant decrease in P100 latency and an increase in P100 amplitude. The present study showed favorable effects of Rajyoga meditation in migraine patients.

Keywords: migraine; P100 amplitude; P100 latency; Rajyoga Meditation; visual evoked potentials

1. Introduction

Migraine is a common disabling primary headache disorder. Many epidemiological studies have documented its high prevalence of personal and socio-economic impacts (Olesen et al., 2018) Prevalence of migraine ranges from 2.6% to 21.7%, with an average of 12% differences between countries and within the same state (Merikangas et al., 2013; Sahithi et al., 2020). The migraine epidemiology showed the tip of the iceberg due to the under-diagnosis of headaches in India. However, a study conducted in Karnataka and NCT of Delhi (unpublished data) showed that the one-year age-standardized prevalence of migraine was slightly more than 25 % (Lipton, Bigal et al., 2003). The migraine rates were reportedly higher in females (70%) than males (30%) and are highest in reproductive years (aged 25 to 55) (Lipton, Pan et al., 2004). Migraine is females' top cause of disability-adjusted life years (DALYs). In separate online estimates figured in 2019, headache disorders were the cause of 5.4% of total Years Lived with disability (YLDs) globally, with 88.2% of these attributable to migraine (Burch et al., 2015). Migraine patients also experience many potential psychiatric co-morbidities, including anxiety, depression, and respiratory problems (Kulkarni et al., 2015).

Traditionally, medications are first-line treatments for migraine therapy. However, only half of the migraineurs have clinically meaningful responses to preventive drug treatments; more than 10% discontinue their drug therapy due to adverse events, and half report dissatisfaction with their current treatment strategies (Leonardi et al., 2005) When preventive treatments are ineffective, there are chances that migraineurs may overuse symptomatic relief medications with a consequent worsening of their headache burden. In addition to well-known evidence-based behavioral interventions like electromyographic biofeedback, relaxation training, thermal biofeedback combined with relaxation training, and cognitive behavioral therapy (Nguyen et al., 2014), many patients are using less-well researched non-pharmacological options such as complementary and alternative medicine (CAM) modalities in the treatment of headache (Lipton, Stewart, et al., 2001). Meditation encompasses a family of complex practices, including yoga meditation, mindfulness meditation, mantra meditation, and Tai chi (Odom et al., 2004) Rajyoga meditation is a form of meditation performed without rituals or mantras. The word 'Rajyoga' originated from 'Raja', meaning king, and 'yoga,' meaning union between Soul (spiritual energy) and Supreme Soul (ocean of spiritual energy) (Ramesh et al., 2013) Rajyoga meditation harmonizes physical, mental, and spiritual power, increasing inner strength to lead a stress-free life. Meditation has various neurophysiological correlates. Different sensory evoked potentials (SEPs), including VEPs, provide a relatively noninvasive way of studying changes in specific sensory pathways during meditation (Barwood et al., 1978). Meditation might modify information processing at the brainstem and thalamic

levels by altering cortical functioning and corticofugal controls (Prbram et al., 1992; Steriade et al., 1988).

Until now, no electrophysiological test is reliable for diagnosing migraine; however, studies found that migraineurs had a habituation deficit of visual evoked potentials (VEP) between attacks (Ambrosini, Iezzi, et al., 2016; Bednář et al., 2014; Coppola, Bracaglia, et al., 2015; Coppola, Parisi, et al., 2013; Rauschel et al., 2016). The electrophysiological and clinical findings during the interictal period may hold the key to a better understanding of migraine pathogenesis. Visual Evoked Potential (VEP) is one such technique regarded as a practical, reliable, noninvasive, widely accepted, and standardized method for evaluating visual pathways. The present study hypothesized the positive effects of Rajyoga meditation in migraine patients as assessed by VEPs.

2. Methods

This repeated-measure study was conducted in the Department of Physiology, RUHS College of Medical Sciences (RUHS-CMS) and associated RDBP Jaipuria Hospital, Jaipur (Rajasthan, India), to evaluate the effect of Rajyoga meditation on VEPs parameters of migraine patients. The study hypothesized no changes in VEP parameters including latencies to N70, P100 and N155 waves (milliseconds), and peak to peak amplitude of P100 wave (microvolts). A total of 185 migraine patients (Group A) and 51 normal healthy controls (Group B) satisfying the inclusion and exclusion criteria were included in the study after approval from the Institutional Ethics committee (Table 1.) The diagnosis of migraine was confirmed at the time of patient recruitment based on criteria laid down by the International Headache Society (IHS) in 2018. All the participants in group A were allowed to continue taking their prophylactic and abortive medications as usual and were asked not to change dosages for the trial duration.

Table 1. Inclusion and exclusion criteria for selection of participants in the study

Inclusion Criteria	Exclusion criteria
1. Migraine patients with or without aura (diagnosed as per IHS 2018) 2. Age ≥ 18 years 3. Gender: Male or Female 4. Duration of migraine ≥ 1 year 5. Frequency of migraine- 4 to 14 days per month 6. Willing to attend weekly sessions and perform daily Rajyog meditation for 30 to 45 minutes.	1. History of practicing meditation or yoga 2. Subjects suffered from a significant systemic illness or psychiatric condition. 3. Plan of pregnancy or pregnant or breastfeeding. 4. New prophylactic migraine medicine started within the past four weeks. 5. Unwilling to maintain stable migraine medication dosages 6. Failure to complete baseline headache log records.

2.1 Rajyoga Intervention

Group A patients underwent weekly sessions of Rajyoga meditation under a trained instructor from Brahma Kumaris center in a dim light room within the department of physiology for three consecutive months. Also, the patients were advised to practice Rajyoga Meditation for half an hour at their homes, preferably in the morning, for three months.

Rajyoga Meditation training was given per the standard technique of Rajyoga Education and Research Foundation of the medical wing of Brahma Kumaris World Spiritual University, Mount Abu, India. During meditation, subjects sit comfortably and visualize their thoughts about soul consciousness with their gazes fixed on a meaningful symbol (a point of light considered as Supreme Soul). This meditation is practiced in four stages (Ramesh et al., 2013):

1. Initiation: Sitting comfortably in a quiet environment with eyes open and relaxing the mind.
2. Meditation: A series of linked positive thoughts about self-identification and supreme provides the fuel for the inner journey to self.
3. Concentration: In this stage, thoughts about the material world subside

without difficulty, as the mind becomes fascinated with its reality and the presence of the Supreme Being becomes evident.

4. Realization: Realizing inner powers of self, including peace, purity, happiness, and final experience of the state of bliss.

In addition, patients were given a standard video recording of the Rajyoga Meditation training and practice to encourage them to practice the same without fail. Compliance was monitored through weekly phone calls and by daily logs of home practice.

A detailed clinical history of all subjects and a thorough physical examination were performed. All participants were assessed using clinical neurological examination, including fundoscopy, measurement of visual acuity, and external ocular movements.

2.2 Data acquisition

The clinical data were collected, and participants underwent visual examination, including fundoscopy, visual acuity, and assessment of external ocular movements. Patients were instructed to come without applying oil to the scalp, shampoo their hair, and dry it. VEPs were recorded with a PC-based, two-channel RMS EMG EP mark II machine and Ag/AgCl disc electrodes. A VEP monitor displaying a checkerboard is used to give the pattern reversal stimulus. A montage consisting of one channel was used for the VEP recording. The subject was asked to sit comfortably in front of the checkerboard pattern at an eye screen distance of 100cm. An amplification that ranged between 20,000 and 1,00,000 was used to record the VEPs. The electrode impedance was kept below 5KΩ. The recordings were performed in a dark and sound-attenuated room. Binocular stimulation was given to both eyes separately with black and white checks that changed the phase.

2.3 VEP analysis

VEPs consists of a series of waveforms of opposite polarity, a negative waveform (N), and a positive waveform (P), followed by the approximate latency. Initially, VEPs of both groups (Group A and Group B) were recorded. Subsequently, Group A participants underwent Rajyog intervention for three months, and VEP recording was repeated to evaluate intervention effectiveness.

Visual evoked potentials were recorded in dark room with a PC based, 2 channel, RMS EMG EP mark II machine and standard silver-silver chloride disc electrodes. A one channel montage was used, and the scalp electrodes were placed over bony landmarks, according to the International 10/20 system. The Oz was used as an active electrode placed over the highest point of the occiput which lies over the visual cortex. The Fz and Cz were used as reference and ground electrodes,

respectively. Visual stimulation was given using checkerboard pattern generated on the monitor, which consisted of black and white checks whose phase was reversed (black to white and white to black) at a fixed rate of two reversals per second. The subject was seated at a fixed distance of 100 cm from the screen and was asked to fixate at the center of the screen. Monocular stimulation was given to both the eyes separately. A sweep length of 250 millisecond was done, and more than 100 responses were averaged. The electrode impedance was kept less than 5 KΩ. The VEP parameters recorded were latencies to N70, P100 and N155 waves, and peak to peak amplitude of P100 wave (Odom et al., 2004; Sharma et al., 2015).

2.4 Statistical analysis

The probability distribution of N70, N155, and P100 latencies (milliseconds) and P100 amplitude (millivolts) were tested using the Shapiro-Wilk test while Levene's test was used to test the equality of variances. The control and intervention groups followed non-normal distribution and had unequal variances. Therefore, descriptive statistics for quantitative data were expressed as the median and interquartile range (IQR), and they were compared using the non-parametric Mann-Whitney U test. Similarly, the pre- and post-intervention groups were tested using the Wilcoxon signed-rank test due to unequal variance. The rank biserial correlation gave the effect size for the Mann-Whitney and the Wilcoxon signed-rank test. The categorical variables were expressed as proportions, and the independence was tested using the chi-squared test. Statistical significance was considered at a 5% significance level ($\alpha = 0.5$). The R 4.1.2 statistical package was used for statistical analysis.

3. Results

In this repeated measure study, 185 migraine patients (Median age =36 years; IQR = 15 years) and 51 healthy controls (Median age = 35 years; IQR = 14 years) were enrolled. Both groups were matched with respect to age (W = 4374.5, p = 0.43) and gender ($\chi^2(1) = 0.14$, p = 0.71). The P100 latency was significantly delayed (W = 2954, p < 0.001, Effect size =-0.374) and P100 amplitude (W = 656, p < 0.001, Effect size = 0.391) was significantly lower in migraine patients than in control group. However, no significant differences were found in N70 latency (W = 3902.5, p = 0.06, Effect size = -0.173) and N155 latency (W = 4008.5, p = 0.10, Effect size = -0.150) (Table 2).

The intervention of Rajyoga meditation in migraine patients showed significant decrease in P100 latency (W = 11306.5, p < 0.001, Effect size = 0.556) and significant increase in P100 peak amplitude (W = 3138, p < 0.001, Effect size = -0.635) (Table 3; Figure 1 and 2).

Table 2. Descriptive statistics and the difference of means between controls (N=51) and migraine patients with no intervention (N=185) using the Mann-Whitney U Test

Variable	Groups	Median	IQR	W	p
N70 Latency	Control	64.62	9.38	3902.5	0.059
	Pre-intervention	67.32	11.47		
P100 Latency	Control	102.62	10.395	2954	< .001
	Pre-intervention	111.9	17		
N155 Latency	Control	148.01	20.185	4008.5	0.101
	Pre-intervention	149.66	19.27		
P100 Peak Amplitude	Control	5.9	0.87	6561	< .001
	Pre-intervention	5.44	1.13		
Age	Control	35	14	4374.5	0.427
	Pre-intervention	36	15		

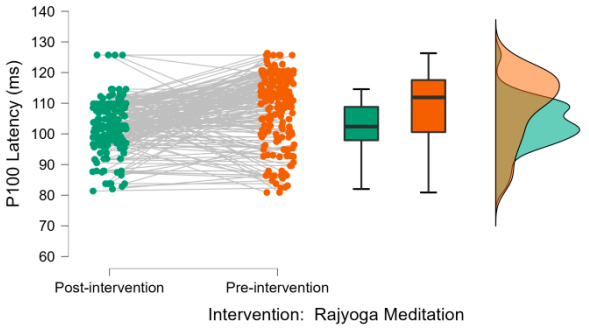

Figure 1. Raincloud plot showed a decrease in P100 latency after three months of intervention with rajyoga meditation

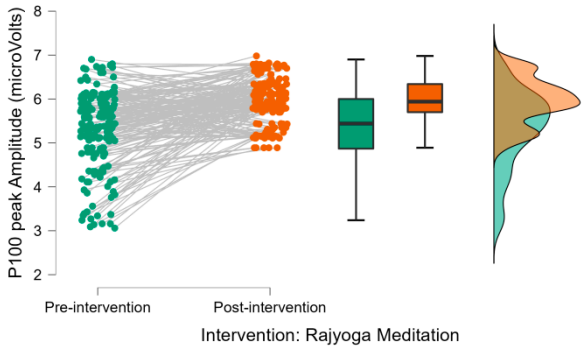

Figure 2. Raincloud plot showed an increase in P100 amplitude after three months of intervention with rajyoga meditation

Table 3. Descriptive statistics and the difference of means between pre-intervention and post-intervention (N=185) using the Wilcoxon signed-rank test

Variables	Groups	Median	IQR	W	*p*
N70 Latency	Pre-intervention	67.32	11.47	10385	0.015
	Post-intervention	65.8	9.34		
P100 Latency	Pre-intervention	111.9	17	11306.5	< .001
	Post-intervention	102.38	10.89		
N155 Latency	Pre-intervention	149.66	19.27	9362	0.239
	Post-intervention	149.85	20.37		
P100 Peak Amplitude	Pre-intervention	5.44	1.13	3138	< .001
	Post-intervention	5.94	0.64		

4. Discussion

Migraine is a neurological disorder manifested with periodic symptoms, most notably a throbbing headache on one side of the head. The periodicity reflects functional and morphological changes in the brain that fluctuate over time. Further, the intensity of headaches relates to lights, sounds, and smells. In the migrainous brain, temporal processing of external stimuli and sequential recruitment of neuronal networks are often dysfunctional. Researchers assessed visual evoked potentials (VEPs) that can reveal altered patterns of the brain's electrophysiological activity and aid in understanding migraine pathophysiology. The non-pharmacologic measures such as meditation, yogic exercises, and deep breathing can be adjuncts to routine antimigraine therapy.

The present study compared P100 latencies and amplitude in visual evoked potentials of healthy controls and migraineurs. Researchers found delayed P100 latency and decrease P100 amplitude in migraine patients compared to controls. In addition, the study evaluated the effect of Rajyoga meditation on migraine patients and found early P100 latencies and higher P100 amplitude after training. Winter et al. found a decrease in P100 (ms) after practicing Rajyoga meditation in migraine patients (Winter et al., 1985) However, in a study, Polich et al. obtained visual evoked potentials from 20 migraine patients and compared them with age-matched controls. They showed no substantial differences in N75, P100, and N145 (latencies and amplitudes), elicited using complete- and half-field reversing checkerboard stimulus presentations (Polich et al., 1986). Mariani et al. compared twenty migraine patients with healthy controls and found significantly longer P100 latency in migraine patients (Mariani et al., 1990).

Although, the present study showed a decrease in P100 amplitude in migraine patients compared to controls, many neurophysiological studies found higher P100 amplitude in migraineurs. The higher P100 amplitudes in visual evoked potentials resulted from decreased habituation between attacks (Schoenen, Wang et al., 1995; Wang et al., 1996). This implies that cortical information processing gets modified in most migraine patients between episodes, which can be considered an endophenotypic disorder biomarker. The underlying neural mechanisms might involve lower preactivation levels of sensory cortices due to thalamocortical dysrhythmia and low serotonergic tone, but these mechanisms are still under research (Ambrosini, Rossi et al., 2003; Coppola, Ambrosini, et al., 2007; Coppola, Pierelli, et al., 2007; De Tommaso et al., 2014). Theoretically, one explanation was seen in the ceiling theory (Knott, Irwin et al., 1973; Schenen, 1996) based on the assumption that for evoked potentials, after reaching a ceiling point, cortical reactivity is reduced, which initiates a habituation response. Also, a lower pre-activation level in migraine patients would cause a delayed or missing habituation because the ceiling would be reached later than in healthy people. In this context, migraine patients' higher

amplitudes of evoked potentials were due to the missing or reduced habituation. However, some researchers could not reproduce these findings (Demarquay et al., 2011; Oelkers, Grosser et al., 1999; Oelkers, Parzer et al., 2005; Omland, Nilsen et al., 2013; Omland, Uglem et al., 2016; Sand, Vingen et al., 2000; Sand, Zhitniy et al., 2008;), attributed to various methodological issues, including the absence of blinding(Coppola, Pierelli, et al., 2007) or differences in migraine phenotypes (Ambrosini, Coppola, et al., 2011).

The study showed substantially reduced N70 and P100 latencies after performing Rajyoga meditation. The shifting autonomic balance favoring parasympathetic instead of sympathetic might explain the above phenomenon. However, it requires further studies on Rajyoga meditation. In addition, there was a significant increase in post-intervention P100 amplitude. Similarly, results obtained by light flashes before, during, and after Qigong meditation showed an increase in VEP amplitudes (N80, P115, N150, P200, N280) in advanced practitioners, not novices and beginners. However, a significant decrease in the VEP amplitudes was obtained within the same study group of Qigong practitioners of other schools (Zhang et al., 2012). On the contrary, Schöne and colleagues (2018) observed that modulations in much higher latency waveforms (500–6.800 ms) resulted in reduced VEP amplitudes acquired during multiple object tracking paradigms in the group that performed training in mindful breath awareness compared to an active control group, trained in muscular relaxation. The results were attributable to an increased ability to ignore irrelevant stimuli with lower attentional effort after meditation training (Schöne et al., 2018). The evoked potentials (EP) results are highly dependent on the onset, the number of repetitions, and the type (e.g., auditory or visual) of stimuli and rely on signal averaging around an event. Most results suggest that meditation affects the processes underlying the generation of endogenous EP; it is still tricky to thoroughly compare these studies because of distinct EP components evaluated, stimuli diversity, and, most importantly, the men participants' mental state.

5. Conclusion

The present study showed favorable effects of Rajyoga meditation on P100 latencies in migraine patients. The migraineurs might consider this non-pharmacologic measure as an adjunct to antimigraine therapy. However, more studies are required to establish the benefits of Rajyoga meditation in migraine.

5.1 Limitations of the study

VEPs recorded close to or within an attack may show normal findings, as VEPs are sensitive to the recording period. Ideally, VEPs recording should be conducted in the interictal period. The study had not considered the interaction of habituation with various groups. In addition, chronic migraineurs might show no VEP habituation.

Contribution of Authors

Equal contribution was made by all the authors in their respective domains.

Competing Interest

There is no competing interest among authors.

Research Quality and Ethics Statement

The present study was in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000. The ethical approval was obtained from the Office of RUHS-CMS Ethics Committee via letter-number RUHS-CMS/ETHICSCOMM./2016-06 dated 30 Jul 2016.

References

Ambrosini, A., Rossi, P., De Pasqua, V., Pierelli, F., & Schoenen, J. (2003). Lack of habituation causes high intensity dependence of auditory evoked cortical potentials in migraine. *Brain*, *126*(9), 2009–2015. https://doi.org/10.1093/BRAIN/AWG206

Ambrosini, Anna, Coppola, G., Gérardy, P. Y., Pierelli, F., & Schoenen, J. (2011). Intensity dependence of auditory evoked potentials during light interference in migraine. *Neuroscience Letters*, *492*(2), 80–83. https://doi.org/10.1016/J.NEULET.2011.01.060

Ambrosini, Anna, Iezzi, E., Perrotta, A., Kisialiou, A., Nardella, A., Berardelli, A., Pierelli, F., & Schoenen, J. (2016). Correlation between habituation of visual-evoked potentials and magnetophosphene thresholds in migraine: A case-control study. *Cephalalgia : An International Journal of Headache*, *36*(3), 258–264. https://doi.org/10.1177/0333102415590241

Anne Sahithi, S. T., Muthu, T., & Saraswathy, R. (2020). Migraine: Update and Future Perspectives. *International Journal of Nutrition, Pharmacology, Neurological Diseases*, *10*(4), 179. https://doi.org/10.4103/IJNPND.IJNPND_26_20

Barwood, T. J., Empson, J. A. C., Lister, S. G., & Tilley, A. J. (1978). Auditory evoked potentials and transcendental meditation. *Electroencephalography and Clinical Neurophysiology*, *45*(5), 671–673. https://doi.org/10.1016/0013-4694(78)90168-2

Bednář, M., Kubová, Z., & Kremláček, J. (2014). Lack of visual evoked potentials amplitude decrement during prolonged reversal and motion stimulation in migraineurs. *Clinical Neurophysiology : Official Journal of the International Federation of Clinical Neurophysiology*, *125*(6), 1223–1230. https://doi.org/10.1016/J.CLINPH.2013.10.050

Burch, R. C., Loder, S., Loder, E., & Smitherman, T. A. (2015). The prevalence and burden of migraine and severe headache in the United States: updated statistics from government health surveillance studies. *Headache*, *55*(1), 21–34. https://doi.org/10.1111/HEAD.12482

Coppola, G., Ambrosini, A., Di Clemente, L., Magis, D., Fumal, A., Gérard, P., Pierelli, F., & Schoenen, J. (2007). Interictal abnormalities of gamma band activity in visual evoked responses in migraine: An indication of

thalamocortical dysrhythmia? *Cephalalgia*, *27*(12), 1360–1367. https://doi.org/10.1111/j.1468-2982.2007.01466.x

Coppola, G., Pierelli, F., & Schoenen, J. (2007). Is the cerebral cortex hyperexcitable or hyperresponsive in migraine? *Cephalalgia*, *27*(12), 1427–1439. https://doi.org/10.1111/j.1468-2982.2007.01500.x

Coppola, Gianluca, Bracaglia, M., Di Lenola, D., Di Lorenzo, C., Serrao, M., Parisi, V., Di Renzo, A., Martelli, F., Fadda, A., Schoenen, J., & Pierelli, F. (2015). Visual evoked potentials in subgroups of migraine with aura patients. *Journal of Headache and Pain*, *16*(1), 1–11. https://doi.org/10.1186/S10194-015-0577-6/FIGURES/4

Coppola, Gianluca, Parisi, V., Di Lorenzo, C., Serrao, M., Magis, D., Schoenen, J., & Pierelli, F. (2013). Lateral inhibition in visual cortex of migraine patients between attacks. *The Journal of Headache and Pain*, *14*(1), 1–11. https://doi.org/10.1186/1129-2377-14-20/FIGURES/6

De Tommaso, M., Ambrosini, A., Brighina, F., Coppola, G., Perrotta, A., Pierelli, F., Sandrini, G., Valeriani, M., Marinazzo, D., Stramaglia, S., & Schoenen, J. (2014). Altered processing of sensory stimuli in patients with migraine. *Nature Reviews. Neurology*, *10*(3), 144–155. https://doi.org/10.1038/NRNEUROL.2014.14

Demarquay, G., Caclin, A., Brudon, F., Fischer, C., & Morlet, D. (2011). Exacerbated attention orienting to auditory stimulation in migraine patients. *Clinical Neurophysiology*, *122*(9), 1755–1763. https://doi.org/10.1016/J.CLINPH.2011.02.013

Knott, J. R., & Irwin, D. A. (1973). Anxiety, stress, and the contingent negative variation. *Archives of General Psychiatry*, *29*(4), 538–541. https://doi.org/10.1001/ARCHPSYC.1973.04200040080013

Kulkarni, G. B., Rao, G. N., Gururaj, G., Stovner, L. J., & Steiner, T. J. (2015). Headache disorders and public ill-health in India: prevalence estimates in Karnataka State. *The Journal of Headache and Pain*, *16*(1). https://doi.org/10.1186/S10194-015-0549-X

Leonardi, M., Steiner, T. J., Scher, A. T., & Lipton, R. B. (2005). The global burden of migraine: measuring disability in headache disorders with WHO's Classification of Functioning, Disability and Health (ICF). *The Journal of Headache and Pain*, *6*(6), 429–440. https://doi.org/10.1007/S10194-005-0252-4

Lipton, R.B., Stewart, W. F., Sawyer, J., & Edmeads, J. G. (2001). Clinical Utility of an Instrument Assessing Migraine Disability: The Migraine Disability Assessment (MIDAS) Questionnaire. *Headache: The Journal of Head and Face Pain*, *41*(9), 854–861. https://doi.org/10.1111/J.1526-4610.2001.01156.X

Lipton, Richard B., Bigal, M. E., Scher, A. I., & Stewart, W. F. (2003). The global burden of migraine. *Journal of Headache and Pain*, *4*(SUPPL. 1), s3–s11. https://doi.org/10.1007/S101940300001/METRICS

Lipton, Richard B., & Pan, J. (2004). Is Migraine a Progressive Brain Disease? *JAMA*, *291*(4), 493–494. https://doi.org/10.1001/JAMA.291.4.493

Mariani, E., Moschini, V., Pastorino, G. C., Rizzi, F., Severgnini, A., & Tiengo, M. (1990). Pattern Reversal Visual Evoked Potentials (VEP-PR) in Migraine Subjects With Visual Aura. *Headache: The Journal of Head and Face Pain*, *30*(7), 435–438. https://doi.org/10.1111/J.1526-4610.1990.HED3007435.X

Merikangas, K. R. (2013). Contributions of epidemiology to our understanding of migraine. *Headache*, *53*(2), 230–246. https://doi.org/10.1111/HEAD.12038

Nguyen, B. N., Vingrys, A. J., & McKendrick, A. M. (2014). The effect of duration post-migraine on visual electrophysiology and visual field performance in people with migraine. *Cephalalgia : An International Journal of Headache*, *34*(1), 42–57. https://doi.org/10.1177/0333102413498939

Odom, J. V., Bach, M., Barber, C., Brigell, M., Marmor, M. F., Tormene, A. P., Holder, G. E., & Vaegan, A. (2004). Visual evoked potentials standard (2004). *Documenta Ophthalmologica*, *108*(2), 115–123. https://doi.org/10.1023/B:DOOP.0000036790.67234.22

Oelkers-Ax, R., Parzer, P., Resch, F., & Weisbrod, M. (2005). Maturation of early visual processing investigated by a pattern-reversal habituation paradigm is altered in migraine. *Cephalalgia*, *25*(4), 280–289. https://doi.org/10.1111/j.1468-2982.2004.00853.x

Oelkers, R., Grosser, K., Lang, E., Geisslinger, G., Kobal, G., Brune, K., & Lötsch, J. (1999). Visual evoked potentials in migraine patients: alterations depend on pattern spatial frequency. *Brain*, *122*(6), 1147–1155. https://doi.org/10.1093/BRAIN/122.6.1147

Olesen, J. (2018). Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache

Disorders, 3rd edition. *Cephalalgia : An International Journal of Headache*, *38*(1), 1–211. https://doi.org/10.1177/0333102417738202

Omland, P. M., Nilsen, K. B., Uglem, M., Gravdahl, G., Linde, M., Hagen, K., & Sand, T. (2013). Visual Evoked Potentials in Interictal Migraine: No Confirmation of Abnormal Habituation. *Headache: The Journal of Head and Face Pain*, *53*(7), 1071–1086. https://doi.org/10.1111/HEAD.12006

Omland, P. M., Uglem, M., Hagen, K., Linde, M., Tronvik, E., & Sand, T. (2016). Visual evoked potentials in migraine: Is the "neurophysiological hallmark" concept still valid? *Clinical Neurophysiology*, *127*(1), 810–816. https://doi.org/10.1016/J.CLINPH.2014.12.035

Polich, J., Ehlers, C. L., & Dalessio, D. J. (1986). Pattern-Shift Visual Evoked Responses and EEG in Migraine. *Headache: The Journal of Head and Face Pain*, *26*(9), 451–456. https://doi.org/10.1111/J.1526-4610.1986.HED2609451.X

Pribam, K. H., & McGuiness, D. (1992). Attention and para-attentional processing. Event-related brain potentials as tests of a model. *Annals of the New York Academy of Sciences*, *658*(1), 65–92. https://doi.org/10.1111/J.1749-6632.1992.TB22839.X

Ramesh, M. G., Sathian, B., Sinu, E., & Rai, K. S. (2013). Efficacy of Rajayoga meditation on positive thinking: An index for self-satisfaction and happiness in life. *Journal of Clinical and Diagnostic Research*, *7*(10), 2265–2267. https://doi.org/10.7860/JCDR/2013/5889.3488

Rauschel, V., Ruscheweyh, R., Krafczyk, S., & Straube, A. (2016). Test-retest reliability of visual-evoked potential habituation. *Cephalalgia : An International Journal of Headache*, *36*(9), 831–839. https://doi.org/10.1177/0333102415613613

Sand, T., & Vingen, J. V. (2000). Visual, long-latency auditory and brainstem auditory evoked potentials in migraine: Relation to pattern size, stimulus intensity, sound and light discomfort thresholds and pre-attack state. *Cephalalgia*, *20*(9), 804–820. https://doi.org/10.1046/j.1468-2982.2000.00098.x

Sand, T., Zhitniy, N., White, L. R., & Stovner, L. J. (2008). Visual evoked potential latency, amplitude and habituation in migraine: a longitudinal study. *Clinical Neurophysiology : Official Journal of the International Federation of Clinical Neurophysiology*, *119*(5), 1020–1027. https://doi.org/10.1016/J.CLINPH.2008.01.009

Schoenen, J. (1996). Deficient habituation of evoked cortical potentials in migraine: a link between brain biology, behavior and trigeminovascular activation? *Biomedicine & Pharmacotherapy = Biomedecine & Pharmacotherapie*, *50*(2), 71–78. https://doi.org/10.1016/0753-3322(96)84716-0

Schoenen, J., Wang, W., Albert, A., & Delwaide, P. J. (1995). Potentiation instead of habituation characterizes visual evoked potentials in migraine patients between attacks. *European Journal of Neurology*, *2*(2), 115–122. https://doi.org/10.1111/J.1468-1331.1995.TB00103.X

Schöne, B., Gruber, T., Graetz, S., Bernhof, M., & Malinowski, P. (2018). Mindful breath awareness meditation facilitates efficiency gains in brain networks: A steady-state visually evoked potentials study. *Scientific Reports 2018 8:1*, *8*(1), 1–10. https://doi.org/10.1038/s41598-018-32046-5

Sharma, R., Joshi, S., Singh, K. D., & Kumar, A. (2015). Visual evoked potentials: Normative values and gender differences. *Journal of Clinical and Diagnostic Research*, *9*(7), 12–15. https://doi.org/10.7860/JCDR/2015/12764.6181

Steriade, M., & Llinas, R. R. (1988). The functional states of the thalamus and the associated neuronal interplay. *Https://Doi.Org/10.1152/Physrev.1988.68.3.649*, *68*(3), 649–742. https://doi.org/10.1152/PHYSREV.1988.68.3.649

Wang, W., Timsit-Berthier, M., & Schoenen, J. (1996). Intensity dependence of auditory evoked potentials is pronounced in migraine. *Neurology*, *46*(5), 1404–1404. https://doi.org/10.1212/WNL.46.5.1404

Winter, A. L. (1985). FVEP in Migraine. In Electrophysiological studies of the visual system of people with classical migrarine. Proquest LLC (2018).

Zhang, W., Zheng, R., Zhang, B., Yu, W., & Shen, X. (2012). An Observation on Flash Evoked Cortical Potentials and Qigong Meditation. *The American Journal of Chinese Medicine, 21*(3–4), 243–249. https://doi.org/10.1142/S0192415X93000285