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# Beta and Gamma EEG Oscillatory Waves of the Frontal Cortex Increase After Wet Cupping Therapy in Healthy Humans

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## ABSTRACT

**Introduction:** Wet cupping therapy is a traditional complementary therapy that alleviates pain, stress and the symptoms of several ailments in humans. However, the effect of wet cupping therapy as recorded with the electroencephalography (EEG) has not been reported. The aim of this study was to investigate the effect of compare beta and gamma activities in the EEG before and after wet cupping therapy in healthy subjects.

**Materials and Methods:** The EEG tracing was recorded from eight healthy right-handed volunteers according to the standard international 10/20 system, using PowerLab 26T (AD Instruments, Bella Vista, Australia) before and after wet cupping therapy. Wet cupping was performed only once per person on 5 points of the posterior neck, bilateral perispinal areas of the neck, and thoracic spine. 3 ml-5 ml of blood was removed per cupping site.

**Results:** In the present study, both beta and gamma activities were significantly higher after wet cupping therapy, compared to the activities of these oscillatory waves recorded before therapy.

**Conclusion:** Wet cupping therapy increases beta and gamma activity in healthy subjects ( $p < 0.05$ ). Beta and gamma activities can be used as a measure of frontal activation in wet cupping therapy. This increase in oscillatory beta and gamma cortical waves may be mediated by stimulation of the peripheral nervous system, and possibly, corresponding increase in secretion of certain neurohumoral factors.

**Key words:** Wet cupping therapy, Beta activity, Gamma activity, EEG

**HOW TO CITE THIS ARTICLE:** Faruk Abdullahi, Cevat Unal, Menizibeya O Welcome, Emelda Nwenendah, Nafisa Umar, Afaf Muhammed, Salma U Faruk, Hauwa Kazaure, Senol Dane, Beta and Gamma EEG Oscillatory Waves of the Frontal Cortex Increase After Wet Cupping Therapy in Healthy Humans, J Res Med Dent Sci, 2019, 7(3): 123-130

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**Received:** 03/04/2019  
**Accepted:** 30/05/2019

## INTRODUCTION

Wet cupping therapy (also known as Al-Hijamah) is a percutaneous pressure- and size- dependent non-specific blood filtration technique that enables the excretion of pathological substances through the fenestrated skin capillaries upon application of negative suction pressure using sucking cups [1]. This complementary therapy has been reported to treat many diseases of differing etiology and pathogenesis [1]. For example, wet cupping therapy has been shown to clear toxic substances such as heavy metals from blood and interstitial fluids [2-4]. Wet cupping therapy has been successfully applied to treat other human maladies, including atherosclerosis, hyperlipidemia, hypertension, coronary heart diseases, gout, hepatitis, and thalassemia [5]. Study by Shekarforoush et al. [6] on animals has also shown

promise of application of this therapy in life threatening cardiac diseases [7,8].

This complementary therapy may have positive effects on brain functions. However, the effect of wet cupping therapy on cortical functions as recorded with electroencephalogram (EEG) in healthy humans has not been reported. The EEG is a non-invasive recording that is used to study cerebral activities in health and disease. The EEG waves are the result of action potentials and multiple excitatory and inhibitory postsynaptic potentials mostly of the neurons of the subcortical and cortical regions of the brain [9-11]. The major EEG waves are delta or  $\delta$ , theta or  $\theta$ , alpha or  $\alpha$ , beta or  $\beta$  and gamma or  $\gamma$  frequency bands. These frequency bands represent cerebral signal processing in sensorimotor and cognitive domains [9,12,13].

In a recent study, it was reported that foot reflexotherapy [14] and footbath therapy [15] increases beta and gamma activities of the EEG in young healthy humans. Wet cupping therapy can hypothetically affect the different EEG waves. Unfortunately, however, there is a lack of study

regarding the effect of wet cupping therapy on EEG waves. While the effects of wet cupping therapy on different maladies of humans have been investigated, [1-8] the effects of this therapy on cerebral information-processing or brain oscillations as recorded on EEG in healthy humans are not known. This study was to investigate the effect of wet cupping therapy on the EEG waves in the healthy humans.

## MATERIALS AND METHODS

### Ethical statement

The experimental protocol was in line with the Declaration of Helsinki and approved by the Research Ethics Committee/Institutional Review Board (REC/IRB) on the Use of Human Subjects (NUN/PHS/REC/IRB-UH/018/09/015). Permission was obtained from the concerned authorities before the participants were approached for possible involvement in the study.

### Participants

Apparently healthy males who worked at different Faculties (Arts, Science, Engineering, and Health Sciences) of the Nile University of Nigeria, Abuja, were involved in the study. Within a period of one week, 51 males who were present in their various faculties were randomly approached for possible involvement in the study. Of the 51 males, 38 agreed to participate in the study. Of these, 2 males were on medication as directed by their physician, but did not disclose the illness for which medication was taken. So these 2 males were excluded from the study. Thirty six healthy right handed males (mean age  $\pm$  standard deviation,  $22.61 \pm 11.34$  years) participated in this study. All participants were right-handed, according to self-report and confirmed by Edinburgh Handedness Inventory [16]. They had comparable education level (15 years-17 years).

### Inclusion criteria

1. Willingness to participate.
2. Absence of any health problem based on recent medical examination. The absence or presence of chronic illnesses and other habits was determined through their past medical history.
3. Total abstinence from drugs. Participants were non-smokers, and were not on medications.

### Exclusion criteria

1. Unwillingness to participate in the study.
2. Presence of health problems such as psychiatric, respiratory, metabolic, cardiac or central and autonomic nervous system disease, which may affect EEG tracing. The Mini-Mental State Examination (MMSE) was initially used to screen participants of cognitive deficit. No participant had cognitive deficit on this test.

3. Individuals using medications or drugs were not considered for participation. Those who fail the drug abuse test were not involved in the study.

### Procedure

Following ethical approval, as described above, the aims and objectives of the study were explicitly explained to the participants before commencing the experiment. All participants gave written informed consent to participate in the study a day before the commencement of the study. The anonymity and confidentiality of participants were assured and their decision to participate voluntarily in this study was respected. Before the day of the experiment, each participant completed a short questionnaire containing MMSE, hours of daily sleep, educational level, past medical history, drug abuse, and medication use. On the day of the experiment, participants reported at 8:30 AM and were requested to relax comfortably in an arm chair in as much as possible to avoid artifacts in the EEG tracing. EEG was recorded in all participants at baseline (before commencement of wet cupping therapy). Thereafter, wet cupping was performed by a physician certificated by the British Cupping Society and Natural Health Institute. A second EEG recording was conducted immediately after this wet cupping therapy. The study lasted for three weeks. In each day of the experiment, a maximum of 3-5 males were allowed to participate.

### Wet cupping therapy

Wet cupping therapy was conducted according to the British Cupping Society and Natural Health Institutes [3,17]. For the cupping therapy, sterile disposable cups 5 cm in diameter were used. Five points of the posterior neck, bilateral perispinal areas of the neck, and thoracic spine were selected for treatment (Figure 1). These points are classic wet cupping points chosen for all cupping therapies. Application areas were cleaned with antiseptic solutions. Cups (Sharon Xie Jiangmen Xinli Medical Apparatus And Instruments Co., Ltd., China) were placed on these points, and negative pressure was applied by a cupping pump (Sharon Xie Jiangmen Xinli Medical Apparatus and Instruments Co., Ltd., China) on the middle level to withdraw blood and intercellular fluid enough. The cups were removed after 2 minutes to 3 minutes. Then, the skin within the cupping sites was punctured to a 2 mm depth by using a 26-gauge disposable lancet. Then, vacuum pumping was applied three times and 3 ml to 5 ml of blood was drained per cupping site. Application sites were covered with sterile pads.

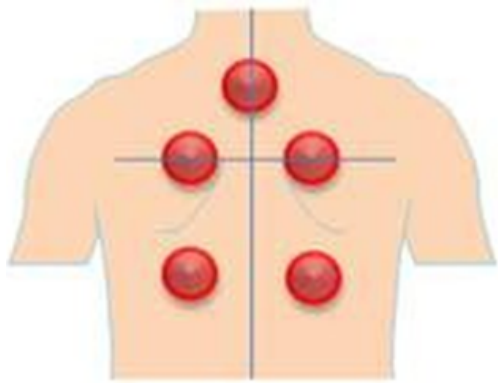


Figure 1: Posterior torso showing points on the skin where wet cupping therapy was applied

**EEG recording**

The EEG signal was recorded according to the standard international 10/20 system, with a sampling rate of 1 kHz. EEG data was recorded by two channel bipolar montage; F4-F8 (right brain hemisphere) and F3-F7 (left brain hemisphere). The digital EEGs were recorded by using PowerLab 26T (AD Instruments, Bella Vista, Australia), a device used for multimodal monitoring of bio-signals. In this study, the EEG was recorded in all participants at baseline (before commencement of wet cupping therapy) and after wet cupping therapy. EEG frequency bands considered for analysis were (1-3 Hz), theta waves (4-7 Hz), alpha waves (8-12 Hz), beta waves (13-30 Hz), gamma<sub>1</sub> waves (31-40 Hz), gamma<sub>2</sub> waves (41-50 Hz) and gamma<sub>3</sub> waves (60-80 Hz).

The electroencephalographic signal processing analyses were performed in MATLAB. The changes in frequency and amplitude of the EEG were calculated by means of power spectral analysis, measured as total power in microvolts-squared divided by frequency ( $\mu V^2/Hz$ ) [17]. We used Discrete Fourier Transform (DFT) to calculate the power spectrum of time domain discrete EEG signal.

Power spectral density (PSD) is frequency response of a periodic or random signal. PSD shows distribution of signal strength depending on the frequency. The EEG data were recorded is a time domain discrete signal.

Power spectral density can be expressed with Equation 1;

$$P(k) = \frac{1}{N} \sum_{i=0}^{N-1} |x_i(k)|^2 \quad (1)$$

Where N is the number of samples and  $x_i()$  is the Discrete Fourier Transform (DFT) of the time domain discrete  $x_i()$  signal.  $x_i()$  is calculated as shown in equation 2;

$$x_i(k) = \sum_{n=0}^{N-1} x_i(n) e^{-j(2\pi/N)nk} \quad (2)$$

**Statistical analysis**

The SPSS statistical software package (SPSS, version 18.0 for windows) was used to perform all statistical calculations. Distributions were evaluated by using one sample Kolmogorov Smirnov test. A two-tailed paired t test (Student's t test) was used for comparisons. Results are expressed as mean  $\pm$  standard deviation (SD). Differences were considered statistically significant at  $p < 0.05$ .

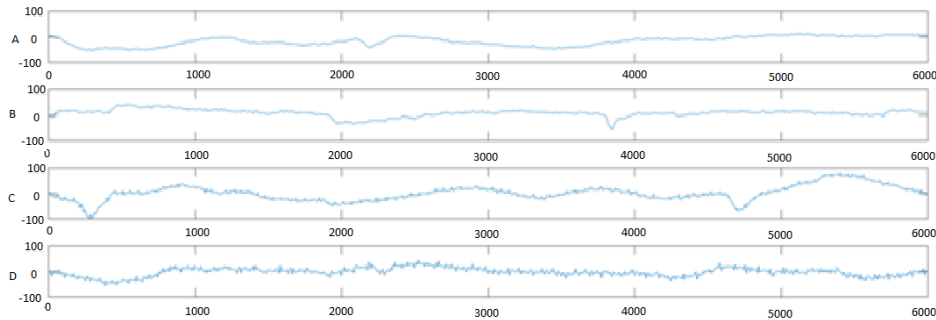
**RESULTS**

In the present study, EEG data of the F4-F8 (the right brain hemisphere) revealed that the powers of beta, gamma<sub>1</sub>, gamma<sub>2</sub> and gamma<sub>3</sub> waves ( $\mu V^2$ ) were increased after wet cupping therapy compared to the EEG tracing of corresponding waves before therapy (beta:  $t=2.21, p=0.04$ ; gamma<sub>1</sub>:  $t=2.37, p=0.04$ ; gamma<sub>2</sub>:  $t=2.48, p=0.03$ ; gamma<sub>3</sub>:  $t=2.51, p=0.02$ ). Comparison between the powers ( $\mu V^2$ ) of other waves (theta, delta and alpha) before and after therapy did not show any significant value. Similarly, percentages of all waves before therapy were not significantly different from their corresponding wave values after therapy (Table 1, Figures 2, 3 and 4).

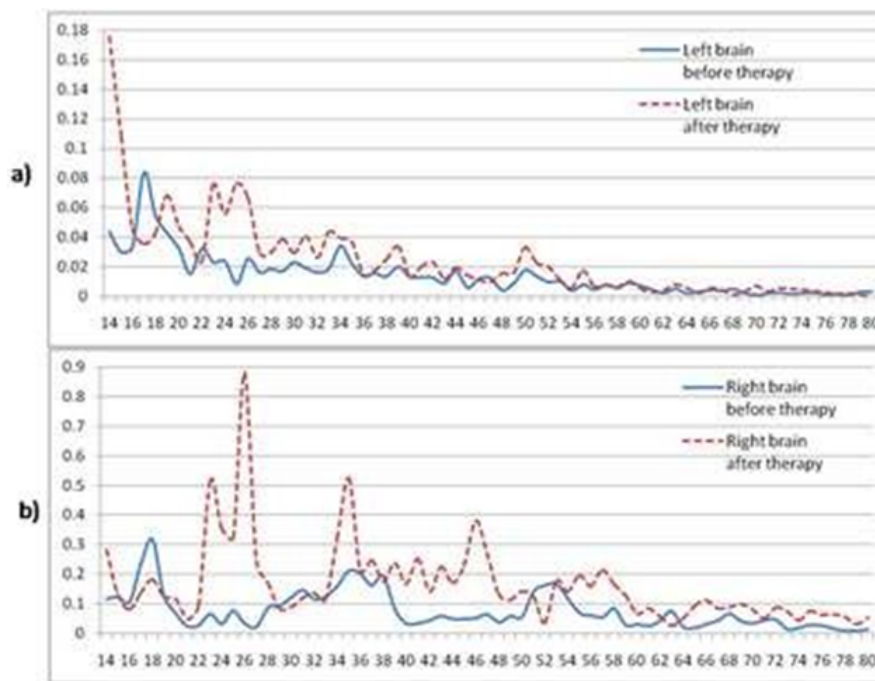
Table 1: Powers and percentages of EEG bands before and after wet cupping therapy in the right brain (F4-F8) hemisphere

Parameters	Before Therapy		After Therapy		t	p
	Mean	SD	Mean	SD		
Total Power ( $\mu V^2$ )	75.91	52.56	51.06	21.12	2.71	0.01
Delta Power ( $\mu V^2$ )	67.29	51.47	39.39	25.52	3.12	0.004
Theta Power ( $\mu V^2$ )	2.78	1.38	2.67	1.07	0.45	NS
Alpha Power ( $\mu V^2$ )	1.41	1.03	1.35	0.46	0.45	NS
Beta Power ( $\mu V^2$ )	2.78	2.29	4.61	3.66	4.71	0
Gamma <sub>1</sub> Power ( $\mu V^2$ )	0.96	0.94	1.76	1.69	4.41	0
Gamma <sub>2</sub> Power ( $\mu V^2$ )	0.68	0.76	1.28	1.32	4.39	0
Gamma <sub>3</sub> Power ( $\mu V^2$ )	0.35	0.38	0.79	0.91	3.36	0.002
Delta Power %	84.3	13.94	70.56	16.42	4.21	0
Theta Power %	4.51	1.55	6.39	2.67	3.44	0.002

Alpha Power %	2.56	1.96	3.85	2.21	3.54	0.001
Beta Power %	5.54	7.19	11.95	9.66	3.69	0.001
Gamma <sub>1</sub> Power %	1.77	2.64	4.32	4.16	3.82	0.001
Gamma <sub>2</sub> Power %	1.32	2.31	2.93	2.67	3.51	0.001
Gamma <sub>3</sub> Power %	0.64	1.08	1.84	2.06	3.45	0.001



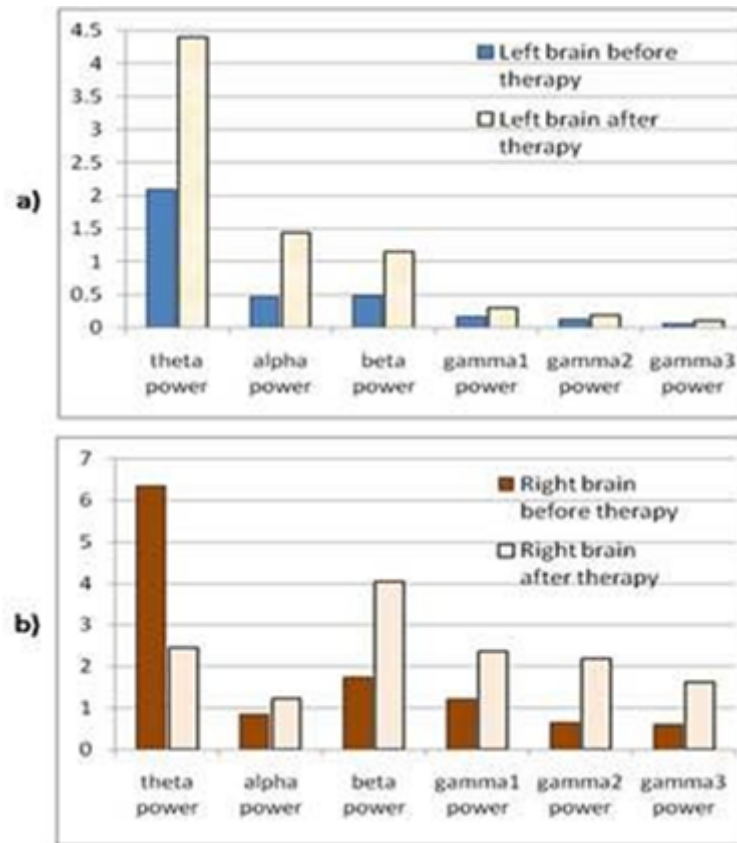
**Figure 2: EEG record of a subject (x axis; time domain (ms), y axis; volts ( $\mu\text{V}$ )) (A) Left brain hemisphere before therapy time domain EEG, (B) Right brain hemisphere before therapy time domain EEG, (C) Left brain hemisphere after therapy time domain EEG, (D) Right brain hemisphere after therapy time domain EEG**



**Figure 3: EEG power spectral density of the same subject (x axis: frequency (Hz), y axis: power ( $\mu\text{V}^2$ )) (A) Left brain hemisphere before and after therapy (4 Hz to 80 Hz), (B) Right brain hemisphere before and after therapy (4 Hz to 80 Hz)**

In the F3-F7 (left hemisphere) EEG, the powers of beta, gamma<sub>1</sub>, gamma<sub>2</sub> and gamma<sub>3</sub> waves ( $\mu\text{V}^2$ ) were increased after wet cupping therapy compared to corresponding EEG tracing recorded before therapy (beta:  $t=2.45$ ,  $p=0.03$ ; gamma<sub>1</sub>:  $t=2.27$ ,  $p=0.04$ ; gamma<sub>2</sub>:  $t=2.19$ ,  $p=0.04$ ; gamma<sub>3</sub>:  $t=2.45$ ,  $p=0.03$ ). Also, there was

significant increase in percentages of gamma<sub>1</sub>, gamma<sub>2</sub> and gamma<sub>3</sub> (gamma<sub>1</sub>:  $t=2.71$ ,  $p=0.03$ ; gamma<sub>2</sub>:  $t=2.18$ ,  $p=0.018$ ; gamma<sub>3</sub>:  $t=2.87$ ,  $p=0.02$ ). The powers of theta, delta and alpha and percentages of theta, delta, alpha and beta waves were not statistically significant (Table 2, Figures 2, 3 and 4).



**Figure 4: The powers of different EEG bands (x axis: band, y axis: power ( $\mu V^2$ )) (A) Left brain hemisphere before and after therapy, (B) Right brain hemisphere before and after therapy**

**Table 2: Powers and percentages of EEG frequency bands before and after foot reflexotherapy in the left brain (F3-F7) hemisphere**

Parameters	Before Therapy		After Therapy		t	p
	Mean	SD	Mean	SD		
Total Power ( $\mu V^2$ )	86.14	62.28	68.06	27.14	1.77	NS
Delta Power ( $\mu V^2$ )	75.48	58.99	55.49	26.09	2.14	0.04
Theta Power ( $\mu V^2$ )	3.77	1.09	3.57	1.39	0.72	NS
Alpha Power ( $\mu V^2$ )	1.91	1.21	1.46	0.53	3.15	0.003
Beta Power ( $\mu V^2$ )	3.24	2.34	4.44	2.55	4.28	0
Gamma <sub>1</sub> Power ( $\mu V^2$ )	1.02	0.84	1.86	1.46	4.82	0
Gamma <sub>2</sub> Power ( $\mu V^2$ )	0.73	0.57	1.24	0.85	4.05	0
Gamma <sub>3</sub> Power ( $\mu V^2$ )	0.37	0.32	0.72	0.67	3.48	0.001
Delta Power %	81.42	7.89	77.43	8.34	4.42	0
Theta Power %	5.94	2.57	5.83	2.04	0.24	NS
Alpha Power %	3.26	3.21	2.81	1.48	1.09	NS
Beta Power %	4.86	2.82	8.24	4.27	6.19	0
Gamma <sub>1</sub> Power %	1.47	0.99	3.36	2.31	6.15	0
Gamma <sub>2</sub> Power %	1.05	0.69	2.32	1.66	5.47	0
Gamma <sub>3</sub> Power %	0.52	0.37	1.34	1.27	4.63	0

## DISCUSSION

Though EEG is a non-routine investigation, it remains one of the most widely used objective methods of investigating brain activities in both normal and pathology [18-26].

This is the first study to report differences in frontal brain oscillatory beta and gamma waves of the EEG in healthy humans before and after wet cupping therapy. The powers of beta, gamma<sub>1</sub>, gamma<sub>2</sub> and gamma<sub>3</sub> waves of the EEG tracing increased in both the right and left hemispheres after cupping therapy compared with corresponding data recorded before cupping therapy. Also, the percentages of all gamma waves in EEG were increased after wet cupping therapy especially in right brain. These results indicate that this complementary therapy might have helpful effects on central nervous system functions in humans.

Similar to our previous results on the effects of reflexotherapy [14] and footbath therapy [15] on cortical functions, this present study also showed that application of wet cupping therapy resulted to frontal cortex activation as evidenced by increase mainly in beta and gamma waves. This suggests that the effect of wet cupping on cortical functions may be due to the skin puncture and vacuum pumping effects. The procedure stimulates cutaneous sensory receptors that consequently generate signals, which are sent to the central nervous system to activate the respective frontal areas [19]. Though wet cupping is widely known to enhance removal of toxins from the body, its effects on the brain is largely due to the local stimulation of cutaneous receptors produced by skin puncture and vacuum pumping. Beta wave is associated with normal waking consciousness, and is normally observed in the fronto-central regions of EEG recording [20]. Beta wave represents sensory motor rhythm and is related to cognitive processing and motor control [21]. Gamma waves are important for perceptual and cognitive processes [22]. Therefore an increase in beta and gamma waves indicates enhanced higher mental functions [23-25,27]. Though the underlying mechanisms of generation of these waves are not exactly clear, animal models suggest a possible role of GABA-A system in the hippocampus, dentate gyrus, and CA1-CA3 system [23]. Indeed, these brain regions are involved in long-term memory formation and cognitive performance [9,14].

Our study suggests that beta and gamma waves can be used as functional markers of cortical activation in wet cupping therapy. This complementary therapy may serve as a means of increasing cognitive functions in humans with cognitive deficit. Indeed wet cupping therapy is currently used as an adjuvant in some neurological diseases such as chronic non-specific neck pain [28], lumbar disc herniation, cervical spondylosis [29], brachialgia paraesthetica nocturna [30], fibrositis [31], fibromyalgia [32], chronic knee osteoarthritis [33] and other pain conditions [34,35]. Interestingly, a recent study reported that stimulation of the left cerebral

hemisphere with wet cupping therapy decreased the autistic symptoms in children with autism [36,37].

However, in contrast to our previous study on foot reflexotherapy, in which delta power for both frontal brain was decreased [14], in this present study, delta power was significantly increased in both hemispheres following wet cupping therapy. Delta wave is a low frequency wave that is associated with sleep, but not related to cognitive activities. Though sleep quality was not assessed in our study before and after cupping therapy, the result suggests that wet cupping therapy may enhance sleep quality or duration. Indeed, Cikar *et al.* showed that wet cupping therapy significantly improved sleep quality in healthy men and women [36].

Cupping therapy relieves the symptoms in a variety of diseases or clinical conditions through its effects on the regional acupoint areas. For example, Tham *et al.* showed that cupping maybe capable of stimulating individual acupuncture points [38]. Among the stimuli, the negative pressure applied during cupping is one of the main factors that induce therapeutic effects. Though the underlying mechanism of therapeutic effects of the negative pressure from cupping is not completely understood, it may be associated with the release of neurohumoral factors resulting from or due to stimulation of the peripheral and central nervous system. For instance, stimulation of superficial and deep tactile and pain receptors can result to the secretion of b-endorphin and adrenocortical hormone into the circulation, and are transported to their receptive sites, where they exert a variety of influences [1,38].

It is important to mention that factors influencing EEG waves, including disease conditions, physiological states, age, gender, as well as artifacts [39-42] were greatly minimized in our study. Importantly, the influence of gender on EEG tracing is increasingly been reported in the literature [43-45]. Consequently we considered only males in the study, due to the gender differences in EEG tracing, and also, the effects of certain physiological state (e.g. menstrual cycle) and hormones on EEG waves [46-48].

## CONCLUSION

Wet cupping therapy increases the frontal brain beta and gamma activities of EEG. The beta and gamma waves can be used as important functional measures of frontal brain activation in wet cupping therapy. This increase in oscillatory beta and gamma cortical waves may be mediated by stimulation of the peripheral nervous system, and possibly, corresponding increase in secretion of certain neurohumoral factors.

## FUTURE DIRECTIONS

Since the present study consisted of only males, whether these results apply to females or children are not known. Therefore, it is imperative for future studies to investigate the cortical electrophysiology of wet cupping therapy on females and children as well as different

categories of patients with neurodevelopmental, neurodegenerative and psychiatric disorders.

#### CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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