European Journal of Integrative Medicine 8 (2016) 453–457

Contents lists available at ScienceDirect

European Journal of Integrative Medicine

journal homepage: www.elsevier.com/eujim

Research paper

Effect of inhalation of essential oil from *Inula helenium* L. root on electroencephalographic (EEG) activity of the human brain

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ARTICLE INFO

Article history:
Received 18 December 2015
Received in revised form 25 January 2016
Accepted 25 January 2016

Keywords:
Alertness
Electroencephalograph
Essential oil
Inhalation
Inula helenium
Theta wave

ABSTRACT

Introduction: In traditional systems of medicine, *Inula helenium* root is widely used for the management of various ailments. The present work investigates the effect of inhalation of essential oil from the root of *I. helenium* on electroencephalographic (EEG) activity of the human brain.
Methods: The effect of inhalation of *I. helenium* essential oil on EEG activity was evaluated by the measurement of the EEG power spectrum in 20 healthy participants. The EEG spectrum values were recorded using QEEG-8 system from 8 ground electrodes according to the International 10–20 System.
Results: The results showed that the inhalation of essential oil of *I. helenium* produced significant changes in the EEG power spectrum values. The reduction of absolute theta (all the regions except T3), beta (Fp1) and mid beta (P4) and relative theta (Fp1, Fp2, F3 and F4) waves were observed during the inhalation. Whereas, the ratio of SMR to theta (Fp1 and P4), SMR ~ mid beta to theta (Fp1) and spectral edge frequency 50% of alpha (P4) significantly increased during the inhalation of *I. helenium* essential oil.
Conclusion: The changes in EEG values due to the inhalation of essential oil of *I. helenium* root may enhance the alertness state of the brain and could be used for the treatment of psychophysiological disorders.

1. Introduction

Historically essential oils from plants have been used widely to treat psychophysiological disorders [1]. It has been observed that fragrances from essential oils can influence the physical and mental conditions of human beings [2]. However, the efficacy of many plants has not been scientifically evaluated [3,4]. The psychological changes induced through the fragrance inhalation of essential oils are generally related to the modulation of olfactory nervous system. Through the olfactory system, the olfactory bulb receives the fragrance signals and provides input to other centers that modify neuronal activity [5,6]. Fragrances affect spontaneous brain activities and cognitive functions and these changes are estimated by electroencephalography (EEG) [7].

Inula helenium L. (Asteraceae) is a perennial herb native to Middle Asia and widely occurs in Asia, Europe and Northern America. The plant is used by traditional healers to treat various diseases such as asthma, bronchitis, cough, indigestion, urinary infections, and skin disorders [8]. The root of *I. helenium* mainly contains eudesmane-type sesquiterpene lactones (alantolactone and isoalantolactone) with various pharamacological properties such as antihelmintic, anti-inflammatory, and antimicrobial activity and the potential to induce detoxifying enzymes [8–10]. The sesquiterpene lactones from *I. helenium* exhibited cytotoxic and antiproliferative activities against human cancer cell lines [11,12]. However, there have been no studies on the effect of fragrance stimulation by the essential oil from *I. helenium* root. The aim of the present study was to investigate the effect of inhalation of essential oil from the root of *I. helenium* on EEG activity of human brain in normal healthy individuals.

2. Materials and methods

2.1. Plant material and extraction of essential oil

The root sample of *I. helenium* was purchased from BN Herb Inc., Pyeongchang, Republic of Korea during the month of August 2012. The essential oil of *I. helenium* root was isolated by steam

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http://dx.doi.org/10.1016/j.eujim.2016.01.005
1876-3820/

Table 1
EEG power spectrum indicators used in this study.

S. No.	Analysis indicators	The full name of the EEG power spectrum indicators	Wavelength range (Hz)
1	AT	Absolute theta	4 ~ 8
2	AA	Absolute alpha	8 ~ 13
3	AB	Absolute beta	13 ~ 30
4	AG	Absolute gamma	30 ~ 50
5	ASA	Absolute slow alpha	8 ~ 11
6	AFA	Absolute fast alpha	11 ~ 13
7	ALB	Absolute low beta	12 ~ 15
8	AMB	Absolute mid beta	15 ~ 20
9	AHB	Absolute high beta	20 ~ 30
10	RT	Relative theta	(4 ~ 8)/(4 ~ 50)
11	RA	Relative alpha	(8 ~ 13)/(4 ~ 50)
12	RB	Relative beta	(13 ~ 30)/(4 ~ 50)
13	RG	Relative gamma	(30 ~ 50)/(4 ~ 50)
14	RSA	Relative slow alpha	(8 ~ 11)/(4 ~ 50)
15	RFA	Relative fast alpha	(11 ~ 13)/(4 ~ 50)
16	RLB	Relative low beta	(12 ~ 15)/(4 ~ 50)
17	RMB	Relative mid beta	(15 ~ 20)/(4 ~ 50)
18	RHB	Relative high beta	(20 ~ 30)/(4 ~ 50)
19	RST	Ratio of SMR to theta	(12 ~ 15)/(4 ~ 8)
20	RMT	Ratio of mid beta to theta	(15 ~ 20)/(4 ~ 8)
21	RSMT	Ratio of SMR ~ mid beta to theta	(12 ~ 20)/(4 ~ 8)
22	RAHB	Ratio of alpha to high beta	(8 ~ 13)/(20 ~ 30)
23	SEF50	Spectral edge frequency 50%	4 ~ 50
24	SEF60	Spectral edge frequency 90%	4 ~ 50
25	ASEF	Spectral edge frequency 50% of alpha	8 ~ 13

distillation technique (Hanil LabTech., Republic of Korea). The distillation was carried out for a period of 150 min (yield, 0.02% w/v).

2.2. Ethics

The study followed the Declaration of Helsinki on Biomedical Research Involving Human Subjects and was approved by the ethics committee from the Kangwon National University Hospital, Chuncheon, Republic of Korea.

2.3. Subjects

Twenty right-handed healthy volunteers (Students) from Department of Biological Environment, Kangwon National University (10 men and 10 women) aged 20–30 years participated in this study. None of the participants had olfactory diseases, physical or mental health problems, smoked or abused drugs. Informed consent was obtained from each subject before participation.

2.4. Experimental design

A single group pre-test and post-test experimental design was used in this study (20 subjects). A careful measurement was carried out before and during the inhalation of essential oil. Prior to experiment, the subjects were screened for an olfactory evaluation test by using the commercial perfumes. The subjects were told the purpose of the study was to determine the effect of inhalation of essential oil on EEG activity. After the EEG recordings, the participants were asked to give their preference and impression of the fragrance of *I. helenium* essential oil. Further, none of the participants indicated that they felt that the essential oil had affected them in any way.

2.5. EEG recordings

The EEGs were recorded using QEEG-8 system (LXE3208, LAXTHA Inc., Daejeon, Republic of Korea). The electrodes (silver/silver chloride) were placed on the scalp at left prefrontal (Fp1), right prefrontal (Fp2), left frontal (F3), right frontal (F4), left temporal (T3), right temporal (T4), left parietal (P3) and right parietal (P4) according to the International 10–20 System. All electrodes were referenced to the ipsilateral earlobe electrodes. The EEG sampling rate of the measured subjects was 256 Hz, filtered in the range of 0.5–50 Hz, and the readings were stored in a computer by the 12-bit AD conversion. The ECI electrode gel (Electro-gel™, Electro-Cap International Inc., Eaton, Ohio, USA) was applied into each electrode to connect with the surface of the scalp in order to drop the electric resistance of the scalp below 5 kΩ.

2.6. Odor administration

Essential oil of *I. helenium* root was used as the odor stimulus. The EEG measurement room was maintained with a constant temperature (23 °C) and humidity (50%). The subjects were instructed to sit quietly, close their eyes and to breathe normally during the measurement. The undiluted essential oil of *I. helenium* (10 μL) was spotted on the filter paper then placed about 3 cm in front of the subject's nose. The fragrance exposure was presented only once per subject. The EEG readings were recoded 45 s before and another 45 s during the inhalation. And the interval time between before and during the analysis was 3 min.

2.7. Data analysis

The mean power values [microvolt (μV)] were calculated for 25 EEG analysis indicators (Table 1). The t-mapping of EEG waves of brain was constructed by using Telescan software package (LXSMD61, LAXTHA Inc., Daejeon, Republic of Korea). The SPSS statistical package version 18 (SPSS, Inc., IL, USA) was used for data analysis on EEG activity before and during the exposure of essential oil by a paired *t*-test based on the EEG power spectrum values.

3. Results

The results of EEG changes and t-mapping of brain are presented in Table 2 and Fig. 1. The main characteristic smells of essential oil from the root of *I. helenium* are woody, balsamic and earthy. Out of 25 EEG indices, significant changes were observed in