The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/2586-940X.htm

Received 1 May 2017
Accepted 1 June 2017

The effects of unilateral Swedish massage on the neural activities measured by quantitative electroencephalography (EEG)

Nattakarn Kaewcum
Research Center for Neuroscience, Institute of Molecular Biosciences, Mahidol University, Salaya, Thailand and
Faculty of Physical Therapy, Rangsit University, Pathum Thani, Thailand, and
Vorasith Siripornpanich
Research Center for Neuroscience, Institute of Molecular Biosciences, Mahidol University, Salaya, Thailand

Abstract

Purpose – It is generally accepted that massage can provide a lot of benefits to human health, especially for the brain functions. Little is known about the effect of unilateral massage on the brain activities. Nowadays, Swedish massage is a modern massage technique that is popular in both treatment and research fields. The purpose of this paper is to investigate the effect of unilateral Swedish massage on brain activities with electroencephalography (EEG) recording.

Design/methodology/approach – In total, 18 healthy adult participants (5 men, 13 women) aged between 22 and 36 years were massaged over one side of arm, forearm, hand, neck and face. Then the same procedures were repeated to another side of the body. EEG was recorded before (baseline) and during each massage condition. The absolute power of four common brain waves consisting of δ (0.5-4 Hz), θ (4-8 Hz), α (8-13 Hz), and β activities (13-30 Hz) from the quantitative EEG analysis between baseline and each massage condition were used to compare with the paired *t*-test.

Findings – The study found the reduction of δ and θ powers over bilateral frontal, fronto-central, and central areas. The increments of α power over the similar brain areas were also observed. These findings indicated the generalized effect of unilateral Swedish massage for inducing relaxation. Moreover, the significant reduction of β power was also found over right central area when left-arm massage was applied. This finding revealed the initial inhibitory effect of Swedish massage over right somatosensory cortex that received sensory stimulation through massage from left side of the body.

Originality/value – Unilateral Swedish massage induced the inhibitory effect at the contralateral somatosensory cortex and then produced the generalized effect which is compatible with relaxation.

Keywords Absolute power, Brain waves, Electroencephalography, Swedish massage, Unilateral massage

Paper type Research paper

Introduction

Presently, the complementary and alternative medicine (CAM) is gaining a lot of attention worldwide. The Cochrane Collaboration defines CAM as that "includes all such practices and ideas which are outside the domain of conventional medicine in several countries and defined by its users as preventing or treating illness, or promoting health and well-being"[1].

The authors would like to gratefully thank Associate Professor Chailerd Pichitpornchai, Department of Physiology, Faculty of Medicine, Siriraj hospital, Mahidol University, Bangkok, Thailand for allowing the authors to use his EEG recording system and also thank you for all participants in this study.

In general, CAM can be categorized into five forms consisting of biologically based approaches (vitamin, mineral, functional foods), energy therapies (visible light, laser beam, electromagnetic), manipulative and body-based therapies (chiropractic, massage, reflexology), mind-body intervention (relaxation, biofeedback) and whole medical systems (homeopathy, acupuncture)[2]. CAM has been proposed to be able to treat several diseases such as cancer, inflammatory bowel disease and rheumatoid arthritis[3-5]. Although there are some arguments regarding the effectiveness of CAM for the treatment of physical illness, it is generally accepted that CAM techniques can induce comfort and relaxation.

There are several research techniques to reveal the relaxation-promoting effect of CAM. Electroencephalography (EEG) is the most commonly used neuroscience equipment to study the neural activities in living humans. The brain waves recorded by EEG were frequently described in term of their frequencies consisting of δ (0.5-4 Hz), θ (4-8 Hz), α (8-13 Hz) and β waves ($>$ 13 Hz)[6]. The brain activities are dynamic and their appearances are mainly dependent on the level of consciousness. β wave, the marker of cortical neuron activities, is predominantly found during awake with active thinking, while α wave is the predominant brain wave during awake and relaxation. Regarding the slow brain activities, θ and δ waves represent the states of drowsiness/light sleep and deep sleep, respectively[6, 7]. The research works using EEG in various types of CAM have been reported. For examples, an EEG study in yoga/tai chi found the trend for θ power increasing which suggested the relaxation effect[8]. Another EEG study in Qigong showed increased θ and α activities that were also related to relaxation[9]. These research works confirmed the utility of EEG as the research tool for demonstration of relaxation-promoting effects of various CAM techniques.

Massage is one type of CAM treatment which is popular[2, 10]. Moraska *et al.*[11] define massage as "the manipulation of soft tissues for the purpose of producing physiological effects on the vascular, muscular or nervous systems of the body." Many research works have suggested that massage provide a lot of benefits in both physiological and pathological states[12-14]. Eriksson *et al.*[13] demonstrated the reduction of muscle stiffness by massage. In addition, the study about Thai foot massage revealed the improvement of balance, range of motion of foot, and foot sensation in diabetes patients after treatment[12]. In patients with stroke, the touch massage also decreased pain feeling and improved quality of life and sensorimotor functions[14]. Moreover, there are a number of research works on the brain effect of massage using EEG recording. A study using the manual lymph drainage (MLD), a type of massage, showed the increment of α and δ powers in psychological stress subjects, which indicated that MLD could promote relaxation[15]. In addition, a research with acupressure massage showed asymmetrical α power reduction between central and posterior brain regions that are proposed to be related with the positive emotion[16]. For the underlying mechanisms of relaxation-promoting effects of massage, it is thought to involve with increased vagal tone and parasympathetic activities as shown by reduction of various physiological parameters including heart rate, blood pressure, anxiety, salivary cortisol and plasma brain-derived neurotrophic factor levels[17-21].

Swedish massage, a type of modern massage, is commonly used as an intervention in a number of research works and also as the standard treatment in several countries[22]. This massage was developed by Per Henrik Ling and became the base of several modern massage techniques[23]. The principle of Swedish massage is to apply pressure on muscle in direction of blood flow back to the heart[10]. Swedish massage composes of five main techniques as effleurage, petrissage, friction, tapoment and vibration[10]. In several experiments on Swedish massage, researchers usually focus on its physiological effects, including reduced blood pressure, heart rate, respiratory rate, body temperature, and inflammatory markers[10, 17, 24-26]. However, only few research works have investigated the effect of Swedish massage on the brain activities measured by EEG[19, 20, 27]. Wu *et al.*[20] found that Swedish massage with aromatherapy led to decrease δ and increase

α waves, indicating the relaxation effect. Moreover, several studies found that Swedish massage on back, neck, shoulders, arms, and hands resulted in increased δ wave, whereas decreased α and β activities. These EEG results suggest the sleep-promoting effects of this kind of massage[19, 27]. These research evidence confirmed the role of Swedish massage on the modulation of cortical arousal. However, to the best of our knowledge, there is no study about the effect of unilateral Swedish massage on brain activities.

As mentioned above, Swedish massage produces the alteration of brain and body functions as a generalized effect, but the information of local neural activity changes after unilateral massage is limited. In this study, we planned to study the effect of unilateral Swedish massage on brain waves measured by EEG in search of the non-invasive intervention that can modulate the neural activities. Our hypothesis is that the unilateral Swedish massage can alter the local cortical activities in contralateral somatosensory cortex and then produce the generalized effect.

Materials and methods

Participants

In total, 18 graduate students (5 male and 13 female) participated in this study. The mean age of participants was 28.11 ± 4.24 years (22-36 years). All were healthy persons with right handedness assessed by Edinburgh Handedness Inventory[28] and free of neurological diseases. Exclusion criteria comprised of history of neurological and psychiatric illnesses including substance abuse, history of significant head injury, and receiving CNS-acting medication. Informed consents were obtained from the participants after careful explanation. The experimental protocol was conducted according to the Helsinki Declaration and approved by the Mahidol University Central Institutional Review Board (MU-CIRB, COA No. MU-CIRB 2017/087.0805).

Massage procedures

The massage procedures were performed by a physical therapist (N.K.) with a moderate pressure at the afternoon period for all participants. Participants lay down on the picnic bed and then Swedish massage with powder was applied to arms and face, respectively. The reason to use powder was to prevent the systemic effects from the absorption of massage oil. During massage, EEG was also recorded. The reason to select arms and face as the target sites of massage is because the brain regions responsible for these body parts are relatively large when compared to the brain area for legs. For arm massage, the procedures cover the massage of arms, forearms, hands and neck. The detailed massage procedures are described below:

- Arm: stroking to arm; thumb kneading over deltoid; single-handed kneading to triceps; single-handed kneading to biceps; picking up to triceps; picking up to biceps; and stroking to arm.
- Forearm: thumb kneading to flexors of wrist; thumb kneading to extensors of wrist; picking up to flexors of the wrist; picking up to extensors of the wrist; and stroking to arm.
- Hand: thumb kneading between metacarpals (dorsal aspect); thumb kneading to thenar and hypothenar eminences and palm; traction to the fingers; and shaking arm.
- Neck: thumb gliding on levator scapulae; digital kneading to pectoralis major; and digital kneading to upper trapezius.

After the arm massage, the facial massage was performed as follows:

- Face: circular kneading below eye; circular kneading to nasolabial furrow; circular kneading over the cheek; circular kneading to masseter; slide fingers out to corner of the mouth; light tapping over the face; and cover the eye and press gently.

In addition, face massage was not performed on the forehead area. The massage in upper face region near the forehead was also carefully performed to avoid any artifact from the muscle activities.

Assessment procedures

Participants were instructed to close the eyes for five minutes in baseline condition. Then, therapist applied Swedish massage on unilateral arm and face (starting with left or right side by randomization), respectively. The duration of massage on each side of the body was 25 minutes consisting of 20 minutes for arm massage and 5 minutes for facial massage. Between arm and face massage conditions, participants were allowed to rest for 5 minutes. After the facial massage was finished, participants were allowed to rest for 20 minutes before receiving massage again over the opposite side of arms and face. All experimental procedures were summarized in Figure 1.

EEG recording

EEG was recorded in three sessions consisting of baseline (eye-closed), during arm massage and during facial massage. Thirty-two Ag-AgCl electrodes attached on the Electro-Cap according to the international 10-20 system[29] were applied to the head of participant. Two additional electrodes were applied on both sides of mastoid bone as the reference points. There were four electrodes placed around the periorbital regions for detecting eye movement artifacts. All electrodes were connected to the input box of the EEG recording system. The EEG software used in this experiment was NeuroScan version 4.3 (Neurosoft, Inc.). After applying Electro-Cap, the EEG gel was applied onto all electrode sites to keep the impedance less than 5 KΩ. The pre-recording filter was set at 0.1-60 Hz. Notch was opened at 50 Hz.

Data analysis

The EEG data were analyzed by Fast Fourier transform (FFT). The absolute power of brain waves consisting of δ (0.5-4 Hz), θ (4-8 Hz), α (8-13 Hz) and β waves (13-30 Hz) were used for comparison among experimental conditions. Before the EEG analysis, any artifacts on EEG data were initially removed by manual selection by experienced Pediatric Neurologist (V.S.). The EEG analysis was performed by cutting the continuous EEG data into small EEG segments with 2,000 milliseconds in length. Artifact rejection was set at ± 80 Hz. Post-recording band-pass filter was set at 0.3-30 Hz. All EEG segments were averaged in frequency domain by FFT and presented in absolute power (μV^2) of four ranges of brain waves.

Statistical analysis

The experimental data were shown as mean ± SD. The Statistical Package for the Social Sciences version 18 was used in this study. The paired *t*-test was used to compare brain waves' power between eye-closed and massage conditions. The significant difference was set at p-value < 0.05.

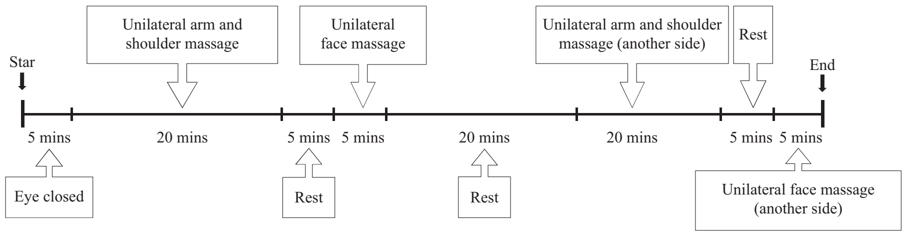


Figure 1. The experimental procedures

Results

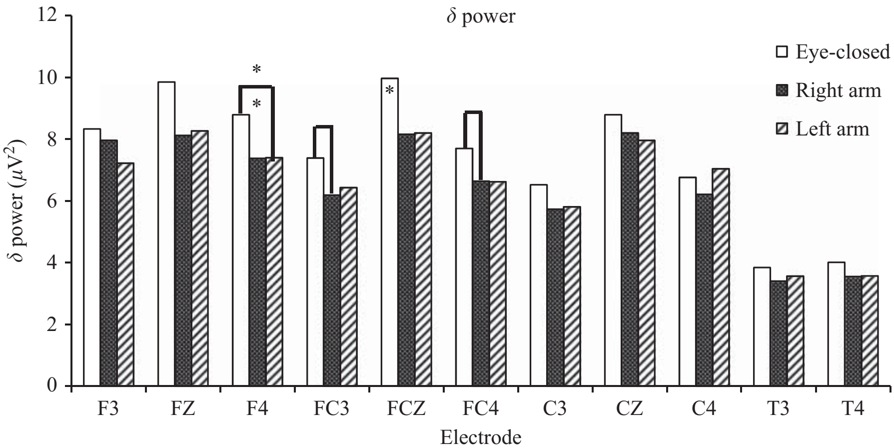
The results in this work were presented in the absolute power of the four brain wave frequencies consisting of δ, θ, α, and β waves in each massage condition compared to eye-closed condition.

During the right-arm massage, the statistically significant reduction of δ powers were observed over FC3 and FC4 electrodes when compared to baseline condition ($p < 0.05$). Similarly, the δ power during left-arm massage was significantly lower than baseline condition at F4 electrode ($p < 0.05$). The qEEG results in the δ range during arm massage conditions compared to eye-closed (baseline) were shown in Figure 2. However, there was no significant difference of mean δ power between baseline and face massage conditions.

In θ range, our results showed reduced θ power at midline electrodes over frontal (FZ), fronto-central (FCZ) and central (CZ) brain areas in nearly all massage conditions, compared to eye-closed condition. Regarding electrodes in both sides of the brain, this work found significantly decreased θ activities over F3, FC3, C3, F4, FC4, C4, and T4 electrodes during right-arm massage, compared to resting-state condition ($p < 0.05$). Likewise, θ power during left-arm massage is also significantly lower than baseline over F3, FC3, C3, T3, F4, FC4, and C4 electrodes ($p < 0.05$). The topographic brain mapping (TBM) of θ power during both arm massage conditions and baseline condition are shown in Figure 3. Regarding the facial massage, the statistically significant reduction of θ power was observed over F3, FC3, C3, F4, FC4, and T4 electrodes ($p < 0.05$) during right-side facial massage. Left-side facial massage also significantly reduced over F4 and FC4 electrodes, compared to baseline ($p < 0.05$) (Table I).

For the α power analysis, this result showed a significant increase in α power during right-arm massage over FZ, F3, F4, FCZ, FC4, PZ, P4, and T3 electrodes ($p < 0.05$), compared to eye-closed recording. However, the mean α power in left-arm massage was not significantly different from baseline condition. Figure 4 showed the TBM of α power among left-arm massage, right-arm massage and baseline conditions. In facial massage, a significant increment of α power was found over FZ, F3, F4, FCZ, FC3, FC4, CZ, C4, PZ, P4, and T3 electrodes in right-side face massage ($p < 0.05$), while α power during left-side face massage also significantly increased over F4 electrode ($p < 0.05$), compared to eye-closed session (Table II).

The analysis of β wave power revealed that left-arm massage had significantly lower β power than eye-closed (baseline) condition over C4 electrode (0.52 ± 0.33 vs 0.59 ± 0.39 for



Notes: *Significant difference, p-value<0.05

Figure 2.
The δ power over frontal (F), fronto-central (FC), central (C) and temporal (T) electrodes comparing between eye-closed and arm massage conditions

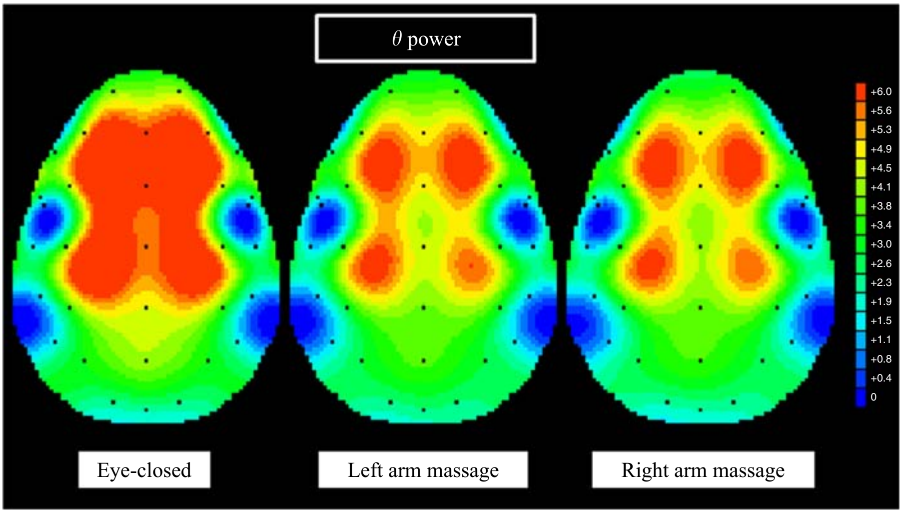


Figure 3. The topographic brain mapping of θ power during eye-closed (baseline), left-arm and right-arm massage conditions

Table I. The θ power over frontal (F), fronto-central (FC), central (C) and temporal (T) electrodes comparing between eye-closed and all massage conditions

		θ power (μV^2)			
		Massage conditions			
Electrode	Eye closed	Right arm	Left arm	Right face	Left face
FZ	5.72 ± 3.08	4.38 ± 2.47*	4.51 ± 2.30*	4.41 ± 2.74*	5.00 ± 2.91*
FCZ	5.95 ± 3.01	4.40 ± 2.35*	4.53 ± 2.27*	4.38 ± 2.58*	5.08 ± 2.91*
CZ	5.30 ± 2.78	3.97 ± 2.17*	4.14 ± 2.17*	4.01 ± 2.48*	4.69 ± 2.79
Left electrode					
F3	4.58 ± 2.40	3.71 ± 2.08*	3.75 ± 1.92*	3.76 ± 2.24*	4.15 ± 2.31
FC3	4.07 ± 2.04	3.20 ± 1.73*	3.30 ± 1.65*	3.26 ± 1.88*	3.70 ± 2.04
C3	3.58 ± 1.76	2.89 ± 1.49*	2.96 ± 1.44*	2.93 ± 1.67*	3.29 ± 1.77
T3	1.55 ± 0.78	1.31 ± 0.69	1.32 ± 0.62*	1.43 ± 0.85	1.47 ± 0.77
Right electrode					
F4	4.88 ± 2.65	3.82 ± 2.10*	3.88 ± 1.99*	3.87 ± 2.38*	4.27 ± 2.39*
FC4	4.22 ± 2.23	3.32 ± 1.84*	3.34 ± 1.76*	3.48 ± 2.20*	3.76 ± 2.11*
C4	3.70 ± 1.92	2.98 ± 1.56*	2.97 ± 1.53*	3.05 ± 1.82	3.33 ± 1.89
T4	1.53 ± 0.80	1.26 ± 0.61*	1.40 ± 0.86	1.32 ± 0.72*	1.54 ± 0.89

Notes: *Significant difference, p-value < 0.05

left-arm message and baseline conditions, respectively; $p < 0.05$). In addition, the reduction of β power tended to observe over C3 electrode during right-arm massage, compared to baseline condition (0.51 ± 0.33 vs 0.57 ± 0.41 for right-arm massage and baseline conditions, respectively; $p = 0.07$). However, there was no statistical difference of mean β power between facial massage and baseline conditions.

After comparing the neural activities between the left and right hemispheres, we did not find any significant difference in all brain wave's powers between cerebral hemispheres in resting-state conditions and all massage conditions.

Discussion

This study seems to be the first experiment to investigate the effect of unilateral Swedish massage on the brain activities. The results showed that unilateral Swedish massage

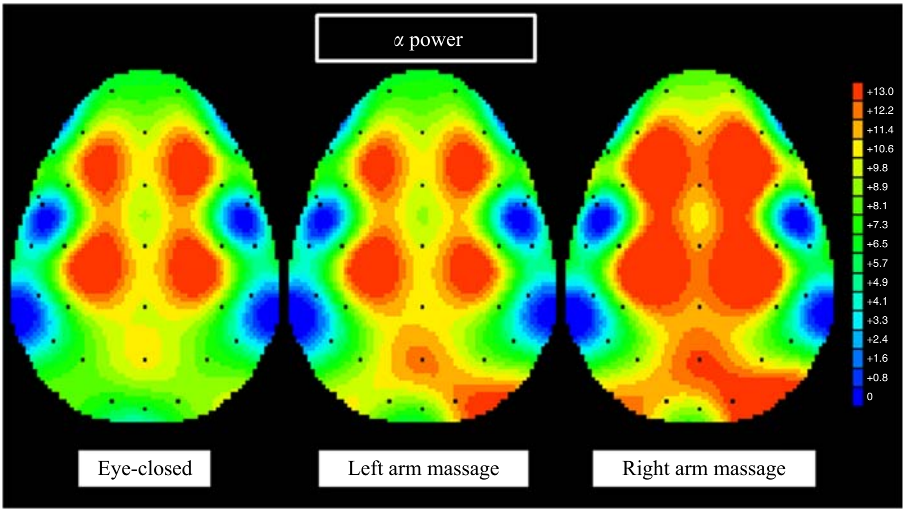


Figure 4.
The topographic brain mapping of α power during eye-closed (baseline), left-arm and right-arm massage conditions

Table II.
The α power over frontal (F), fronto-central (FC), central (C), centro-parietal (CP), parietal (P) and temporal (T) electrodes comparing between eye-closed and all massage conditions

		α power (μV^2)			
		Massage conditions			
Electrode	Eye closed	Right arm	Left arm	Right face	Left face
FZ	8.85 ± 11.17	10.42 ± 11.71*	8.84 ± 8.11	11.10 ± 12.16*	9.88 ± 8.90
FCZ	9.41 ± 12.08	10.92 ± 12.52*	9.36 ± 8.69	11.62 ± 12.94*	10.25 ± 9.20
CZ	9.49 ± 12.29	10.80 ± 12.51	9.49 ± 9.02	11.50 ± 12.95*	10.17 ± 9.16
CPZ	9.46 ± 12.18	10.83 ± 12.32	9.87 ± 9.89	11.59 ± 12.84	10.38 ± 9.48
PZ	9.87 ± 12.56	11.96 ± 12.98*	11.39 ± 12.06	12.81 ± 13.83*	11.65 ± 11.24
Left electrode					
F3	7.72 ± 10.41	9.14 ± 11.02*	7.62 ± 7.26	9.67 ± 11.18*	8.43 ± 7.83
FC3	7.46 ± 9.99	8.59 ± 10.54	7.32 ± 6.95	9.07 ± 10.60*	7.93 ± 7.30
C3	7.35 ± 9.55	8.06 ± 9.86	7.09 ± 6.58	8.50 ± 9.86	7.52 ± 6.76
CP3	7.12 ± 9.23	7.83 ± 9.25	7.17 ± 6.55	8.15 ± 9.24	7.54 ± 6.71
P3	7.39 ± 9.00	8.49 ± 9.07	8.13 ± 7.59	8.60 ± 8.97	8.54 ± 8.07
T3	2.93 ± 4.44	3.39 ± 4.78*	2.81 ± 2.96	3.56 ± 4.80*	3.04 ± 3.14
Right electrode					
F4	7.94 ± 10.14	9.44 ± 10.57*	7.85 ± 7.13	10.05 ± 10.93*	8.78 ± 7.82*
FC4	7.72 ± 10.10	8.98 ± 10.38*	7.42 ± 7.00	9.52 ± 10.64*	8.22 ± 7.39
C4	7.70 ± 9.94	8.70 ± 10.03	7.13 ± 6.98	9.13 ± 10.17*	7.73 ± 7.03
CP4	7.38 ± 9.35	8.46 ± 9.35	7.20 ± 7.04	8.80 ± 9.44	7.56 ± 6.60
P4	7.48 ± 9.10	9.38 ± 9.96*	8.37 ± 8.90	9.75 ± 9.97*	8.33 ± 7.52
T4	3.00 ± 4.25	3.40 ± 4.26	2.87 ± 2.69	3.58 ± 4.30	3.17 ± 2.88

Notes: *Significant difference, p-value < 0.05

increased α power, whereas decreased δ, θ and β powers. The alteration of brain wave powers were mainly observed over frontal, fronto-central, and central electrodes. In general, δ and θ rhythms are commonly found in drowsy and sleep periods, while α and β activities are the principle brain waves during waking state. Specifically, α wave is mainly observed during awake with relaxation, while the reduction of slow brain activities including θ and δ waves refers to wakefulness[7, 30]. Therefore, the EEG characteristics found in our study were compatible with awake and relaxation. Several studies also demonstrated the relaxation effects of Swedish massage[10, 11, 19, 31]. Other physiological changes found in Swedish massage including reduction of blood pressure, heart rate, respiratory rate, body temperature, and also anxiety and stress levels were compatible with parasympathetic nervous system activation[10, 11, 19, 31]. In addition, our finding was in line with Wu *et al.*[20] who found that Swedish massage with aromatherapy can reduce δ rhythm and increase α activity. They suggested that these EEG findings were similar to the EEG pattern of meditation and neurofeedback training. Moreover, another study used the moderate pressure of Swedish massage similar to our study which also showed decreased heart rate and self-reported stress as well as feeling of relaxation[7, 31]. On the contrary, there were two studies that used the Swedish massage on back, shoulders, arms, hands and neck. They found increased δ activity and decreased α and β activities which are compatible with sleep-promoting effect[19, 27]. Another study also revealed increased θ and decreased α and β activities after facial massage[32]. They suggested that facial massage also induced drowsiness[32]. Moreover, other studies on the various massage techniques found different results compared to this study. A type of massage called MLD in psychologically stressed participants showed the relaxation effect evidenced by an increment of α and δ powers[15, 33]. A study with acupressure massage revealed asymmetrical α power reduction between central and posterior brain areas that may relate to positive emotion[16]. Furthermore, the Thai traditional massage in patients with scapulocostal syndrome showed the relaxation effect evidenced by increased δ power and decreased θ, α and β powers[34]. The discrepancy of EEG findings among research studies on the CNS effects of massage is explained by the difference in characteristics of massage used in experiments, such as duration and frequency of massage, and posture of participant[19, 27, 32]. In our study, the unilateral massage used in the current work may be another important reason of different EEG patterns.

By comparing the arm and facial massages, this study found that arm massage could induce brain wave altering more than facial massage. The reason may be the difference between duration and procedure of massage. Arm was massaged by hands and fingers for 15 minutes, whereas face was massaged only by fingers for 5 minutes. Thus, the arm massage usually provides more sensory information to the brain than facial massage that may lead to the higher degree of EEG changes. In addition, the result in this study also revealed that right-side massage could induce more brain wave's changes than left-side massage. The reason may be all participants in current work are right-handed persons who prefer to use right hand more than left hand leading to more activities on the right side. Thus, the muscle spasm and pain commonly occur over right side of the body. Massage can reduce pain and muscle spasm via an increased inhibitory tone[35]. The direct activation by massage over one side of body may reduce the spinal reflex excitability as well as the upper motor neuron activities in motor cortex leading to a decrease activation of the lower motor neuron in the spinal cord[35]. Therefore, the massage on the frequently used limb usually triggers more neural activities in the brain, especially in sensorimotor cortex than the massage on the opposite limb.

Considering that the cortical activities are determined by β wave, a significant change of β activities was found over the C4 electrode when massage was applied on the left side. The reduction of β wave over C4 site indicates the diminished cortical activities in the right somatosensory cortex, the brain area for receiving somatosensory information from the left side of body. In addition, the decreased β activities during right-arm massage was also found over C3 electrode near the edge of significance ($p = 0.07$). These qEEG changes look interesting, because they suggest that unilateral Swedish massage can inhibit cortical activities over contralateral somatosensory cortex as the local effect. This finding may be explained by when participant received unilateral Swedish massage, the sensory receptors are activated by tactile and pressure stimulation[19]. Tactile and pressure information travels to the brain by spinothalamic tract and dorsal column-medial lemniscal pathway. Both of them transmit signal to the contralateral cerebral hemisphere in somatosensory cortex. Moreover, the present study also showed increased α and decreased δ and θ activities over bilateral frontal, fronto-central, and central brain regions as mentioned above. These EEG changes were not different between left and right hemispheres suggesting the generalized effect of Swedish massage. Taken together, the unilateral Swedish massage initially inhibits the cortical activities over the contralateral somatosensory cortex, and then provides the generalized effect on both cerebral hemispheres. The generalized effect of unilateral Swedish massage is likely due to the spreading of inhibitory signal from somatosensory cortex to the opposite cortical area via the corpus callosum.

Limitation

There are some limitations in this study. First is the difficulty to apply massage over the forehead region during facial massage. Second, the duration of facial massage and arm massage is not equal. These factors may explain the minimal EEG changes during facial massage, compared to arm massage.

Conclusions

Our study reveals the relaxation-promoting effect considered as the generalized effect of unilateral Swedish massage. The increased α power while reduced absolute powers in other brain wave frequencies are compatible with relaxing sensation. In addition, unilateral Swedish massage also produces the local inhibitory effect on the contralateral somatosensory cortex as demonstrated by the reduction of β power.

References

1. Berman BM. The cochrane collaboration and evidence-based complementary medicine. J Altern Complement Med. 1997 Summer; 3(2): 191-4. doi: 10.1089/acm.1997.3.191
2. Bonevski B, Wilson A, Henry DA. An analysis of news media coverage of complementary and alternative medicine. PLoS One. 2008 Jun; 3(6): e2406. doi: 10.1371/journal.pone.0002406
3. Brien SB, Leydon GM, Lewith G. Homeopathy enables rheumatoid arthritis patients to cope with their chronic ill health: a qualitative study of patient's perceptions of the homeopathic consultation. Patient Educ Couns. 2012 Dec; 89(3): 507-16. doi: 10.1016/j.pec.2011.11.008
4. Kessel KA, Lettner S, Kessel C, Bier H, Biedermann T, Friess H, *et al.* Use of Complementary and Alternative Medicine (CAM) as part of the oncological treatment: survey about patients' attitude towards CAM in a University-Based Oncology Center in Germany. PLoS One. 2016; 11(11): e0165801. doi: 10.1371/journal.pone.0165801
5. Opheim R, Lie Hoivik M, Bernklev T, Jelsness-Jorgensen LP, Moum B. The use of complementary and alternative medicine among patients with inflammatory bowel disease is associated with reduced health-related quality of life. Gastroenterol Res Pract. 2016; 2016: 6453657. doi: 10.1155/2016/6453657
6. Teplan M. Fundamentals of EEG measurement. Meas Sci Rev. 2002; 2(2): 1-11.
7. Boylan M. Moderate pressure massage is best for relaxation and reducing stress. JATMS. 2005; 11(4): 181-2.
8. Field T, Diego M, Hernandez-Reif M. Tai chi/yoga effects on anxiety, heartrate, EEG and math computations. Complement Ther Clin Pract. 2010 Nov; 16(4): 235-8. doi: 10.1016/j.ctcp.2010.05.014
9. Henz D, Schollhorn WI. EEG brain activity in dynamic health qigong training: same effects for mental practice and physical training? Front Psychol. 2017; 8: 154. doi: 10.3389/fpsyg.2017.00154

10. Gholami-Motlagh F, Jouzi M, Soleymani B. Comparing the effects of two Swedish massage techniques on the vital signs and anxiety of healthy women. Iran J Nurs Midwifery Res. 2016 Jul-Aug; 21(4): 402-9. doi: 10.4103/1735-9066.185584

11. Moraska A, Pollini RA, Boulanger K, Brooks MZ, Teitlebaum L. Physiological adjustments to stress measures following massage therapy: a review of the literature. Evid Based Complement Alternat Med. 2010; 7(4): 409-18.

12. Chatchawan U, Eungpinichpong W, Plandee P, Yamauchi J. Effects of Thai foot massage on balance performance in diabetic patients with peripheral neuropathy: a randomized parallel-controlled trial. Med Sci Monit Basic Res. 2015 Apr; 21: 68-75. doi: 10.12659/MSMBR.894163

13. Eriksson CM, Lacourpaille L, Heales LJ, Tucker K, Hug F. Massage induces an immediate, albeit short-term, reduction in muscle stiffness. Scand J Med Sci Sports. 2015 Oct; 25(5): e490-6. doi: 10.1111/sms.12341

14. Lämås K, Häger C, Lindgren L, Wester P, Brulin C. Does touch massage facilitate recovery after stroke? A study protocol of a randomized controlled trial. BMC Complement Altern Med. 2016; 16(1): 50. doi: 10.1186/s12906-016-1029-9

15. Shim JM, Kim SJ. Effects of manual lymph drainage of the neck on EEG in subjects with psychological stress. J Phys Ther Sci. 2014 Jan; 26(1): 127-9. doi: 10.1589/jpts.26.127

16. Chang KM, Luo SY, Chen SH, Wang TP, Ching CT. Body massage performance investigation by brain activity analysis. Evid Based Complement Alternat Med. 2012; 2012: 252163. doi: 10.1155/2012/252163

17. Moyle W, Cooke ML, Beattie E, Shum DH, O'Dwyer ST, Barrett S, *et al.* Foot massage and physiological stress in people with dementia: a randomized controlled trial. J Altern Complement Med. 2014 Apr; 20(4): 305-11 quiz 40-1; doi: 10.1089/acm.2013.0177

18. Westman KF, Blaisdell C. Many benefits, little risk: the use of massage in nursing practice. Am J Nurs. 2016 Jan; 116(1): 34-9, quiz 40-1. doi: 10.1097/01.NAJ.0000476164.97929.f2

19. Field T, Ironson G, Scafidi F, Nawrocki T, Goncalves A, Burman I, *et al.* Massage therapy reduces anxiety and enhances EEG pattern of alertness and math computations. Int J Neurosci. 1996 Sep; 86(3-4): 197-205.

20. Wu JJ, Cui Y, Yang YS, Kang MS, Jung SC, Park HK, *et al.* Modulatory effects of aromatherapy massage intervention on electroencephalogram, psychological assessments, salivary cortisol and plasma brain-derived neurotrophic factor. Complement Ther Med. 2014 June; 22(3): 456-62. doi: 10.1016/j.ctim.2014.04.001

21. Harris M, Richards KC. The physiological and psychological effects of slow-stroke back massage and hand massage on relaxation in older people. J Clin Nurs. 2010 Apr; 19(7-8): 917-26. doi: 10.1111/j.1365-2702.2009.03165.x

22. Willison KD, Andrews GJ, Cockerham WC. Life chance characteristics of older users of Swedish massage. Complement Ther Clin Pract. 2005 Nov; 11(4): 232-41. doi: 10.1016/j.ctcp.2004.10.003

23. Moyer CA, Rounds J, Hannum JW. A meta-analysis of massage therapy research. Psychol Bull. 2004 Jan; 130(1): 3-18. doi: 10.1037/0033-2909.130.1.3

24. da Silva TA, Stripari Schujmann D, Yamada da Silveira LT, Caromano FA, Fu C. Effect of therapeutic Swedish massage on anxiety level and vital signs of intensive care unit patients. J Bodyw Mov Ther. 2017; 21(3): 565-68. doi: 10.1016/j.jbmt.2016.08.009

25. Gregory R, Gilles C, Aude A, Laurie L, Leïla B, Jean-Cyr Y, *et al.* Effects of massage therapy on anxiety, depression, hyperventilation and quality of life in HIV infected patients: a randomized controlled trial. Complement Ther Med. 2017 Jun; 32: 109-14. doi: 10.1016/j.ctim.2017.05.002

26. Supa'at I, Zakaria Z, Maskon O, Aminuddin A, Nordin NA. Effects of Swedish massage therapy on blood pressure, heart rate, and inflammatory markers in hypertensive women. Evid Based Complement Alternat Med. 2013; 2013: 171852. doi: 10.1155/2013/171852

27. Diego MA, Field T, Sanders C, Hernandez-Reif M. Massage therapy of moderate and light pressure and vibrator effects on EEG and heart rate. Int J Neurosci. 2004 Jan; 114(1): 31-44. doi: 10.1080/00207450490249446

28. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory. Neuropsychologia. 1971 Mar; 9(1): 97-113.
29. Jasper HH. The ten-twenty electrode system of the international federation. Electroencephalogr Clin Neurophysiol. 1958; 10: 371-5.
30. da Silva FL. EEG: origin and measurement. In Milert C, Lemieux L, editors, EEG-fMRI. 23rd ed. New York, NY, Berlin and Heidelberg: Springer. 2010; 19-38.
31. Field T, Diego M, Hernandez-Reif M. Moderate pressure is essential for massage therapy effects. Int J Neurosci. 2010 May; 120(5): 381-5. doi: 10.3109/00207450903579475
32. Jodo E, Yamada Y, Hatayama T, Abe T, Maruyama K. Effects of facial massage on the spontaneous EEG. Tohoku Psychologica Folia. 1988; 47(1-4): 8-15.
33. Shim JM, Yeun YR, Kim HY, Kim SJ. Effects of manual lymph drainage for abdomen on the brain activity of subjects with psychological stress. J Phys Ther Sci. 2017 Mar; 29(3): 491-4. doi: 10.1589/jpts.29.491
34. Buttagat V, Eungpinichpong W, Kaber D, Chatchawan U, Arayawichanon P. Acute effects of traditional Thai massage on electroencephalogram in patients with scapulocostal syndrome. Complement Ther Med. 2012 Aug; 20(4): 167-74. doi: 10.1016/j.ctim.2012.02.002
35. Weerapong P, Hume PA, Kolt GS. The mechanisms of massage and effects on performance, muscle recovery and injury prevention. Sports Med. 2005; 35(3): 235-56.

Corresponding author
Vorasith Siripornpanich can be contacted at: vorasith.sir@mahidol.ac.th