STUDY OF BRAIN ACTIVITY ANALYSIS OF DEEP BREATHING

WANEE ROJVIROJ

MASTER OF SCIENCE

IN

ANTI-AGING AND REGENERATIVE SCIENCE

SCHOOL OF ANTI-AGING AND REGENERATIVE MEDICINE

MAE FAH LUANG UNIVERSITY

2013

STUDY OF BRAIN ACTIVITY ANALYSIS OF DEEP BREATHING

WANEE ROJVIROJ

THIS INDEPENDENT STUDY IS A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE E IN ANTI-AGING AND REGENERATIVE SCIENCE

SCHOOL OF ANTI-AGING AND REGENERATIVE MEDICINE
MAE FAH LUANG UNIVERSITY
2013

STUDY OF BRAIN ACTIVITY ANALYSIS OF DEEP BREATHING

WANEE ROJVIROJ

THIS INDEPENDENT STUDY HAS BEEN APPROVED
TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
IN
ANTI-AGING AND REGENERATIVE SCIENCE
2013

INDEPENDENT STUDY COMMITTEE

....CHAIRPERSON
(Prof. Dr. Thamthiwat Nararatwanchai)

....ADVISOR
(Prof. Dr. Vichit Punyahotra)

....CO-ADVISOR
(Asst. Prof. Dr. Wichian Sittiprapaporn)

....CO-ADVISOR
(Dr. Ariya Sarikaphuti)

....EXTERNAL EXAMINER
(Assoc. Prof. Dr. Wongdyan Pandii)

ACKNOWLEDGEMENTS

First, I would like to express my sincere appreciation to Professor Dr. Vichit Punyahotra (Advisor), Assistant Professor Dr. Wichian Sittiprapraporn, Dr. Ariya Sarikaphuti, and Associate Professor Dr. Wongdyan Pandii for their excellent guidance's and suggestions which encouraged me throughout this study. Without their support, this work would not have been a success.

I am grateful to the staff of School of Anti-Aging and Regenerative Medicine Mae Fah Luang University for their professionalism in handling their work.

In particular, my sincere gratitude also extends to all my colleagues and others who have provided helpful opinions and suggestions at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. And last but not least, I thank my family for their cheerfulness.

Wanee Rojviroj

Independent Study Title Study of Brain Activity Analysis of Deep Breathing

Author Wanee Rojviroj

Degree Master of Science (Anti-Aging and Regenerative Science)

Advisor Prof. Dr. Vichit Punyahotra

ABSTRACT

Study of Brain Activity Analysis of Deep Breathing was examined in sixteen healthy participants on stress level, and each type of brainwaves related to deep breathing. All brainwaves were recorded by electroencephalogram (EEG). Deep breathing rate was at six breaths per minute: four seconds for inhalation, two seconds for holding the air, and four seconds for exhalation, respectively. The study found that deep breathing induced relaxation and improved mental health as confirmed by Thai Stress Test. In addition, deep breathing affected to both Theta and Delta brainwaves during resting state as in eyes-closed trial. The deep breathing at trial 2 and 3, ranging approximately four to six minutes might be the most appropriate time for the participants to successfully accumulate alpha brainwave.

Keywords: Deep Breathing/Brain Activity/Relaxation

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF FIGURES (continued)

Figure **Page**

LIST OF FIGURES (continued)

Figure **Page**

SYMBOLS AND ABBREVIATION

n	=	Sample size
$\bar{x}$	=	Mean
$\bar{d}$	=	Mean difference
$S\bar{d}$	=	Standardized mean difference
SD	=	Standard deviation
EO	=	Eyes-open
EC	=	Eyes-closed
Pre	=	Before deep breathing trials
Post	=	After deep breathing trials
TST	=	Thai Stress Test
DB	=	Deep breathing
Neg	=	Negative feeling
Pos	=	Positive feeling
p	=	Probability value (P-value) of a statistical hypothesis test
t	=	t-test
*	=	Statistical significant level at 0.05

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Nowadays, people are in the midst of modern life and technology. Most people are hardly able to avoid confronting frustrated situations; as it is inevitable to encounter with stress. Stress is a response mechanism to stressor such as workload, lifestyle, environment, physical, emotions and so on. Stress is categorized as one of the most toxic substance to human body. It is one of the brain activities that is opposite to relaxation. It greatly reduces overall quality of life and accelerates body aging processes. There are many attempts to discover techniques to counter stress by invention of new products and adaptation to the environment. Moreover, most techniques needed special equipment which are costly and require time consuming procedure. Therefore, there is a need to look back to the basic of life support that can be utilized from nothing. The vital activity which humans have subconsciously done is "Breathing". In fact, human will not be alive without breathing. They need oxygen to provide all individual cell to carry out cellular respiration, and to get rid of carbon dioxide. Breathing is special in several aspects. It is the only function that can be performed consciously as well as unconsciously, and it can be completely voluntary or involuntary. Breathing is the bridge between mind and body, the connection between consciousness and unconsciousness. It is the key to health and wellness, a function we can learn to regulate and develop in order to improve our physical, mental and spiritual well-being. (Weil, 2012) The process of breathing is divided into two phases, inspiration (inhalation) and expiration (exhalation) (David, 2012).

However, most people do not know that they can make use of breathing. They do not recognize how to take full advantage of the nourishing, health-giving properties of breathing. In fact, breathing is voluntary and controllable either with respect to rate or type of respiration. Knowing how to perform simple breathing techniques can reduce stress, lower blood pressure, calm a racing heart, and help many systems in the body without taking drugs. Breathing has direct connections to emotional states and moods: observe a person who is angry, afraid or upset, and it is clear that person that would breathe rapidly, shallowly, noisily and irregularly. However, we can control or practice our breathing to be deep, slow, quiet and consistent (Weil, 2012).

Diaphragmatic breathing, abdominal breathing, belly breathing are also known as deep breathing. The diaphragm is a large muscle located between the chest and the abdomen. When it contracts it is forced downward causing the abdomen to expand. This causes a negative pressure within the chest forcing air into the lungs. The negative pressure also pulls blood into the chest improving the venous return to the heart. This leads to improved stamina in both disease and athletic activity. Like blood, the flow of lymph, which is rich in immune cells, is also improved. By expanding the lung's air pockets and improving the flow of blood and lymph, abdominal breathing also helps prevent infection of the lung and other tissues. But most of all it is an excellent tool to stimulate the relaxation response that results in less tension and overall sense of well-being. (The Benefits of Abdominal breathing, n.d.) Deep breathing can effectively counter stress, and is considered as one of relaxation techniques. This is because naturally human body counters abnormal behaviors via parasympathetic system, and deep breathing fully brings forth this mechanism. That is, deep breathing regulates heart rate, blood pressure, and breathing frequency of the person with stress. It is considered by some to be a healthier way to breathe, and also by others a useful form of complementary and alternative treatment. There are many significant benefits of deep breathing, such as reduction in the risk of heart disease, lower blood pressure, and pain reduction. (Abbey, 2011) Scientifically speaking, deep breathing breaks the cycle of stress and also promotes alpha which is the band that is related to body and mind relaxation. Alpha is defined as brainwaves that cycle between the frequencies of 8-12 Hz, which is classified as a state of relaxation. Alpha is the dominant brainwave activity when the body and mind are relaxed. Alpha wave activity is common among highly creative individuals who have a clear mind or are experiencing relaxation (Alpha Brain Waves, n.d.). Deep breathing can also promote Theta, which occur during extreme mind relaxation, and Delta, the deepest state of complete relaxation. It should be a great benefit if a person can integrate all knowledge and demonstrate the correlation between deep breathing and relaxation. Certainly, if deep breathing is to create Alpha, Theta, and Delta, it should be valuable to human well-being. In terms of practice, deep breathing can be performed with no cost, no equipment, no membership required – in fact, deep breathing can be done by anyone, anywhere and at any time. Deep breathing definitely promotes health and is acknowledged as one of the most effective anti-aging methods.

1.2 Objective

1.2.1 To study the effect of deep breathing on stress level.

1.2.2 To analyze brain activity resulting from deep breathing as a whole.

1.2.3 To analyze brain activity resulting from deep breathing particularly on relaxation bands, (Alpha, Theta, and Delta)

1.3 Research Hypothesis

1.3.1 Deep breathing may improve mental health.

1.3.2 Deep breathing may induce relaxation.

1.3.3 Deep breathing may affect Alpha, Theta, and Delta.

1.4 Conceptual Framework

The study was to analyze brain activities resulting from deep breathing. The expected results were relaxation and improvement of mental health leading to the anti-aging process.

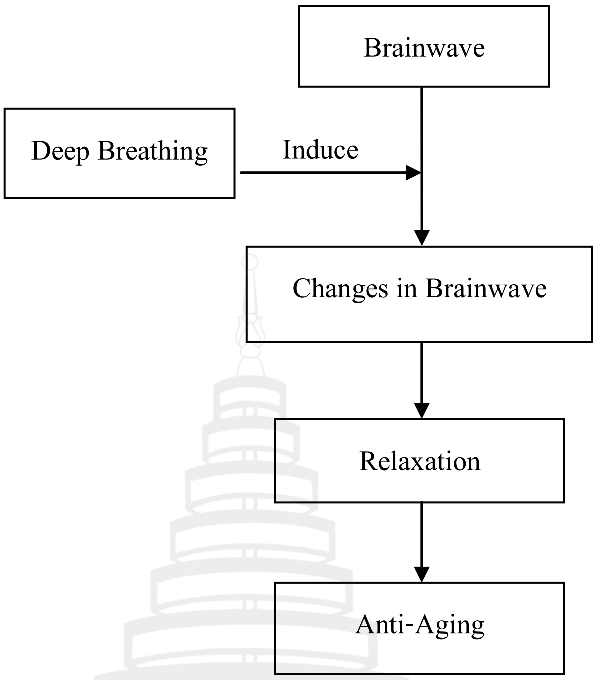


Figure 1.1 Conceptual Framework

CHAPTER 2

LITERATURE REVIEW

2.1 Breathing

2.1.1 Mechanism of breathing

Breathing is divided into two distinct categories. One is spontaneous involuntary (autonomic) breathing, which maintains homeostasis of the arterial blood gases. The other is voluntary breathing, which is involved in higher brain function. The former breathing is performed mainly by diaphragmatic inspiratory activity that is controlled by the respiratory center in the lower brainstem. The latter breathing is mainly exerted by the abdominal expiratory activity that is governed by a higher brain system, the neocortex or limbic system. (Fumoto, Sato-Suzuki, Seki, Mohri & Arita, 2004) The act of breathing engages the diaphragm, a strong sheet of muscle that divides the chest from the abdomen. As you breathe in, the diaphragm drops downward, pulling your lungs with it and pressing against abdominal organs to make room for your lungs to expand as they fill with air. As you breathe out, the diaphragm presses back upward against your lungs, helping to expel carbon dioxide (Figure 2.1).

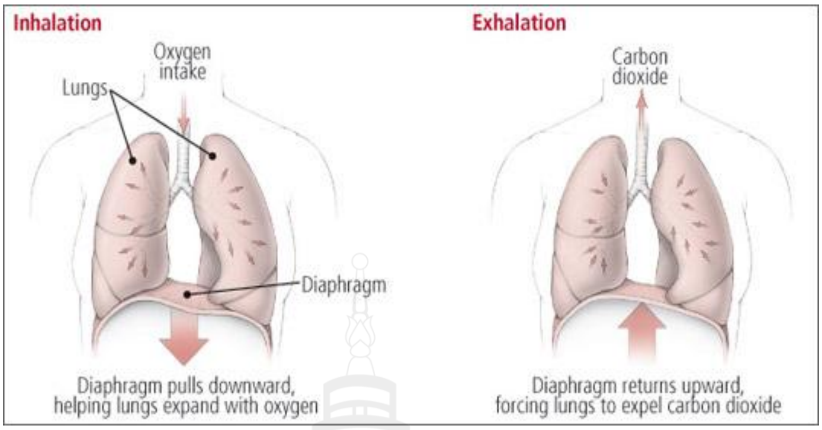


Figure 2.1 Movement of diaphragm during inhalation and exhalation

Shallow breathing hobbles the diaphragm's range of motion. The lowest portion of the lungs, which is where many small blood vessels instrumental in carrying oxygen to cells reside, never gets a full share of oxygenated air. That can make a person feel short of breath and anxious. While deep abdominal breathing encourages full oxygen exchange - that is, the beneficial trade of incoming oxygen for outgoing carbon dioxide. Not surprisingly, this type of breathing slows the heartbeat and can lower or stabilize blood pressure ("Take a Deep Breathing", 2009).

Modern technology has made us sedentary most of the day. There is less need to breathe deeply, so we have developed a habit of shallow breathing. When we are in a hurry and rushed, our breathing follows suit. When we are stressed, anxious or focused on a problem, the body contract. We bend forward, head down, arms together, with muscles tensed. All of these postures constrict breathing. This shallow breathing style becomes a habit reinforced by our daily lifestyle (Davenport, 2010).

2.1.2 Types of breathing

2.1.2.1 Clavicular breathing is the most shallow and worst possible type. The shoulders and collarbone are raised while the abdomen is contracted during inhalation. Maximum effort is made, but a minimum amount of air is obtained. Overuse of upper-body breathing can be a sign of anxiety, stress or a respiratory condition (Lorraine, 2010).

2.1.2.2 Shallow breathing, thoracic breathing, or chest breathing is done with the rib muscles expanding the rib cage. This sort of breathing draws minimal breath into the lungs, usually by drawing air into the chest area using the intercostal muscles rather than throughout the lungs via the diaphragm. Shallow breathing can result in or be symptomatic of rapid breathing and hyperventilation.

2.1.2.3 Deep breathing, diaphragmatic breathing, abdominal breathing or belly breathing are categorized as voluntary breathing. It is done by contracting the diaphragm, a muscle located horizontally between the chest cavity and stomach cavity. Air enters the lungs and the belly expands during this type of breathing. This deep breathing is marked by expansion of the abdomen rather than the chest when breathing. Deep abdominal breathing is the best, for it brings air to the lowest and largest part of the lungs. Breathing is slow and deep, and proper use is made of the diaphragm. It is considered by some to be a healthier way to breathe, and is considered by some a useful form of complementary and alternative treatment.

2.1.3 Benefits of deep breathing

Deep breathing benefits to systems, organs, functions of our body. Deep breathing plays roles in relaxing mind and body, strengthening immune system, improving cellular regeneration and so on. The studies have confirmed benefits of deep breathing, as exemplified below:

The study of Sivakumar, Prabhu, Baliga, Pai, and Manjunatha (2011) revealed that even a short duration of deep breathing (2-10 minutes) is also beneficial for the lung functions Therefore, the researcher applied this short duration concept to the experimental design.

The study of Heather Mason et al. (2013) demonstrated the positive cardiovascular and respiratory effect of yogic slow breathing in the yoga beginner. As yogic slow breathing instructions is quite similar to deep breathing.

The study of Fumoto et al. (2004) found that slow Voluntary Abdominal Breathing (VAB) for 20 minutes in an eyes-closed condition showed that subjects had a feeling of vigor-activity with a tendency of reduced anxiety during and/or after VAB, as assessed by POMS and STAI questionnaire scores.

Edwards (2006) published his personal experiences with various breathing methods including deep breathing that confirmed the improving of quality of life.

2.2 Stress and Relaxation

The study of Fumoto et al. (2004) found that slow Voluntary Abdominal Breathing (VAB) for twenty minutes in an eyes-closed condition caused considerable changes in electroencephalogram (EEG) reading. The increase in high-frequency alpha activities was linked to the state of vigor-activity with a tendency of reduced anxiety.

Stress is a state of overabundance of beta or higher activity, a type of anxiety. Stress is a biological term which refers to the consequences of the failure of a human or animal body to respond appropriately to emotional or physical threats to the organism, whether actual or imagined. Stress makes a person age quickly and it also decreases overall quality of life. Stress is opposite to relaxation, the theory is that voluntarily creating to the relaxation response through regular use of relaxation techniques could counteract the negative effects of stress (www.nccam.nih.gov).

Relaxation is more than a state of mind; it physically changes the way of human functions. Relaxation response slows heart rate, lowers blood pressure, and decreases levels of stress hormones and oxygen consumption. The oxygenation of the brain tends to normalize brain function, reducing anxiety levels.

Relaxation techniques include a number of practices such as progressive relaxation, guided imagery, biofeedback, self-hypnosis, and deep breathing exercises. The goal is similar in all: to consciously produce the body's natural relaxation response, lower blood pressure, and a feeling of calm and well-being. Relaxation techniques often combine breathing and focused attention to calm the mind and the body. To relax using deep breathing or breathing exercises, a person consciously slow the breathing and focus on taking regular and deep breaths. Slow, deep, rhythmic breathing reduces stress, promotes relaxation of mind and body. Deep breathing can also increase brain's ability to produce these brainwaves, allowing to better deal with stress.

Deep breathing is one of the benefits of relaxing body and mind. This is because when the breath is deep, it sends a message to the brain to calm down and relax. Deep breathing for relaxation can also influence gene expression related to inflammation, oxidative stress, and cellular metabolism. The longer a person practices deep breathing, the more pronounced the benefits for any particular condition and for gene activity will be. It is also the most powerful thing that can do to maintain the integrity of your DNA. All anti-aging is based on this understanding.

2.3 Brainwave

There were many studies concerning the changing of brainwave and variety of breathing. The study of Fumoto et al. (2004) found that slow Voluntary Abdominal Breathing (VAB) for twenty minutes in an eyes-closed condition effected on the electroencephalogram (EEG) changing. Since the eyes were closed, the rhythmical alpha wave was dominant at the beginning of VAB. This rhythmical alpha wave came to appear occasionally during the VAB. The lower amplitude and higher frequency replaced the earlier rhythmical alpha wave. In preliminary of their study, they had the subjects do VAB in an eyes-open condition (VAB-EO) and they found that alpha waves appeared during VAB-EO.

The study of Yu (2011) revealed that Electroencephalography (EEG) detected increased alpha band activity and decreased theta band activity during and after Focused attention on Tanden breathing.

The human brain consists of billions of tiny nerve cells called neurons. For the brain to work, these neurons transmit signals to each other every millisecond through trillions of intersections called synapses. Each synapse consists of the ends of two neurons separated by a very small gap that is measured in nanometers. When a neuron receives a signal, it creates an electrical impulse that triggers the release of chemicals called neurotransmitters. The neurotransmitters then travel across the gap and arrive at the receiving end of another neuron where they bind to special molecules called receptors. This process takes place at lightning speed as the signal is passed with tremendous accuracy from neuron to neuron. Nonetheless, it is extremely essential to all of the brain's function such as learning, memorizing, analyzing, planning, and calculating.

Since neurons communicate using electrical impulses, when millions of brain cells talk to each other at the same time, they generate a significant amount of electrical activity that can be detected using sensitive scientific instruments. This electrical activity in the brain is known as a brainwave pattern. It's called a "brainwave" due to its wave-like characteristics.

Brainwaves have been studied since the 1930's after Hans Berger recorded the first electroencephalograph (EEG) of the electrical activity of the human brain from the surface of the head. EEG is a painless procedure that uses small, flat metal discs (electrodes) attached to the scalp to detect electrical activity in your brain. Electrodes are hooked by wires to a computer that records the electrical activity inside the brain. A machine can show the activity as a series of wavy lines drawn by a row of pens on a moving piece of paper or as an image on the computer screen. The brain produces four main types of brainwave which are shown by EEG readings. Each type of brain wave produces the listed effects at specific frequencies:

Gamma Brainwaves (over 30 Hz): Gamma brain waves are considered the brain's optimal frequency of functioning, increased levels of compassion, conscious awareness of reality and increased mental abilities

Beta Brainwaves (13-30 Hz): The fastest, representing the most intense state of alertness, high mental activity, maximum mind power, logical thinking, and normal awake consciousness associated with busy tasks, relaxed and reflective state. Alertness, good for inspiration, learning facts fast, meditative mind. ("Brain Wave States & How to Access Them", n.d.)

Alpha Brainwaves (8-12 Hz): Alpha brainwaves are common state for the brain and occurs whenever a person is alert. Alpha band promotes mental resourcefulness, aids in the ability to mentally coordinate, and enhances overall sense of relaxation.

Theta Brainwaves (4-7 Hz): a very relaxed state associated with meditation and some sleep states. Extreme relaxation, creativity, as well as vibrant mental imagery. ("Electroencephalogram (EEG)". n.d.).

Delta Brainwaves (0-3 Hz): the lowest brain frequencies, possibly indicating subconscious thoughts and information, deep dreamless sleep, and deep relaxation. Deep and refreshing sleep allows the body and brain to rest and repair.

Table 2.1 Types of Brainwave

Type	Frequency (Hz)	Brain Activity
Gamma	Over 30	Increased levels of compassion, conscious awareness of reality
Beta	13-30	Alertness and concentration
Alpha	8-12	Promotes mental resourcefulness, relaxation
Theta	4-7	Meditation, drowsiness, extreme relaxation
Delta	0-3	Subconscious thoughts and information, deep sleep, deep relaxed

In summary, deep breathing grants many benefits to both physical and mental health. It is also linked to changes in brain signals, as confirmed by many studies discussed before; however, they are based on experienced practitioners such as Zen meditation, or on the condition of twenty or more minutes of deep breathing. There was no previous study on relations between shorter period of deep breathing and brain signals on inexperienced participants or experienced but not regular practice. This independent research pays attention to the effect of short periods, two minutes in this case, of deep breathing in each interval on brain signals. If the results concur with the hypothesis, it will prove to have many advantages to the practitioners, particularly both physical and mental health.

CHAPTER 3

RESEARCH METHODOLOGY

This research is a prospective experimental study.

3.1 Participants

3.1.1 Sample size

Sixteen participants, age ranged from 25-55 years which were twelve females and four males, volunteered for this study. All participants were healthy and carefully screened according to the inclusion and exclusion criteria.

3.1.2 Inclusion criteria

3.1.2.1 Healthy Male or Female, aged range from 25-55 years

3.1.2.2 No smoking, alcohol and drugs

3.1.2.3 No psychiatric problem and convulsion or epilepsy

3.1.2.4 No meditation practicing within one month prior to the experiment

3.1.3 Exclusion Criteria

3.1.3.1 Present of cerebrovascular disorder

3.1.3.2 Present of systemic condition affected the brain wave

3.1.3.3 Pregnancy

3.1.3.4 Using medication affecting EEG

3.1.4 Discontinuation Criteria

3.1.4.1 Denial of research continuation

3.1.4.2 Any complication during research

3.2 Research Instrumentations

3.2.1 Personal profiles recording

The personal profiles include gender, age, nationality, weight, height, and personal health history.

3.2.2 EEG Recorder

The researcher used EEG Recorder namely Brain Actor (Figure 3.1) which is a 2-channel EEG device recorder for analyzing and recording brain on 2 channels by Learnmon program. This kind of instrument can detect brainwave and display as graph to demonstrate frequency and power. (Brain Actor 2-channel EEG, n.d.) The International 10-20 System of Electrode Placement is the most widely used method to describe the placement of electrodes at specific intervals along the head. Each electrode site has a letter to identify the lobe, along with a number or another letter to identify the hemispheric location. “The International 10-20 System of Electrode Placement”, n.d.). (Figure 3.2)

Figure 3.1 Brain Actor

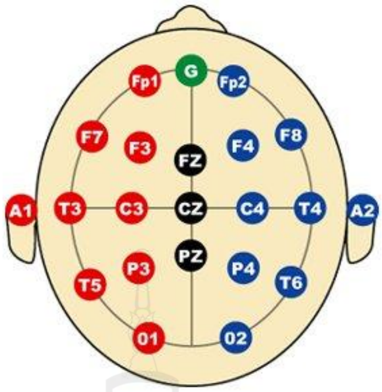


Figure 3.2 International 10-20 System of Electrode Placement

3.2.3 Stress Level Evaluation

Thai Stress Test (TST) by Phatthaayuttawat (2000) was used to evaluate stress level. The test is a two dimensional rating scales which each scale composed of twelve index items. The total of both parts are composed of twenty four questions. The first twelve questions represent negative feeling while the latter denote positive one. The test is characterized in 3 levels as Likert.

Table 3.1 Matrix table of Thai Stress Test

Negative Scales score (Sum of Item 1-12)	**Positive Scales score (Sum of Item 13-24)**				
	12-36	**9-11**	**6-8**	**3-5**	**0-2**
0-1	1	2	3	4	5
2-3	2	3	4	5	6
4-5	3	4	5	6	7
6-7	4	5	6	7	8
8-36	5	6	7	8	9

The sum of rating scale is grouped by the standard scale from the matrix table. Participants answer questions in both negative and positive feelings by rating them on computer by Super Lab Pro Version 2.0.4 before and after deep breathing.

Results of Thai Stress Test after grouping are interpreted into 4 levels: Excellent mental health, normal mental health, mild stress, and stressful (Table 3.2).

Table 3.2 Stress Level for Thai stress Test

Group	Stress level
1	Excellent mental health
2,3,4	Normal mental health
5,6	Mild stress
7,8,9	Stressful

3.2.4 Deep breathing

Deep breathing was an inducer and independent variable in this study. It was done by contracting the diaphragm, a muscle located horizontally between the chest cavity and stomach cavity. Prior to the experimental trials, participants would be instructed to train deep breathing as follow:

First, to confirm that a participant was doing deep breathing by asking the participant placed one hand on the chest and the other on the abdomen. While taking a deep breath in, the hand on the abdomen should rise higher than the one on the chest. This insured that the diaphragm was pulling air into the bases of the lungs.

Second, taking a slow deep breath in through the nose imagining that all the air in the room was sucked for a count of four (four seconds). Holding the air that sucking in for a count of two (two seconds)

Third, slowly exhaled through the mouth for a count of four (four seconds). As all the air was released with relaxation, gently contracted the abdominal muscles to completely evacuate the remaining air from the lungs.

Last, repeated the cycle five more times for a total of six deep breaths and tried to breathe at a rate of one breath every ten seconds (six breaths per minute). The participant would be given a practice session for several times to become familiar with deep breathing.

3.3 Methods

3.3.1 All volunteers which age ranged from 25 to 55 years who met the criteria were selected as participants.

3.3.2 All personal health history of participants were interviewed and recorded.

3.3.3 All participants were not allowed to drink alcohol and caffeine at least 24 hours before experiment and had adequate sleeping.

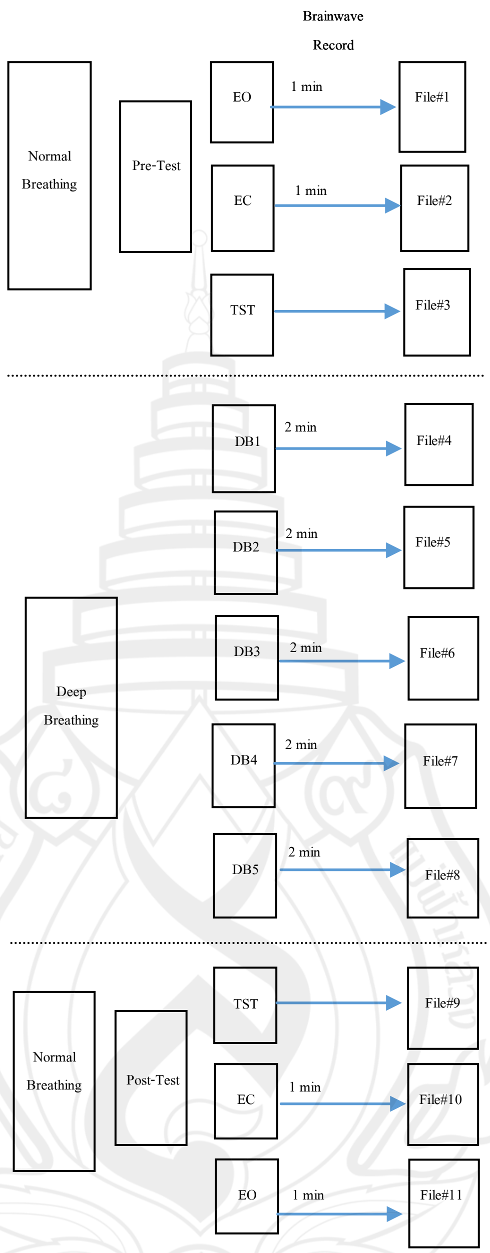
3.3.4 Hair washing and drying must be performed at the night prior to experiment. Made sure that the hair was clean and free of sprays, oils, creams, and lotions

3.3.5 Participant might sit and rest for 10 minutes before the experiment was started.

3.3.6 Electrodes which made with silver-silver chloride were fixed at two areas of the brain, Mid-Frontal (Fz) and Vertex or Mid-Central (Cz). Frontal Pole (Fp) was fixed to be a ground while the left and right ear lobe were used as references according to the international 10/20 system and study of Fumoto et al. (2004).

3.3.7 Starting the experiment as guided by the experiment paradigm (Figure 5).

3.3.8 Figure 5 wholly illustrated experimental paradigm in this study. The experiment consisted of three main sections – pre-test normal breathing, deep breathing, and post-test normal breathing. In the first section, participant was asked to perform three short trials, comprising one-minute normal breathing with eyes-open, one-minute normal breathing with eyes-closed, and Thai Stress Test evaluation. The following section was made up of five identical trials; in each trial, the participant was asked to perform deep breathing for two minutes. The final trials were similar to the first except the order of the tasks was reversed. After deep breathing trials, Thai Stress Test was taken followed by one-minute eyes-closed normal breathing and one-minute eyes-open normal breathing. During each trial, data were collected in separated files. The whole experiment was expected to last about half an hour.



Note. There was 1-minute break between each trial in order to set the instruments.

Legend EO: Eyes-open condition EC: Eyes-closed condition

TST: Thai Stress Test DB1-5: Deep breathing trials

Figure 3.3 Experimental Paradigm

3.4 Data Collection

The researcher collected brainwave data (11 files) and TST questionnaire.

3.4.1 Study Variables

The sole independent variable in this study was deep breathing. The variables that would then be impacted from deep breathing were stress level, brain activity, and brainwaves that were directly related to relaxation. These were the Alpha, Theta, and Delta waves. The controlled environment ranged from the participant's age, sex, nationality, and individual underlying diseases.

3.4.2 Data Analysis

This study utilized descriptive analysis, namely sample size, mean, standard deviation, and TST assessment to analyze the experiment data collected from each participants. TST questionnaire and brain wave data were also statistically analyzed using paired t-test. The confidential interval in the statistics were at 95% with $p \leq 0.05$.

3.5 Ethic Consideration

The research proposal will be sent to the Mae Fah Luang Ethical Committee for approval. The information will then be confidentially collected and will not, in any circumstance, be disclosed to the public. Presented information and illustrations will also be in a generalized and anonymous manner. Participants fully have the right not to answer any question and to withdraw from this research at any time.

CHAPTER 4

RESULT AND DISCUSSION

This study was a prospective experimental research which was designated to analyze the impact of deep breathing on stress level, brain activity as a whole and brain activity particularly on relaxation bands resulting from deep breathing. All procedures were conducted in sixteen volunteered participants, aged 25-55 years (twelve women and four men) step by step as guided in the experimental paradigm.

Data Analysis and Statistics

The data were analyzed and presented into 3 parts:

1. Personal profiles
2. Analyzing of deep breathing on Thai Stress Test
    1) Behavior response (psychological reactions)
    2) Stress level
3. Electrophysiological data
    1) Comparison of trial pairs
    2) Brainwave bands

This research used parametric statistics methods. Paired t-test was used to analyze TST while paired t-test was used for analyzing Electrophysiological data. The results were considered to be statistically significant when p-values were less than 0.05.

4.1 Personal Profiles

Sixteen healthy volunteers, four males and twelve females, were categorized as follow:

Table 4.1 Personal profiles of the participants

Variable	**n**	**Variable**	**n**
Age (years)		Weight (kg)	
20 - 29	9	45 - 54	7
30 - 39	4	55 - 64	2
40 - 49	0	65 - 74	3
50 - 59	3	75 - 84	4
Occupation		**Height (cm)**	
Freelance	4	150 - 159	6
Self-employed	4	160 - 169	6
Office worker	3	170 - 179	4
Civil servant	1		
Doctor	1	Total	16
Housewife	1		
Teacher	1		

4.2 Analysis of Deep Breathing on Thai Stress Test (TST)

Thai Stress Test by Sucheera Phatthaayuttawat et al. (2000) was a tool in part of the study. It was believed to be appropriate for testing behavior response and stress level.

4.2.1 Behavior response (psychological reactions)

Thai Stress Test was used to evaluate stress level. Behavior response was used to evaluate negative and positive feelings in sixteen participants before and after deep breathing trials. Analyzed by paired t-test, the study found the statistical results as described below (Table 4.2).

The mean of stress level in negative feeling after deep breathing was lower than prior the task. This pair expressed a significant result with p-value = 0.010. On the other hand, the mean stress level in positive feeling after was higher than prior to deep breathing task. The paired t-test showed p-value = 0.045.

Table 4.2 Stress evaluation in negative and positive feeling before and after deep breathing

Stress Evaluation	$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Negative feeling before deep breathing	6.0	5.3	1.7	2.4	2.941	0.010
Negative feeling after deep breathing	4.3	4.4				
Positive feeling before deep breathing	27.2	4.6	-2.3	4.2	-2.191	0.045
Positive feeling after deep breathing	29.5	4.8				

There were statistical significances at the level 0.05 of questionnaire answering both in negative and positive feelings before and after deep breathing. Negative feelings had a trend to decrease while positive feelings possessed an increasing trend.

4.2.2 Stress Level

Negative and positive feelings of sixteen participants were assessed into 4 stress levels: Excellent mental health, normal mental health, mild stress, and stressful. Each level was also demonstrated in number, as shown in Table 4.3.

4.2.2.1 Excellent mental health group

Before deep breathing, there were four participants grouped into excellent mental health. This number rose from four to seven after the task. Table 4.3 showed the numerical trend of better mental health after deep breathing.

4.2.2.2 Normal mental health group

Before and after deep breathing, there were five participants in normal mental health. This number did not change.

4.2.2.3 Mild stress group

Before deep breathing, there were seven participants grouped into mild stress. This number dropped from seven to four after the task. Table 4.3 showed the trend of better mental health after deep breathing.

4.2.2.4 Stressful group

None of participants were grouped into stressful level both before and after deep breathing.

Table 4.3 Stress level interpretation before and after deep breathing task in number

Stress Level Interpretation	Pre	Post
	Number	Number
Excellent mental health	4	7
Normal	5	5
Mild stress	7	4
Stressful	0	0
Total	**16**	**16**

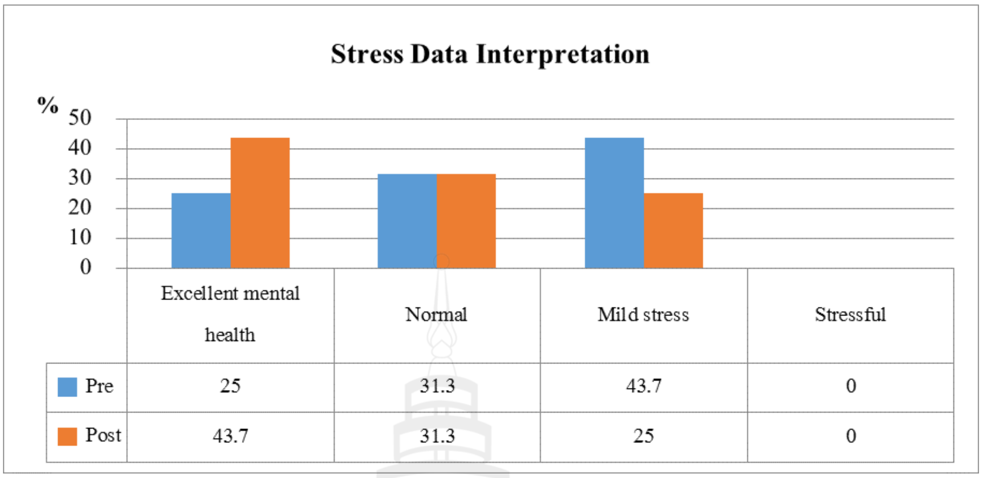


Figure 4.1 Stress level interpretation in a form of bar chart

In conclusion of Thai Stress Test on behavior response and stress level, it could explain that the participants felt more relaxed and less stressful. The number of excellent mental health showed crucial signs of relaxation arising while mild stress number decreased after deep breathing. This task was beneficial to the participants and could lead them towards stress relieved. This finding could be supported by the study of Fumoto M. et al., (2004); that was, the subjects had a feeling of vigor-activity with a tendency of reduced anxiety during and/or after voluntary abdominal breathing as assessed by POMS and STAI questionnaire scores.

We therefore conclude that deep breathing may potentially induce relaxation, which is directly related to the research hypothesis.

4.3 Electrophysiological Data

According to the study objectives analyzing brain activity, electrophysiological data used parametric statistic methods and paired t-test for analyzing the experiment. The results would be presented into comparison trial pair and brainwave bands.

4.3.1 Comparison of trial pairs

4.3.1.1 Eyes-open before and after deep breathing: There was no significance in this comparison.

4.3.1.2 Eyes-closed before and after deep breathing: The statistic expressed the significance at the level 0.05 of eyes-closed before and after deep breathing in Beta, Theta, and Delta but not included Alpha.

4.3.1.3 Thai Stress Test before and after deep breathing: There was no statistically significant difference in this trial pair.

In conclusion of the comparison between trial pairs, the results demonstrated the significant changes in brainwave, notably in the pair of eyes-closed before and after deep breathing in the second trial pair. The implication occurred in Beta, Theta and Delta.

These findings could be explained that deep breathing also affected the changing of two relaxation bands, Theta and Delta but not included Alpha during resting after deep breathing in eyes-closed trials. This finding could be supported by the study of Fumoto M. et al., (2004); that is, during resting in the eyes-closed condition, the disappearance of the low-frequency Alpha band was replaced by the occurrence of a Theta/Delta band. This occurring related to the research hypothesis that was deep breathing may affect relaxation brain wave bands.

Referring to Electrophysiological statistical data, the study did not find the significant changes in brainwave in the first and the third trial pairs. These discoveries might be affected from uncomfortable feeling during or after performing five trials of deep breathing as guided in the paradigm. Moreover, some of the participants were not familiar to the task since they had little or no experience practicing deep breathing.

However, according to the study hypothesis focusing on Alpha, Theta and Delta, the significant data of these three bands in this trial pair were also demonstrated in Amplitude, Mindmirror and 3D landscape in the section of brainwave analysis.

4.3.2 Brainwave

The findings expressed the interesting significance on brainwave in the experimental pairs. These would be classified into five categories: Gamma, Beta, Alpha, Theta and Delta brainwaves

In terms of Beta, the data were tabulated showing the significance in the experiment. The significant in the pair of eyes-closed before and after deep breathing had also shown on the table. Moreover, the remaining brainwaves which are directly related to relaxation will be analyzed in depth and presented in Amplitude, Mindmirror and 3D landscape illustrations.

4.3.2.1 Gamma brainwave

There was no significance in comparison trial pair, eyes-closed before and after deep breathing.

4.3.2.2 Beta brainwave

The study found the significance at level 0.05 in twelve trial pairs. The outcome expressed in frequency and number of waves both in Fz and Cz electrode sites (Table 4.4). There was significance in comparison trial pair, eyes-closed before and after deep breathing.

Table 4.4 Beta brainwave experimental data at the Fz and Cz electrode sites

		$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Pair 1	eyes-closed before deep breathing (Cz)	14.44	1.63	0.56	0.96	2.33	0.03
	eyes-closed after deep breathing (Cz)	13.88	1.50				
Pair 2	deep breathing trial 2 (Fz)	13.81	5.42	2.00	3.44	2.32	0.03
	eyes-open before deep breathing (Fz)	11.81	4.23				
Pair 3	deep breathing trial 3 (Fz)	13.69	4.56	1.88	2.92	2.57	0.02
	eyes-open before deep breathing (Fz)	11.81	4.23				

Table 4.4 (Continued)

		$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Pair 4	deep breathing trial 1 (Cz)	14.69	8.15	0.75	4.28	-2.88	0.01
	eyes-open before deep breathing (Cz)	21.00	11.08				
Pair 5	deep breathing trial 2 (Cz)	16.00	10.13	2.06	5.30	-2.17	0.05
	eyes-open before deep breathing (Cz)	21.00	11.08				
Pair 6	deep breathing trial 3 (Cz)	15.00	9.31	1.06	3.17	-2.58	0.02
	eyes-open after deep breathing (Cz)	21.00	11.08				
Pair 7	deep breathing trial 5 (Cz)	14.31	9.14	0.38	2.99	-3.24	0.01
	eyes-open after deep breathing (Cz)	21.00	11.08				
Pair 8	deep breathing trial 1 (Fz)	12.75	3.96	-0.19	4.25	-3.64	0.00
	eyes-open after deep breathing (Fz)	16.94	6.57				
Pair 9	deep breathing trial 2 (Fz)	13.81	5.419	0.88	2.96	-2.658	0.018
	eyes-open after deep breathing (Fz)	16.94	6.567				
Pair 10	deep breathing trial 3 (Fz)	13.69	4.557	0.75	3.15	-2.719	0.016
	eyes-open after deep breathing (Fz)	16.94	6.567				
Pair 11	deep breathing trial 4 (Fz)	13.94	6.093	1.00	3.48	-2.366	0.032
	eyes-open after deep breathing (Fz)	16.94	6.567				
Pair 12	deep breathing trial 5 (Fz)	13.38	4.897	0.44	3.48	-2.950	0.010
	eyes-open after deep breathing (Fz)	16.94	6.567				

Pair 1: Eyes-closed before deep breathing and eyes-closed after deep breathing at Cz electrode site, $p = 0.034$.

Pair 2: Deep breathing trial 2 and eyes-open before deep breathing at Fz electrode site, $p = 0.035$

Pair 3: Deep breathing trial 3 and eyes-open before deep breathing at Fz electrode site, $p = 0.021$

Pair 4: Deep breathing trial 1 and eyes-open before deep breathing at Cz electrode site, $p = 0.011$

Pair 5: Deep breathing trial 2 and eyes-open before deep breathing Cz electrode site, $p = 0.047$

Pair 6: Deep breathing trial 3 and eyes-open after deep breathing at Cz electrode site, p = 0.021

Pair 7: Deep breathing trial 5 and eyes-open after deep breathing at Cz electrode site, p = 0.005

Pair 8: Deep breathing trial 1 and eyes-open after deep breathing at Fz electrode site, p = 0.002

Pair 9: Deep breathing trial 2 and eyes-open after deep breathing at Fz electrode site, p = 0.018

Pair 10: Deep breathing trial 3 and eyes-open after deep breathing at Fz electrode site, p = 0.016

Pair 11: Deep breathing trial 4 and eyes-open after deep breathing at Fz electrode site, p = 0.032

Pair 12: Deep breathing trial 5 and eyes-open after deep breathing at Fz electrode site, p = 0.010

4.3.2.3 Alpha brainwave

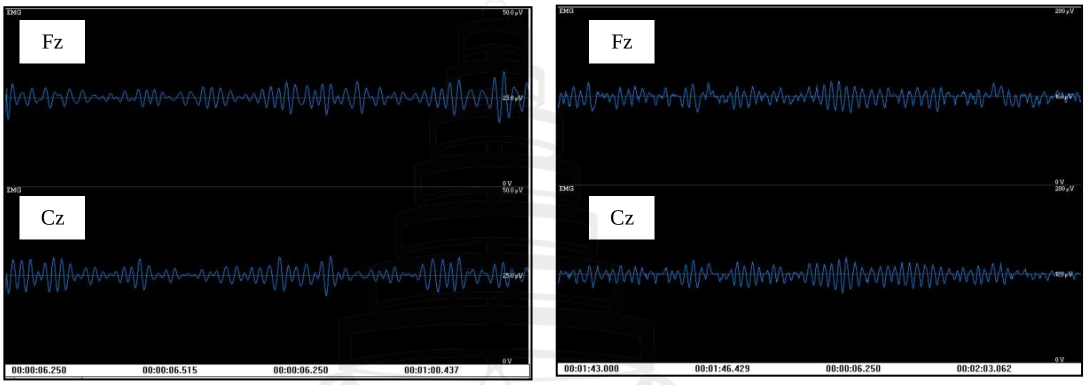
Since Alpha brainwave is a state of relaxation band. The analysis found the significance at 0.05 in four trial pairs. The result expressed in the number of waves at the same area (Fz) and, as shown in the following table. There was no significance found in all comparison trial pairs in this band.

Table 4.5 Alpha brainwave experimental data at Fz electrode site

		$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Pair 1	deep breathing trial 2	14.88	8.48	2.50	3.72	2.69	0.017
	eyes-open before deep breathing	12.38	7.17				
Pair 2	deep breathing trial 3	14.44	8.29	2.06	3.86	2.14	0.049
	eyes-open before deep breathing	12.38	7.17				
Pair 3	deep breathing trial 2	14.88	8.48	3.31	3.57	3.71	0.002
	eyes-open after deep breathing	11.56	6.398				
Pair 4	deep breathing trial 3	14.44	8.294	2.88	5.00	2.298	0.036
	eyes-open after deep breathing	11.56	6.398				

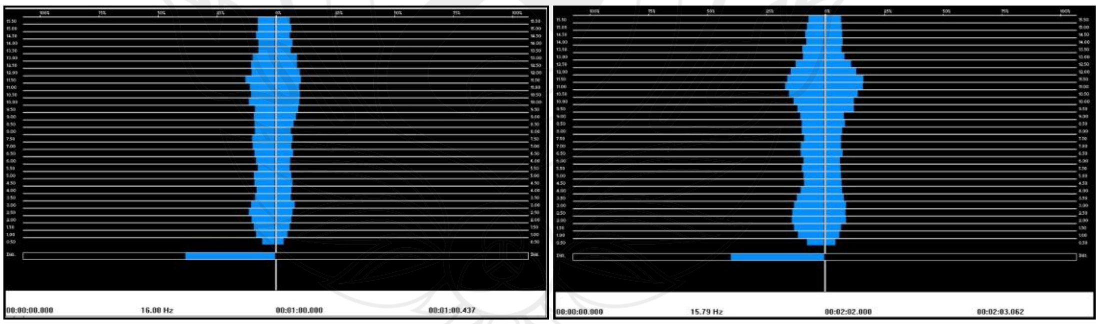
1. Pair 1: Eyes-open before deep breathing and deep breathing trial 2

The mean of number of wave in eyes-open before the task and the mean after deep breathing trial 2 were at 12.38 and 14.88. The result demonstrated the significant increase in number of waves with $p = 0.017$. The illustrations in Amplitude, Mindmirror and 3D landscape were shown below:



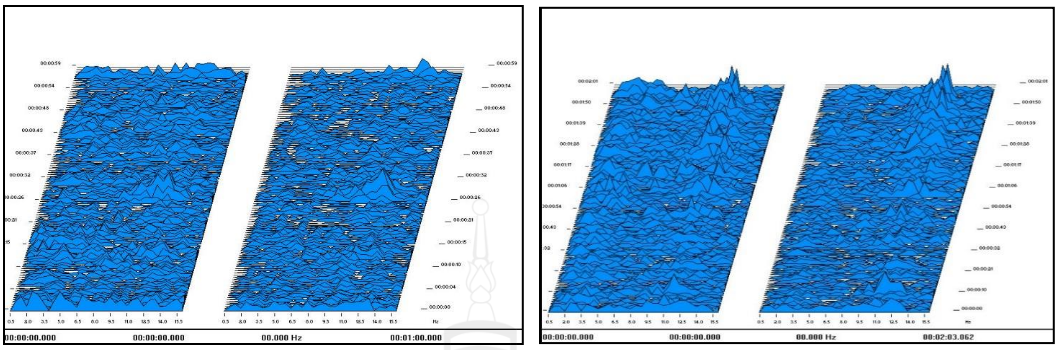
(a) eyes-open before deep breathing (b) deep breathing trial 2

Figure 4.2 Amplitude representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode



(a) eyes-open before deep breathing (b) deep breathing trial 2

Figure 4.3 Mindmirror representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode site

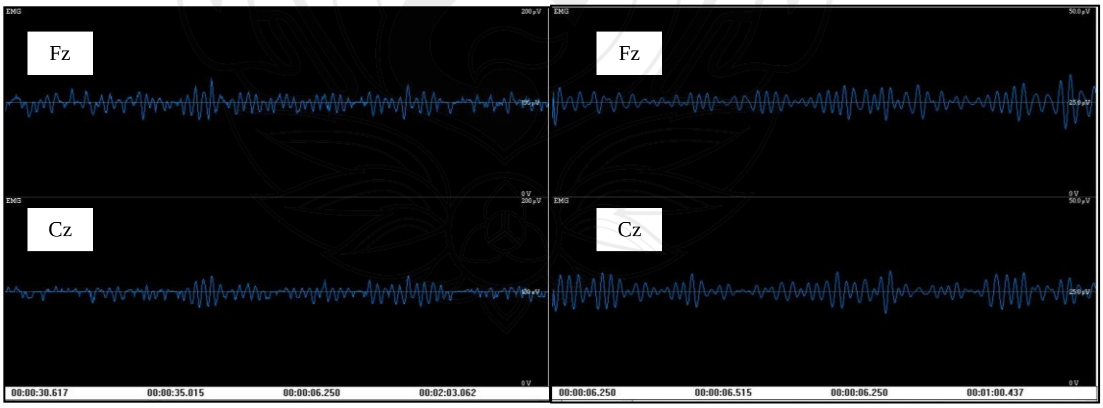


(a) eyes-open before deep breathing (b) deep breathing trial 2

Figure 4.4 3D landscape representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode site

2. Pair 2: Eyes-open before deep breathing and deep breathing trial 3

The mean of eyes-open before deep breathing and the mean of deep breathing trial 3 at Fz electrode site were found to be at 12.38 and 14.44. The result demonstrated the significant increase in number of waves with $p = 0.049$. The illustrations in Amplitude, Mindmirror and 3D landscape were shown below.

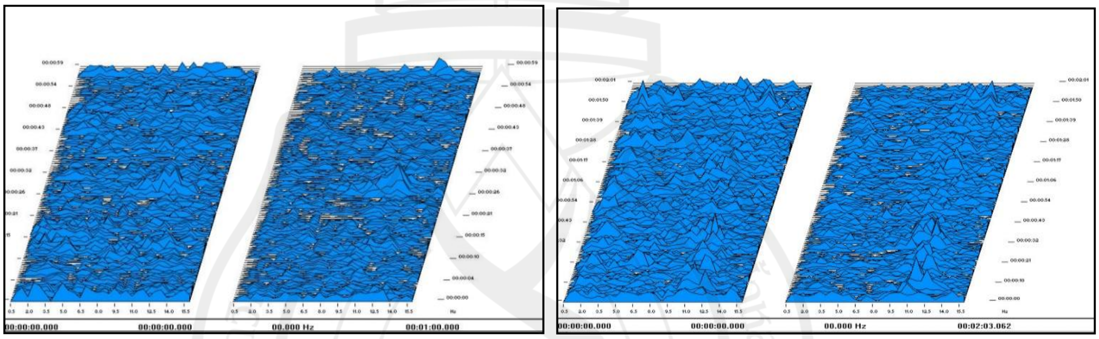


(a) eyes-open before deep breathing (b) deep breathing trial 3

Figure 4.5 Amplitude representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode site

(a) eyes-open before deep breathing (b) deep breathing trial 3

Figure 4.6 Mindmirror representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode site

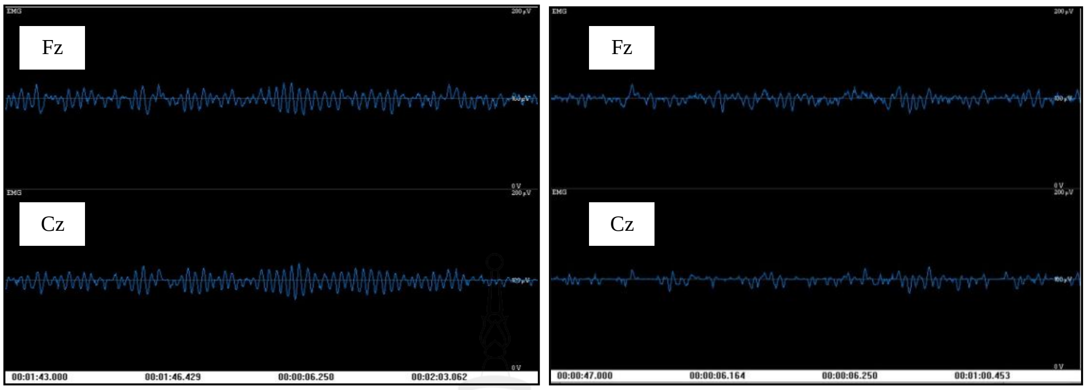


(a) eyes-open before deep breathing (b) deep breathing trial 3

Figure 4.7 3D landscape representation of Alpha brainwave demonstrating the increasing number of waves at Fz electrode site

3. Pair 3: Second deep breathing trial and eyes-open after deep breathing

The mean of the second deep breathing trial and the mean of eyes-open after deep breathing at Fz electrode site were 14.88 and 11.56. The result demonstrated the significant decrease in number of waves in percent with $p = 0.002$. The illustrations in Amplitude, Mindmirror and 3D landscape were demonstrated below:

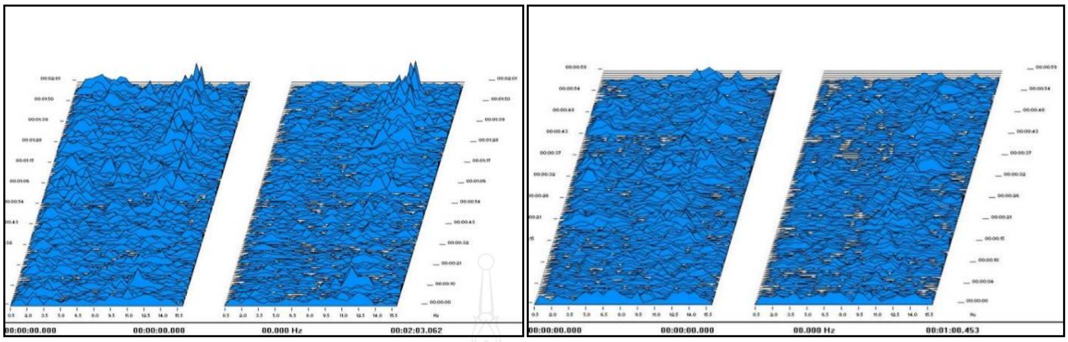


(a) deep breathing trial 2 (b) eyes-open after deep breathing

Figure 4.8 Amplitude representation of Alpha brainwave demonstrating the decreasing number of waves at Fz electrode site

(a) deep breathing trial 2 (b) eyes-open after deep breathing

Figure 4.9 Mindmirror representation of Alpha wave demonstrating the decreasing number of waves at Fz electrode site

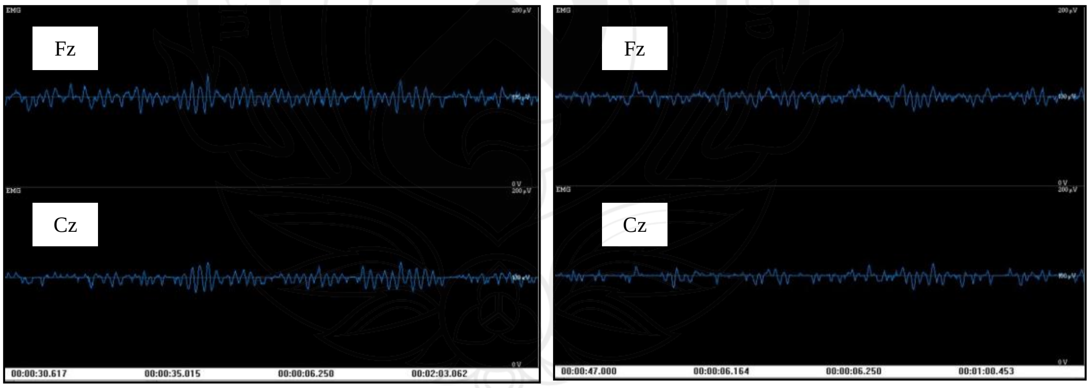


(a) deep breathing trial 2 (b) eyes-open after deep breathing

Figure 4.10 3D landscape representation of Alpha brainwave demonstrating the decreasing number of waves at Fz electrode site

4. Pair 4: Deep breathing trial 3 and eyes-open after deep breathing

The mean of deep breathing trial 3 and the mean of eyes-open after deep breathing at Fz electrode site were 14.44 and 11.56. The result demonstrated the significant decrease in number of waves in percent with p = 0.036. The illustrations in Amplitude, Mindmirror and 3D landscape were displayed below:

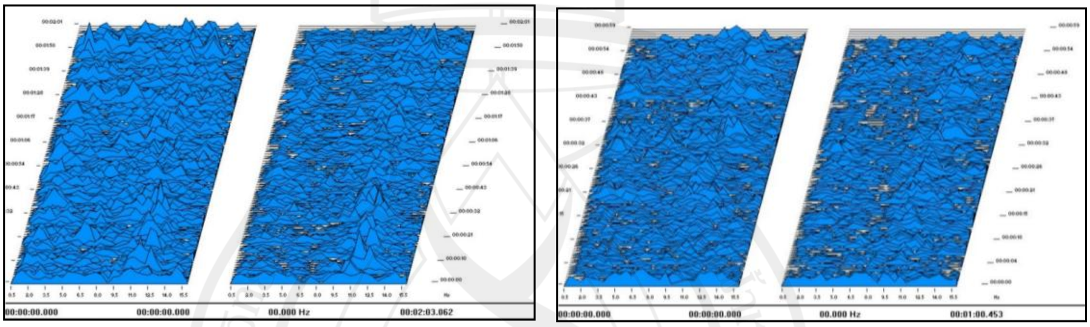


(a) deep breathing trial 3 (b) eyes-open after deep breathing

Figure 4.11 Amplitude representation of Alpha brainwave demonstrating the decreasing number of waves at Fz electrode site

(a) deep breathing trial 3 (b) eyes-open after deep breathing

Figure 4.12 Mindmirror representation of Alpha brainwave demonstrating the decreasing number of waves at Fz electrode site



(a) deep breathing trial 3 (b) eyes-open after deep breathing

Figure 4.13 3D landscape representation of Alpha brainwave demonstrating the decreasing number of waves at Fz electrode site

The findings did not show the significant change in three comparison trial pairs. The supporting might be that performing many (five) trials or had a little or no experienced deep breathing, participants might obtain anxiety or uncomfortable feeling.

However, the study found the significance at the level 0.05 in four trial pairs in number of waves at the same area (Fz). First pair was eyes-open before deep breathing and deep breathing trial 2. The second pair was eyes-open before deep breathing and deep breathing trial 3. The third was deep breathing trial 2 and eyes-open after deep breathing. The last was deep breathing trial 3 and eyes-open after deep breathing. Since Alpha is a relaxation brainwave band which is the dominant brain wave activity when the body and mind are relaxed. Therefore, the results were also analyzed in details according to the study objective. The study demonstrated that deep breathing potentially affected the changing of Alpha wave which showed the significant difference at the level 0.05. The number of waves at Fz area increased in deep breathing trial 2 and 3 compared to eyes-open before deep breathing. On the other hand, Alpha wave at Fz in eyes-open after deep breathing compared to deep breathing trial 2 and 3, a decrease in the number of waves.

Therefore, we could explain this occurring that at deep breathing trial 2 and 3, participants felt more relaxed and stress-relieved. This findings correlated to the study of Fumoto M.et al, (2004) which reported that a neuronal system may operate to evoke the Alpha bands in the EEG either in eyes-open or eyes-closed. The behavior of voluntary abdominal breathing in eyes-open condition clearly induced a new development of Alpha activity.

It might assume that in this experimental design, participants felt more relaxed at deep breathing trial 2 and 3, comparing to eyes-open before and after deep breathing. Therefore, performing deep breathing at trial 2 or 3, approximately four to six minutes would be appropriate for brain developing Alpha, a state of relaxed wave in this sample group.

4.3.2.4 Theta brainwave

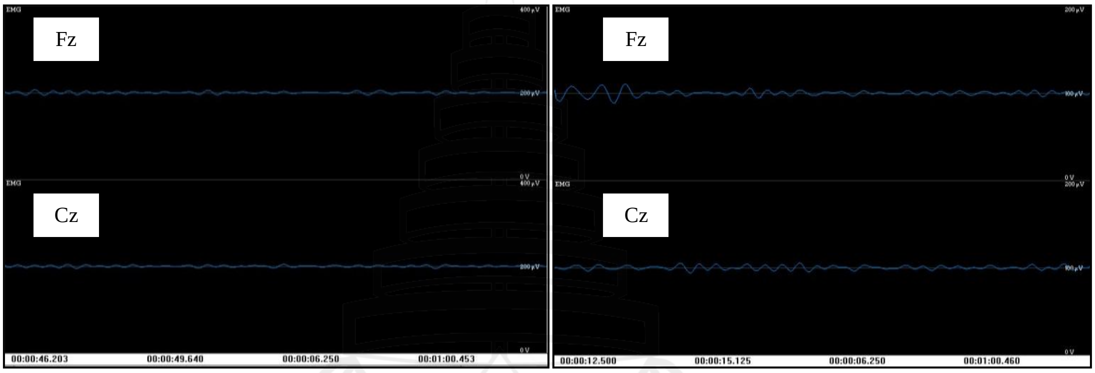
The study found the significance at the level 0.05 in one trial pair in frequency at Cz electrode site

Pair 1: eyes-closed before deep breathing and eyes-closed after deep breathing

The mean of eyes-closed before deep breathing and the mean of eyes-closed after deep breathing at Cz electrode site were 5.28 and 5.73. The results were demonstrated the significant increase in frequency with $p = 0.035$. The illustrations in Amplitude, Mindmirror and 3D landscape have shown below. This pair had significance in comparison trial pair, eyes-closed before deep breathing and eyes-closed after deep breathing.

Table 4.6 Theta brainwave experimental data

		$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Pair 1	eyes-closed before deep breathing	5.28	0.87	-0.45	0.78	-2.32	0.035
	eyes-closed after deep breathing	5.73	0.82				



(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure: 4.14 Amplitude representation of Theta brainwave demonstrating the increasing frequency at Cz electrode site

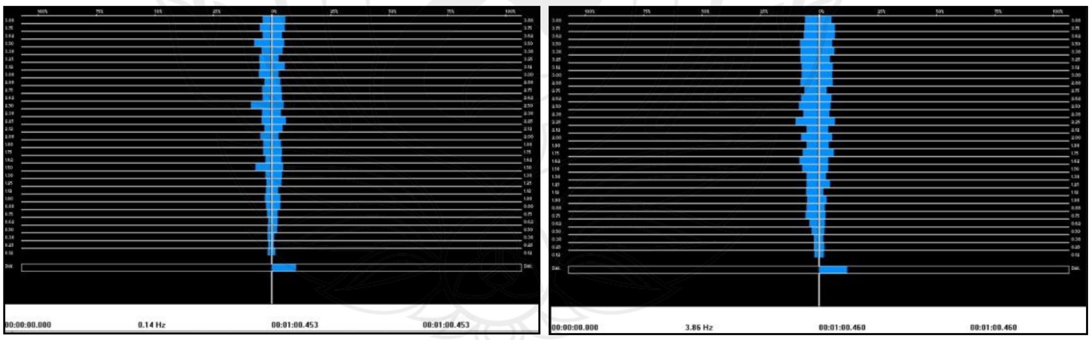
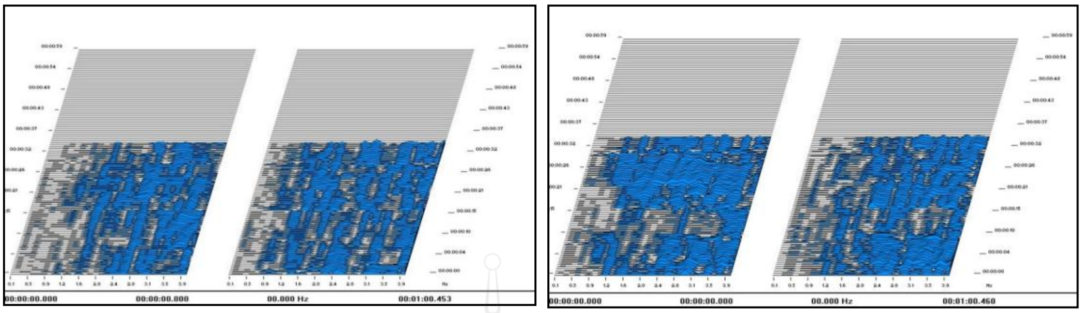

(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.15 Mindmirror representation of Theta brainwave demonstrating the increasing frequency at Cz electrode site



(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.16 3D landscape representation of Theta brainwave demonstrating the increasing frequency at Cz electrode site

The comparison trial pair of eyes-closed before and after deep breathing, the study found a significant at the level 0.05 in frequency at Cz electrode site. There was an increasing of frequency after the task. This finding could be supported by the study of Fumoto M. et al. (2004), that was during resting in the eye-closed condition, the disappearance of the low-frequency Alpha band was replaced by the occurrence of a Theta/Delta band. Theta wave, the band plays in state of relaxation. Theta wave usually becomes apparent when a person was extremely relaxed or initially falling asleep. Theta wave would also show up strongly in a state of deep meditation. It may promote improved concentration, major reductions in stress, and improved memory retention. Under the effect of Theta wave, blood pressure, breathing, and heart rate will all slow to a much more restful and healthy level which in turn promotes natural healing. Both of the study and existed theories supported the research hypothesis that was deep breathing may induce relaxation.

4.3.2.5 Delta brain wave

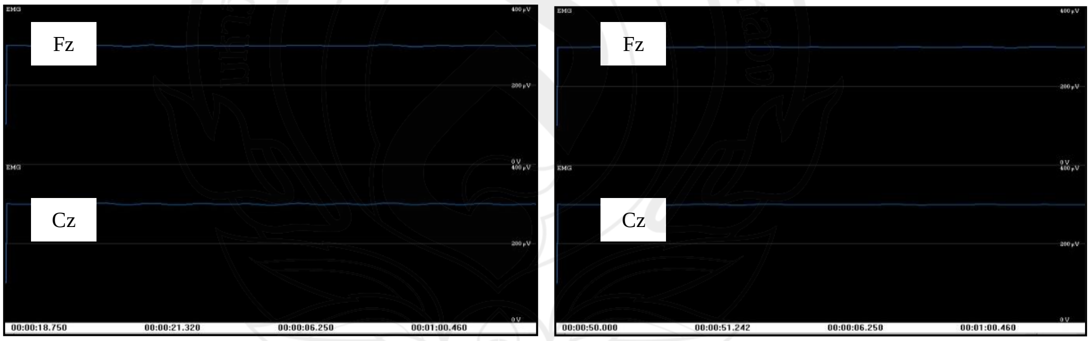
The study found the significance at the level 0.05 in three trial pairs. The result expressed in the number of waves and frequency at the same Cz electrode site (Table 4.7). The illustrations in Amplitude, Mindmirror and 3D landscape in each pair were shown below. There were two pairs that had significances in comparison trials including eyes-closed before and after deep breathing.

Table 4.7 Delta brain wave experimental data at Cz electrode site

		$\bar{x}$	SD	$\bar{d}$	$S\bar{d}$	t	p
Pair 1	eyes-closed before deep breathing	2.56	0.33	0.41	0.61	2.656	0.018
	eyes-closed after deep breathing	2.16	0.57				
Pair 2	eyes-closed before deep breathing	6.19	2.07	-0.81	1.22	-2.657	0.018
	eyes-closed after deep breathing	7.00	2.76				
Pair 3	deep breathing trial 1	2.38	0.38	0.37	0.64	2.299	0.036
	eyes-open before deep breathing	2.01	0.68				

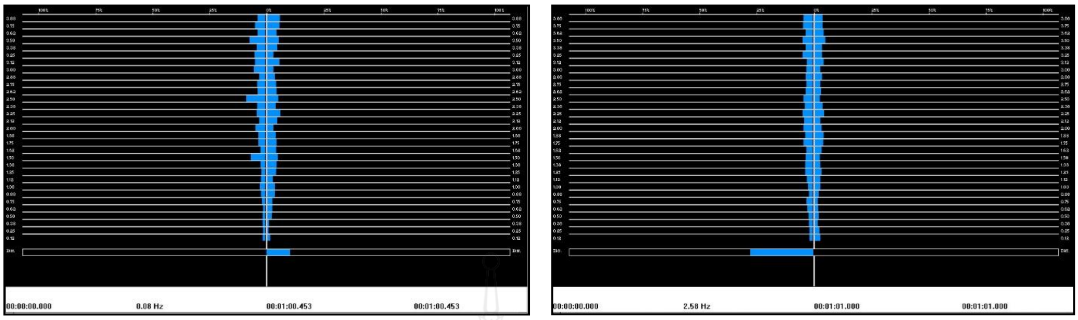
Pair 1: Eyes-closed before deep breathing and eyes-closed after deep breathing

The mean of frequency in eyes-closed before and the mean after deep breathing at Cz electrode site were at 2.56 and 2.16. The result demonstrated the significant decrease in frequency with p = 0.018. This pair had significance in the part of comparison trial pair.



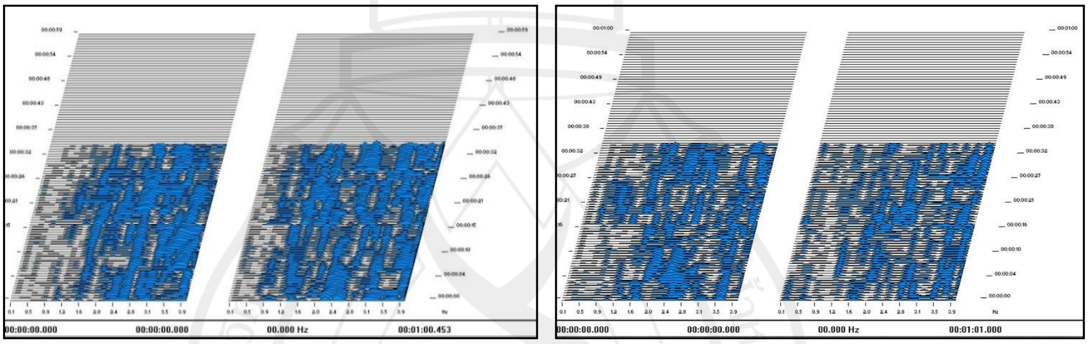
(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.17 Amplitude representation of Delta brainwave demonstrating the decreasing frequency at Cz electrode site



(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.18 Mindmirror representation of Delta brainwave demonstrating the decreasing frequency at Cz electrode site

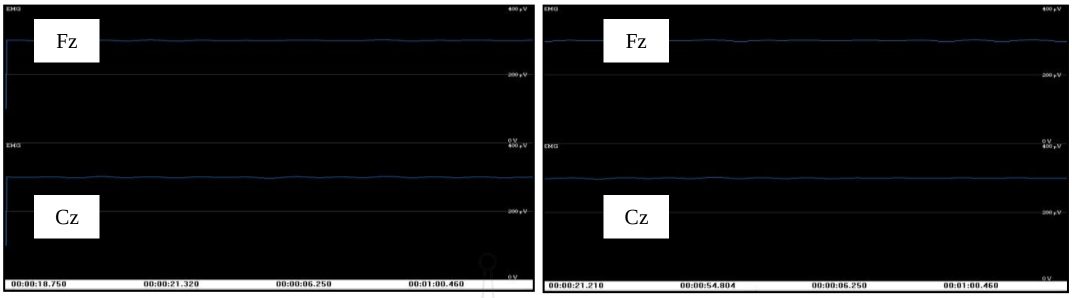


(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.19 3D landscape representation of Delta brainwave demonstrating the decreasing frequency at Cz electrode site

Pair 2: Eyes-closed before deep breathing and eyes-closed after deep breathing

The mean of number of waves in eyes-closed before and after deep breathing were found to be at 6.19 and 7.00. The result demonstrated the significant increase in number of waves with p = 0.018. This pair had a significance in comparison trial pair.

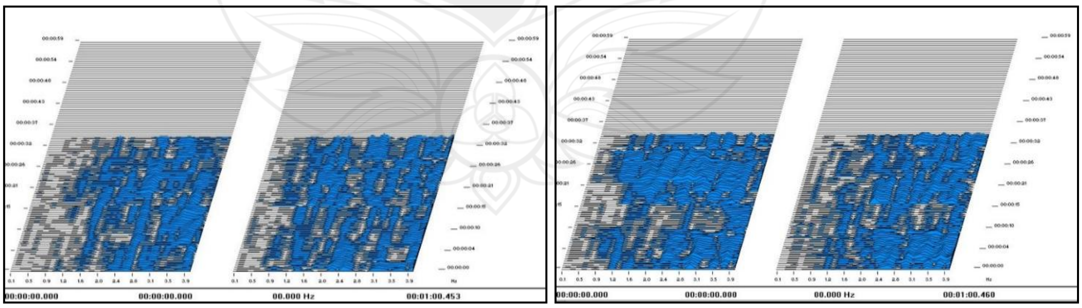


(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.20 Amplitude representation of Delta brainwave demonstrating the increasing number of waves at Cz electrode site

(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.21 Mindmirror representation of Delta brainwave demonstrating the decreasing number of waves at Cz electrode site

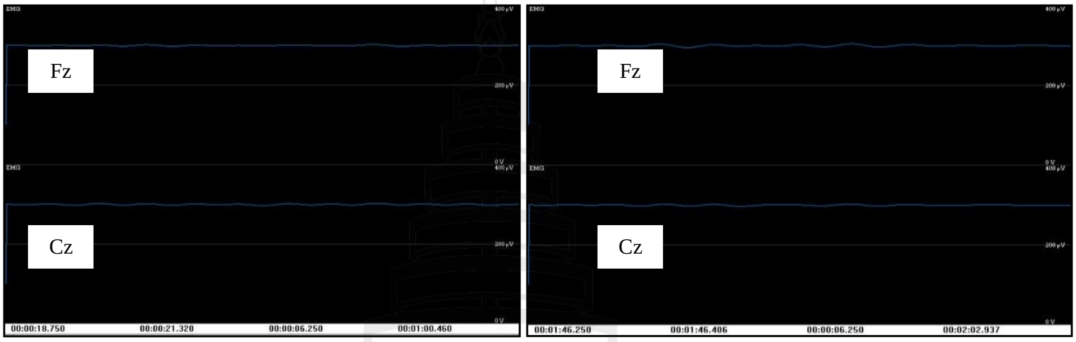


(a) eyes-closed before deep breathing (b) eyes-closed after deep breathing

Figure 4.22 3D landscape representation of Delta brainwave demonstrating the increasing number of waves at Cz electrode site

Pair 3: Eyes-open before deep breathing and deep breathing trial 1

The mean of frequency in eyes-open before deep breathing and deep breathing trial 1 at Cz electrode site were 2.01 and 2.38. The result demonstrated the significant increase in frequency with p = 0.036.

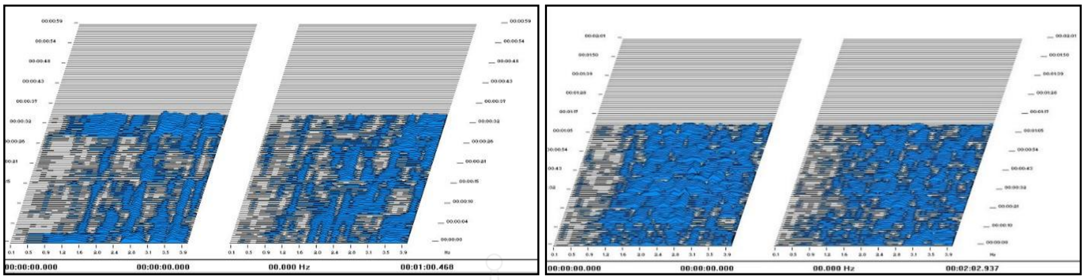


(a) eyes-open before deep breathing (b) deep breathing trial 1

Figure 4.23 Amplitude representation of Delta brainwave demonstrating the increasing frequency at Cz electrode site

(a) eyes-open before deep breathing (b) deep breathing trial 1

Figure 4.24 Mindmirror representation of Delta brainwave demonstrating the increasing frequency at Cz electrode site



(a) eyes-open before deep breathing (b) deep breathing trial 1

Figure 4.25 3D landscape representation of Delta brainwave demonstrating the increasing number of waves at Cz electrode site

Statistical results showed the significance at the level 0.05 in Delta brainwave. Three trial pairs demonstrated distinguished outcome; (a) the frequency in eyes-closed after deep breathing decreased compared to before, (b) the number of waves in eyes-closed after deep breathing increased compared to before, and (c) the frequency increased in deep breathing trial 1 comparing to eyes-open before starting procedure. In three pairs, there were two significant pairs in eyes-closed before and after deep breathing.

The occurrence of Delta wave complied with the study of Fumoto M. et al., (2004), which suggested that the occurrence of a Theta/Delta band replaced Alpha band during resting in eyes-closed condition. Theoretically, Delta is the slowest brain waves that human mind generates. It would dominate during deep sleep. Delta state is a dreamless, completely unconscious sleep state that allows your body and brain to rest and repair. It is during this deepest state of complete relaxation that the body heals itself, and resets its internal clock. Therefore, it could conclude that after deep breathing, participants created Delta as they were in the state of complete relaxation.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research was an experimental study which was designed in order to study the effect of deep breathing on stress level. The study, in addition, was designed to analyze brain activity, brain activity focusing on relaxation bands resulting from deep breathing. Sixteen healthy participants, aged 25-55 years (twelve women and four men) volunteered in the study and screened by inclusion and exclusion criteria. All of them had no experienced deep breathing or refrained from meditation practicing within one month prior to the experiment. No one denied or developed any complication during the experiment. The experiment composed of eleven trials following the experimental paradigm. Electroencephalogram (EEG) recorded brainwaves and divided the data into eleven files. Eyes-open, eyes-closed, and Thai Stress Test were done before deep breathing in order to be used for brain-wave data baseline and for stress level evaluation. The induced task of this study or independent variable was deep breathing conducted in five trials. Thai Stress Test, eyes-closed, and eyes-open trials were carried out again after deep breathing. The dependent variables were stress level, brain activity and brain activity focusing on Alpha, Theta and Delta.

The study after being analyzed by Thai Stress Test found that deep breathing created relaxation and improved mental health. Deep breathing affected Theta and Delta during resting in eyes-closed trial.

Therefore, it could be concluded that deep breathing may induce relaxation, improve mental health and affect relaxation brain wave bands, which are Theta and Delta. These findings considerably correlated to the research hypothesis. Moreover, the analysis found that deep breathing in trial 2 and 3 ranging from four to six minutes might be appropriate time for the participants to create Alpha.

5.2 Recommendation

The study of brain activity analysis of deep breathing critically analyzed in breadth different brain waves in various bands following the experimental paradigm of the researcher. There are several advantages that are worth notable for:

5.2.1 Expected benefits and applications:

The results show that deep breathing could cause various changes in behavior of the brain waves. These alterations could easily lead the practitioners to mental relaxation. Deep breathing could healthily affect every function in human body which ultimately could be concluded that it is one of the most effective and least costly anti-aging processes.

5.2.2 Research contribution:

This study could truly serve as the fundamental case for future related studies. They could vary in a number of ways:

5.2.2.1 Sample group

Age: the study would design to research in various ranges of age or specific group such as students, young adults or elderly.

Sex: the research could be designed specifically for either male or female.

Occupation: different groups of occupation that are more exposed to stress and negative health conditions could be selected to observe how effective deep breathing can be.

Practitioner status: those with frequent or regular practitioners might be selected to see if long term practice can stabilize the desirable health conditions arising from deep breathing.

5.2.2.2 Breathing methods

Type: different types of breathing, for example, Anapanasati, Pranayama or Breathing in Zen, can be nominated.

Instruction: Various instructions of breathing could be chosen.

Duration of breathing: Different duration of deep breathing trial should be considered for further study.

5.2.2.3 Electrophysiological data: future studies in brain waves may be conducted to study the patterns and behavior of specific brainwave in depth.

Referring to the results from this study, there is no mistake that deep breathing can be very beneficial and is no doubt the key to better-quality health. The researcher strongly recommends that this practice be regularly applied in real life because of the fact that it can be performed with no cost, no equipment, no membership required and can be done by anyone, anywhere and at any time. And so, it can be said that, deep breathing gives excellent benefits to human body and is undoubtedly the best practice in anti-aging.

REFERENCES

REFERENCES

Abbey, E. (2011). *18 Benefits of deep breathing and how to breathe deeply?.* Retrieved November 15, 2013, from http://www.onepowerfulword.com/2010/10/18-benefits-of-deep-breathing-and-how.html

Alpha Brain Waves. (n.d.). *Definition, Functions & Benefits.* Retrieved September 28, 2013, from http://www.brainwavesblog.com/alpha-brain-waves/# sthash.Eu1lxN1J.dpuf

Brain Actor 2-channel EEG. (n.d.). Retrieved October 17, 2013, from http://www.microsofttranslator.com/ bv.aspx?ref=SERP&br=ro&mkt=en-ww&dl=en&lp=DE_EN&a=http%3a%2f%2fwww.shift-academy.com%2fProdukte%2fdetails%2fBrainActor-2-Channel-EEG-1

Brain Wave States & How to Access Them. (n.d.). Retrieved October 10, 2013, from http://synthesislearning.com/article/brwav.htm

Davenport, B. (2010). *Breathe Deeply. Live Longer.* Retrieved September 15, 2013, from http://liveboldandbloom.com/10/health/breathe-deeply-live-longer

David, C. D. (2012). *Breathing.* Retrieved August 20, 2013, from http://www.nlm.nih.gov/ medlineplus/ency/anatomyvideos/000018.htm

Edwards, S. (2006). Experiencing the meaning of breathing. *Indo-Pacific Journal of Phenomenology, 6*(Ed1), 1-13.

Electroencephalogram (EEG). (n.d.). Retrieved October 17, 2013, from http://www.emedicinehealth.com /electroencephalogram_eeg-health/article_em.htm

Fumoto, M., Sato-Suzuki, I., Seki, Y., Mohri, Y. & Arita, H.. (2004). Appearance of high-frequency alpha band with disappearance of low-frequency alpha band in EEG is produced during voluntary abdominal breathing in an eyes-closed condition. *Neuroscience Research, 50*(3), 307-317.

Lorraine, S. (2010). *Diaphragmatic Breathing Vs. Clavicular Breathing*, Retrieved September 11, 2013, from http://www.livestrong.com/article/190830-diaphragmatic-breathing-vs-clavicular-breathing/

Mason, H., Vandoni, M., Debarbieri, G., Codrons, E., Ugargol, V., Bernardi, L. (2013). Cardiovascular and respiratory effect of yogic slow breathing in the yoga beginner: what is the bestapproach?. *Evid Based Complement Alternat Med. 2013*, 743504. doi: 10.1155/2013/743504.

Phattharayuttawat, S. (2000). The Development of the Thai Stress Test. *Psychiatry Journal, 45*(3), 237-250.

Sivakumar, G., Prabhu, K., Baliga, R., Pai, M. K. & Manjunatha, S. (2011). Acute effects of deep breathing for a short duration (2-10 minutes) on pulmonary functions in healthy young volunteers. *S-Indian J Physiol Pharmacol*, *55*(2), 154-159.

Take a Deep Breathing. (2009). Retrieved September 10 , 2013, from http://www.health.harvard.edu/newsletters/Harvard_Mental_Health_Letter/2009/May/Take-a- deep breath

The Benefits of Abdominal breathing. (n.d.). Retrieved June 16, 2014, from http://www.amsa.org/healingthehealer/breathing.cfm

The International 10-20 System of Electrode Placement. (n.d.). Retrieved October 17, 2013, from http://www.immrama.org/eeg/electrode.html

Weil, A. (2012). *Spirit and Inspiration*. Retrieved November 5, 2013, from http://www.drweil.com/ drw/u/ART00519/An-Introduction-to-Breathing.html

Yu, X., Fumoto, M., Nakatani, Y., Sekiyama, T., Kikuchi, H., Seki, Y., Sato-Suzuki, I. & Arita, H. (2011). Activation of the anterior prefrontal cortex and serotonergic system is associated with improvements in mood and EEG changes induced by Zen meditation practice in novices. *Int J Psychophysiol*, *80*(2),103-111.

APPENDICES

APPENDIX A

INFORMED CONSENT FORM

หนังสือยินยอมให้ทำการวิจัย (Informed Consent Form)

(หนังสือยินยอม)

ชื่อโครงการ ....

ชื่อผู้วิจัย ....

ชื่อผู้เข้าร่วมโครงการ ....อายุ..............

คำยินยอมจากผู้เข้าร่วมโครงการ

ข้าพเจ้า... ได้ทราบรายละเอียดของโครงการวิจัยและการทดลองทางห้องปฏิบัติการ ตลอดจนประโยชน์ที่จะเกิดขึ้นต่อผู้เข้าร่วมโครงการจากผู้วิจัยแล้ว และยินยอมให้ทำการวัดคลื่นไฟฟ้าสมองเพื่อการทดลองในโครงการที่มีชื่อข้างต้น และข้าพเจ้ารู้ว่าถ้ามีปัญหาหรือข้อสงสัยที่เกิดขึ้น ข้าพเจ้าสามารถถามผู้วิจัยได้ และข้าพเจ้าสามารถไม่เข้าร่วมโครงการวิจัยนี้ก็ได้

ลงชื่อ..(ผู้เข้าร่วมโครงการ)

( )

ลงชื่อ..(พยาน)

( )

วันที่...........เดือน.....................พ.ศ.........

คำอธิบายของผู้วิจัย

ข้าพเจ้าได้อธิบายรายละเอียดของโครงการ ตลอดจนประโยชน์ ที่เกิดจากการวัดคลื่นไฟฟ้าสมองของผู้เข้าร่วมโครงการในการทดลองทางห้องปฏิบัติการให้แก่ผู้เข้าร่วมโครงการแล้ว

ลงชื่อ..(ผู้วิจัย)

( )

วันที่...........เดือน.....................พ.ศ..........

APPENDIX B

AUTHORIZATION FORM FOR THE APPLICATION OF THAI STRESS TEST

ภาควิชาจิตเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล มหาวิทยาลัยมหิดล
Department of Psychiatry, Faculty of Medicine Siriraj Hospital, Mahidol University
อาคารเฉลิมพระเกียรติ ชั้น 8 โรงพยาบาลศิริราช เลขที่ 2 ถ.พรานนก ต.ศิริราช อ.บางกอกน้อย กทม. 10700 โทร. 662 – 4127542, โทรสาร 662 – 4113430
Chalermphrakiet Building 8th Floor Siriraj Hospital Bangkok - noi, Bangkok 10700 Thailand Tel. 662 – 4127542, Fax. 662 – 4113430

๒๒ กรกฎาคม ๒๕๕๗

เรียน คณบดีสำนักวิชาเวชศาสตร์ชะลอวัยและฟื้นฟูสุขภาพ

เรื่อง อนุญาตให้ใช้แบบประเมินความเครียดสำหรับคนไทย เพื่อการทำวิจัย

ยินดีให้ใช้แบบประเมินความเครียดสำหรับคนไทย (Thai Stress Test) เพื่อประกอบการทำงานวิจัยเรื่อง "Study of Brain Activity Analysis of Deep Breathing" ของนักศึกษากลุ่มวิจัยคลื่นสมองมหาวิทยาลัยแม่ฟ้าหลวง

ทั้งนี้เมื่อผลงานวิจัยดังกล่าวมีการสำเร็จลุล่วงและมีการตีพิมพ์ ขอให้ส่งผลงานวิจัยมาให้ทราบด้วยจักเป็นพระคุณอย่างสูง

(รศ.ดร. สุชีรา ภัทรายุตวรรตน์)

ภาควิชาจิตเวชศาสตร์ คณะแพทยศาสตร์ศิริราชพยาบาล
อาคารเฉลิมพระเกียรติชั้น ๘
e-mail: sisucheera@gmail.com
Tel: ๐๒-๔๑๙-๔๒๗๗
Fax: ๐๒-๔๑๙-๔๒๙๘

THAI STRESS TEST

แบบวัดความเครียดสำหรับคนไทย (Thai Stress Test)

ส่วนที่ 1 (ข้อ 1-12: บอกความรู้สึกทางด้านลบ) ข้อความข้างล่างต่อไปนี้

เป็นข้อความที่ท่านจะใช้บรรยายเกี่ยวกับตัวท่านเอง โปรดอ่านข้อความในแต่ละข้อ และพิจารณาเลือกตอบข้อความที่ตรงกับ**ความรู้สึกของท่านในขณะนี้** ข้อความต่อไปนี้ไม่มีคำตอบที่ถูกหรือผิด ท่านจึงไม่ควรจะใช้เวลานานเกินควรในการพิจารณาคำตอบในข้อหนึ่งข้อใด แต่จงเลือกคำตอบที่ท่านคิดว่าบรรยายความรู้สึกของท่านในขณะนี้ได้ชัดเจนที่สุด

ความรู้สึก	ระดับความรู้สึก		
	รู้สึกบ่อย ๆ	**รู้สึกเป็นครั้งคราว**	**ไม่เคยรู้สึกเลย**
1. ท่านรู้สึกเหงา และว้าเหว่			
2. ท่านรู้สึกไม่มีความสุขเลย			
3. ท่านมีความรู้สึกเบื่อหน่าย ท้อแท้ไม่อยากทำอะไรเลย			
4. ท่านรู้สึกกระวนกระวายเกือบตลอดเวลา			
5. ท่านรู้สึกกังวลเกือบตลอดเวลา			
6. ท่านรู้สึกไม่สบายใจโดยหาสาเหตุไม่ได้			
7. ท่านรู้สึกไม่ค่อยมีสมาธิในการกระทำสิ่งต่าง ๆ			
8. ท่านรู้สึกไม่อยากทำในสิ่งที่เคยสนใจทำเป็นประจำ			
9. ท่านอยากจะถอยหนี ไม่อยากพบปะพูดคุยกับคนอื่น			
10. ท่านรู้สึกหมดกำลังใจ			
11. ท่านรู้สึกสิ้นหวัง			
12. ท่านรู้สึกว่าตนเองไม่มีคุณค่า			

ส่วนที่ 2 (ข้อ 13-24: บอกความรู้สึกทางด้านบวก) ข้อความข้างล่างต่อไปนี้

เป็นข้อความที่ท่านจะใช้บรรยายเกี่ยวกับตัวท่านเอง โปรดอ่านข้อความในแต่ละข้อ และพิจารณาเลือกตอบข้อความที่ตรงกับ**ความรู้สึกของท่านในขณะนี้** ข้อความต่อไปนี้ไม่มีคำตอบที่ถูกหรือผิด ท่านจึงไม่ควรจะใช้เวลานานเกินควรในการพิจารณาคำตอบในข้อหนึ่งข้อใด แต่จงเลือกคำตอบที่ท่านคิดว่าบรรยายความรู้สึกของท่านในขณะนี้ได้ชัดเจนที่สุด

ความรู้สึก	**ระดับความรู้สึก**		
	รู้สึกบ่อย ๆ	**รู้สึกเป็นครั้งคราว**	**ไม่เคยรู้สึกเลย**
13. ท่านรู้สึกภาคภูมิใจว่า ท่านเป็นคนเก่ง			
14. ท่านรู้สึกภาคภูมิใจว่าท่านเป็นคนที่มีความสามารถ			
15. ท่านรู้สึกภาคภูมิใจว่าท่านไม่ได้ด้อยไปกว่าใคร			
16. ท่านรู้สึกพอใจกับชีวิตความเป็นอยู่ในขณะนี้			
17. ท่านรู้สึกว่าสิ่งต่างๆรอบตัวท่าน ยังมีอะไรบางอย่างที่ทำให้ท่านมีความสนใจเป็นพิเศษอยู่			
18. ท่านรู้สึกยินดีและพึงพอใจกับการที่ตนเองได้รับความสำเร็จในบางสิ่งบางอย่าง			
19. ท่านรู้สึกกระตือรือร้นในการกระทำสิ่งต่างๆในชีวิตประจำวัน			
20. ท่านยังรู้สึกสนุกสนานกับการพบปะพูดคุยกับคนอื่นที่อยู่รอบตัวท่าน			
21. การคิดและการตัดสินใจของท่านยังเป็นปกติเหมือนก่อน			
22. ท่านรู้สึกว่าชีวิตนี้ยังมีความหวัง			
23. ท่านรู้สึกมีกำลังใจที่จะปรับปรุงเปลี่ยนแปลงตนเองในทางที่ดีหรือก้าวหน้าขึ้น			
24. ท่านรู้สึกว่าจิตใจของท่านเป็นปกติ			

วิธีการตอบแบบวัด และเกณฑ์การให้คะแนน

ข้อคำถามแต่ละข้อจะมีการเรียงลำดับตัวเลือกในลักษณะมาตราส่วนประมาณค่า(Rating Scale) 3 ระดับ โดยมีเกณฑ์การให้คะแนนเป็นช่วง 0, 1, 3 ดังนี้

0 หมายถึง ไม่เคยรู้สึกเครียดเลย

1 หมายถึง รู้สึกเครียดเป็นครั้งคราว

3 หมายถึง รู้สึกเครียดบ่อย ๆ

เกณฑ์การให้คะแนนระดับความเครียด คือ ให้คะแนนเป็นช่วง 0, 1, 3 โดยรวมคะแนนแต่ละด้านเทียบกับตารางเมตริก ดังนี้

คะแนนข้อ 1-12 บอกความรู้สึกทางด้านลบ

คะแนนข้อ 13-24 บอกความรู้สึกทางด้านบวก

เกณฑ์การจัดกลุ่มคะแนนแบบวัดความเครียด โดยเปรียบเทียบกับตารางเมตริก

คะแนนรวมด้านNegative (1-12)	**คะแนนรวมด้าน Positive (13-24)**				
	12-36	**9-11**	**6-8**	**3-5**	**0-2**
0-1	1	2	3	4	5
2-3	2	3	4	5	6
4-5	3	4	5	6	7
6-7	4	5	6	7	8
8-36	5	6	7	8	9

การแปลผลแบบวัดความเครียด

1. สุขภาพจิตดีมาก (EXcellent mental health)
2. สุขภาพจิตปกติ (Narmal mental health)
3. ภาวะเครียดเล็กน้อย (Mild Stress)
4. ภาวะเครียดมาก (Stressful)

กลุ่ม	**ระดับความเครียด**
1	สุขภาพจิตดีมาก
2, 3 , 4	ปกติ
5 , 6	เครียดเล็กน้อย
7, 8 , 9	เครียดมาก

CURRICULUM VITAE

CURRICULUM VITAE

NAME	Mrs. Wanee Rojviroj
DATE OF BIRTH	3 March 1962
ADDRESS	36 Soi Phueng-Mee 7, Bangjak, Prakhanong, Bangkok Thailand 10260

EDUCATIONAL BACKGROUND

1990	Bachelor Degree of Education Early Childhood Sukhothaithammathirat University, Thailand
1983	Bachelor Degree of Nursing Chulalongkorn University, Thailand

WORK EXPERIENCE

2004- Present	Thai Language teacher Bangkok Patana International School, Bangkok, Thailand
1986-1992	Head of Daycare Center Faculty of Nursing, Khon-Kaen University, Thailand