Lightweight Electroencephalohraphic Study of Spatial Ability in Adult Obesity

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***Abstract*—The purpose of this study was to investigate the effect of spatial ability task to the spatial ability performance and EEG activity. Seven obese patients were participated in this study. The instructions were introduced to all participants to practice the spatial ability task. While performing the spatial ability task, EEG activities were recorded by using the lightweight EEG device, Mindwave Mobile, NeuroSky, Inc. The results revealed that some EEG activities including delta wave, theta wave, and alpha waves, respectively, were increased with statistically significant at the 0.05 level compared to the baseline while performing the spatial ability task.**

Keywords-Brain; Obesity; Brain; Spatial abilities; Attention

I. INTRODUCTION

Brain is an organ that is easily affected by the physical changes, especially in the modern time when people are easily poisoned by the increasing pollution. When the poisonous substances enter the body, every organ, including the brain will be endangered. Abnormalities will occur to the brain in terms of memory, eyesight, intellect, and balance. Because of these damages, people should know how to protect themselves from the poisonous substances [1-3]. Theoretically, spatial abilities are called as the mental capacities including construction, transformation and interpretation of mental images, respectively [4]. These abilities reflect the use of mental imagery in order to manipulate spatial representations.

Several previous studies determined the different factors composing the spatial abilities [4]. There are four factors including visualization, orientation and spatial relations, respectively. Theoretically, the visualization is known as the ability to mentally manipulation of the pictorially presented object. The ability of comprehending all elements arrangement was corresponded to the orientation. In contrast, the capacity of rapidly and accurately mental mage rotation is known to correspond to the spatial relation ability [4].

In addition, the mental rotation task and the spatial relation included in the mental imagery were reported to be linked with the spatial abilities. While performing the mental rotation task, these mental rotation and spatial relation were intimately related as rapidly rotating a mental image [4,10]. The integration of these neurophysiological parameters could help to contribute us to understand how the EEG correlates with the psychopathological conditions [13].

Electroencephalography (EEG) is traditionally used to measure the brainwaves. Each type of brainwave is associated with one's state of consciousness and different mood state [5-8]. From all types of brainwave, beta brainwave is seen in normal activities as well as stressful conditions or difficulties in mental concentration. On the other hand, alpha wave is seen in wakefulness, relaxed, effortless and alertness condition. Therefore, persons with high alpha wave and low in beta wave could indicate status of relaxation, arousal, less stress and better concentration [10-14]. To explore the modifications of electrical activities in relation to spatial abilities of obesity was the purpose of this study. In order to detect modifications of EEG oscillations, we used the lightweight EEG device for EEG activity recordings. The measurement of EEG activity was mostly done by letting the participants did the spatial ability task developed by SuperLab version 2.0 and then measure the EEG activity.

II. MATERIALS AND MEDTHODS

A. Participants

The experiment was done with seven volunteers, aged between 19-59 years old. All participants were in good health. They have no congenital illness, no record of brain surgery, not taking medicines or drugs that affect to nervous system. Seven obese patients (mean age: 33.20±8.97, mean BMI: 28.12±3.71). The 19 years or older with BMI of 23 kg/m2 or higher were selected in the study. Several exclusion criteria were monitored such as having left handedness, reporting with the medical and neurologic diseases history, binging the eating disorders as well as other psychiatric disorders, respectively. Those participants who had history of head trauma or the assumption of central nervous system which were active drugs in the two weeks prior to study entry as well as the presence of EEG abnormalities during the baseline recording were also excluded. After

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describing information and the aims of the study, the written informed consents were provided before participating in the study according to the Helsinki declaration standards.

B. Tools and Equipments

In this study, we recorded the personal information, namely, age, gender, nationality, and history of illness of all participants. The electroencephalography (EEG) was applied by using the neuroheadset displaying the output, analyze and record EEG activities. The international 10-20 system displaying the electroencephalography output was outlined the principles of analytical check. The five main oscillations were recorded including delta (0.1‑3 Hz), theta (4.0‑7.0 Hz), alpha (8.0‑13.0 Hz), beta (14.0 ‑ 30.0 Hz), and gamma (31.0 ‑ 60.0 Hz), respectively.

In this study, the commercially lightweight EEG device named NeuroSky's Mindwave Mobile was used in recording the signal processing unit at the headband arrangement via a single electrode application. Base on the specification, this effectiveness of lightweight EEG device provides two 100-state outputs which are operated at 1 Hz. It is known to minimize aforementioned difficulties in conducting accurate user studies as the principle advantage of this device (see Figure 1).

Figure 1. NeuroSky Mindwave Mobile Lightweight Electroencephalogram

In this study, spatial ability test was used as a tool to understand how the human brain function in reasoning and remembering the spatial relations among objects or space. According to the previous study, four main common types of spatial abilities were traditionally introduced such as spatial or visuo-spatial perception, spatial visualization, mental folding and mental rotation, respectively [11]. In our daily life, these our abilities have unique properties and importance to many types of tasks, for example, the spatial visualization is characterized as complicated multi-step manipulations of spatially presented information. In addition, the spatial working memory is known as the ability to temporarily store a certain amount of visual-spatial memories under attentional control in order to complete a task [11-13]. Therefore, measuring EEG activity while performing the spatial ability test run by SuperLab Pro. 2.0 compared to baseline. Moreover, the present study used the SuperLab Pro. 2.0 to develop the spatial ability test for EEG activity measurement.

C. Statistical analysis

The demographic data of all participants were analyzed by using descriptive analysis with qualitative data summarized in term of frequency and percentage, with quantitative data summarized in term of average and standard deviation. Using inferential statistic compared each type of EEG activities by compared *t*-test. Every tests were set to the statistic significant at $p<0.05$.

III. Result and Discussion

According to Table I, it was found that delta, theta and alpha oscillations gradually increased while beta and gamma oscillations were not changed. In addition, delta, theta and alpha oscillations increased with statistically significant at the 0.05 level while performing the spatial ability task. On the other hand, beta and gamma oscillations were found to be sustained while performing the spatial ability task.

TABLE I. Comparasion of EEG power spectra while performing the spatial ability task in obesity

EEG Power Spectra	Baseline		Spatial Ability Task		*p*-value
	Mean	SD	Mean	SD	
Delta	0.02	0.17	1.27	0.05	0.03*
Theta	0.07	0.11	1.51	0.02	0.05*
Alpha	0.01	0.02	1.30	0.04	0.01*
Beta	0.08	0.01	0.10	0.23	0.82
Gamma	0.03	0.08	0.07	0.45	0.40

*$p < 0.05$

According to Table II, it was found that delta frequency band was increased with statistically significant at the 0.05 level while performing the spatial ability task compared to baseline (baseline: 0.02±0.17μV; spatial task: 1.27±0.05μV; t(13) = 0.21; p=0.03).

TABLE II. Delta frequency band while performing the spatial ability task in obesity

EEG Power Spectra	Baseline		Spatial Task		*t*	*p*-value
	Mean	SD	Mean	SD	0.21	0.03*
Delta	0.02	0.17	1.27	0.05		

*$p < 0.05$

According to Table III, it was found that theta frequency band was increased with statistically significant at the 0.05 level while performing the spatial ability task compared to baseline (baseline: 0.07±0.11μV; spatial task: 1.51±0.02μV; t(13) = 0.03; p=0.05).

TABLE III. Theta frequency band while performing the spatial ability task in obesity

EEG Power Spectra	Baseline		Spatial Task		*t*	*p*-value
	Mean	SD	Mean	SD	0.03	0.05*
Theta	0.07	0.11	1.51	0.02		

*$p < 0.05$

Similarly, it was found that alpha frequency band was found to be increased with statistically significant at the 0.05 level while performing the spatial ability task compared to baseline (baseline: 0.01±0.02μV; spatial task: 1.30±0.04μV; t(13) = 0.71; p=0.01).

TABLE IV. ALPHA FREQUENCY BAND WHILE PERFORMING THE SPATIAL ABILITY TASK IN OBESITY

EEG Power Spectra	Baseline		Spatial Task		t	p-value
	Mean	SD	Mean	SD	0.71	0.01*
Alpha	0.01	0.02	1.30	0.04		

*$p < 0.05$

According to Table V, it was found that beta frequency band did not change while performing the spatial ability task compared to baseline (baseline: 0.08±0.01μV; spatial task: 0.10±0.23μV; t(13) = 0.37; p=0.82).

TABLE V. BETA FREQUENCY BAND WHILE PERFORMING THE SPATIAL ABILITY TASK IN OBESITY

EEG Power Spectra	Baseline		Spatial Task		t	p-value
	Mean	SD	Mean	SD	0.37	0.82
Beta	0.08	0.01	0.10	0.23		

Finally, it was found that gamma frequency band was not changed while performing the spatial ability task compared to baseline (baseline: 0.03±0.08μV; spatial task: 0.07±0.45μV; t(13) = 1.34; p=0.40).

TABLE VI. GAMMA FREQUENCY BAND WHILE PERFORMING THE SPATIAL ABILITY TASK IN OBESIY

EEG Power Spectra	Baseline		Spatial Task		t	p-value
	Mean	SD	Mean	SD	1.34	0.40
Gamma	0.03	0.08	0.07	0.45		

The results revealed that delta, theta, and alpha waves were increased with statistically significant while performing the spatial ability task. Participants have shown significantly mean improvement in speed, memory, attention, flexibility and problem solving, respectively. The present study stays in the line with previous studies demonstrated that the attention was related to sensorimotor rhythm [14,15]. In addition, the increase of theta and delta frequency bands which were consistent with previous studies mentioning alpha and theta oscillations increased in the frontal lobe [16,17]. Moreover, the loss of inhibitory control was shown more activation in the frontal lobe in some previous studies [16,18]. These previous results were characterized by groups of patients who had addictive disorders [16,18]. Moreover, some previous studies revealed the important role in memory processes were functioned by theta and alpha oscillations. This role is also regulated the emotion in the human brain [17,19]. Similarly, both working memory load and long-term memory coding were also reported to associate with the increase of both alpha and theta oscillations [17,18]. However, theta and alpha oscillations responded specifically to visual emotional stimulation and to negative emotions were reported in other previous studies, respectively [20]. Alpha oscillation related to the neural activity is recently reported that it is involved with the inhibitory mechanism functioning in facilitating the information while processing the spatial abilities tasks.

Some previous studies revealed other areas including surgery, mathematics or engineering education was influenced by the spatial abilities training [23]. Moreover, one study showed a significant correlation between spatial abilities and arithmetic abilities [5]. This previous study found the relationship between spatial abilities and the subtraction task [5]. Additionally, one previous study showed that spatial abilities were actually impact capacities in scientific learning [25]. Vanderberg and Kuse, for instance, developed the mental rotation test as a well-known spatial abilities training [23]. After that a computerized version of this mental rotation test was developed by Hoyek *et al.* [24] in order to train students' spatial abilities. Hoyek's computerized version was used to explore the improvement in learning ability [24]. Other important study used the mental rotation test to evaluate the ability of motor imagery process of both heathy participants and those patients with brain injuries [25]. This previous study demonstrated the left-hand motor-imagery task in relation to the spatial abilities [25].

V. CONCLUSION

This study investigated the effect of spatial ability task to the spatial ability performance and EEG activities. While performing the spatial ability task, EEG activities were recorded by using the lightweight EEG device, Mindwave Mobile (NeuroSky, Inc., USA). It was found that electrical activities including delta, theta and alpha waves were increased with statistically significant at the 0.05 level compared to the baseline while performing the spatial ability task.

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