Development of eye-hand coordinate activities program of increasing visuospatial working memory in elderly with type 2 diabetes mellitus : Electroencephalogram study

Nittaya Suriyapan* Pratchaya Kaewkaen** Pattrawadee Makmee** Peera Wongupparaj**

ABSTRACT

Background: Development of an eye-Hand coordination program to enhance visuospatial working memory in the elderly with type 2 diabetes mellitus are beneficial to the health of people and quality of life.

Objectives: The aims of this research study were to develop an eye-hand coordination program and to examine the program's effectiveness by comparing alpha and beta waves of the EEG observed in the experimental and control groups when given a spatial working memory task.

Methods: The experimental research study involved the elderly with type 2 diabetes mellitus aged 60-75 years from the chronic disease club of Tharuea Hospital, Phra Nakhon Sri Ayutthaya Province. Sixty participants were randomly selected according to the inclusion criteria and equally assigned to the experimental and control group, 30 each. The programme consisted of three 27-minute sessions and included fourteen memory tasks per session. The Psychology Experiment Building Language (PEBL) was used to control the Corsi Block-Tapping Task, Emotiv EPOC EEG headsets were used, Instruments included MMSE, PHQ-9, WHOQOL and ST-5, Data were analyzed using independent and dependent t-tests.

Results: The study found that 1) the eye-hand coordination program was effective and 2) when compared to the control group, the experiment group regularly showed an improvement in QOL and MMSE, a decrease in ST-5 and PHQ-9 scores, and an increase in visuospatial memory span in the Corsi block tapping task. In addition, the experimental group showed increased alpha and beta brain waves in the frontal, parietal and occipital lobes compared to the control group ($p<.05$).

Conclusion: Eye-hand coordination could improve spatial working memory in older people with type 2 diabetes mellitus.

Keywords: eye-hand coordination activities, stress, type 2 diabetes mellitus, visuospatial working memory

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การพัฒนาโปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือ ในการเพิ่มความจำขณะคิดด้านภาพและมิติสัมพันธ์ของผู้สูงอายุที่เป็นโรคเบาหวานชนิดที่ 2 : การศึกษาคลื่นไฟฟ้าสมอง

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บทคัดย่อ

บทนำ : การพัฒนาโปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือในการเพิ่มความจำขณะคิดด้านภาพและมิติสัมพันธ์ของผู้สูงอายุที่เป็นโรคเบาหวานชนิดที่ 2 เป็นประโยชน์ต่อสุขภาพและคุณภาพชีวิตที่ดีขึ้น

วัตถุประสงค์การวิจัย : พัฒนาโปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือ และเพื่อเปรียบเทียบผลการใช้โปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือ จากกิจกรรมทดสอบความจำขณะคิดด้านภาพและมิติสัมพันธ์ รวมทั้งศึกษาคลื่นไฟฟ้าสมอง (คลื่นอัลฟ่า คลื่นเบต้า) ระหว่างกลุ่มทดลองและกลุ่มควบคุม

วิธีการวิจัย : เป็นการวิจัยเชิงทดลอง คัดเลือกอาสาสมัครจากชมรมผู้สูงอายุ คลินิกโรคเรื้อรัง โรงพยาบาลท่าเรือ อำเภอท่าเรือ จังหวัดพระนครศรีอยุธยา ประเทศไทย จำนวน 60 คน อายุระหว่าง 60-75 ปี แบ่งเป็นกลุ่มทดลองและกลุ่มควบคุม โปรแกรมการฝึกมี 3 ช่วง ช่วงละ 27 นาที จำนวน 14 ครั้ง เครื่องมือที่ใช้ในการศึกษาคือ Psychology Experiment Building Language, Corsi Block-Tapping Task, Emotiv EPOC EEG headset, MMSE, PHQ-9, WHOQOL และ ST-5 การวิเคราะห์ข้อมูลโดยใช้การทดสอบค่าที

ผลการวิจัย : พบว่าโปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือมีการพัฒนาอย่างมีประสิทธิ ภาพและกลุ่มทดลองที่ได้รับการฝึกโปรแกรมอย่างเป็นประจำ มีคุณภาพชีวิตเพิ่มขึ้น ผลการทดสอบสภาพสมองเสื่อมเบื้องต้นลดลง ระดับความเครียดและภาวะซึมเศร้าลดลง โดยมีช่วงของความจำเพิ่มขึ้น นอกจากนี้ กลุ่มทดลองมีคลื่นอัลฟ่าและคลื่นเบต้าที่สมองบริเวณส่วนหน้า ส่วนพาไรทัล และส่วนท้ายสูงกว่ากลุ่มควบคุมหลังได้รับการฝึกโปรแกรมการฝึก อย่างมีนัยสำคัญทางสถิติที่ระดับ .05

สรุปผล : โปรแกรมการกระตุ้นประสานสัมพันธ์ตาและมือ สามารถเพิ่มความจำขณะคิดด้านภาพและมิติสัมพันธ์ของผู้สูงอายุที่เป็นโรคเบาหวานชนิดที่ 2

คำสำคัญ : ความจำขณะคิดด้านภาพและมิติสัมพันธ์ ความเครียด โรคเบาหวานชนิดที่ 2 การกระตุ้นประสานสัมพันธ์ตาและมือ

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**วิทยาลัยวิทยาการวิจัยและวิทยาการปัญญา มหาวิทยาลัยบูรพา

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Introduction

Eye-hand coordination exercises are not often used in brain training. A clear understanding of cognitive training also seems to be useful in understanding the process of control and decline in cognition after a diagnosis of diabetic mellitus (DM) and the factors that influence this. It is very important for nurses and professional health and care providers of patients with type 2 diabetes mellitus (T2DM) to be aware of this[1]. In fact, while glucocorticoid excess (overt or subclinical) has been demonstrated to cause diabetes or to worsen metabolic control,[2] the relationship between cortisol levels, insulin resistance, and chronic complications in T2DM patients without hypercortisolism is still a matter of debate. In recent years, the secretion of the hypothalamic-pituitary-adrenal (HPA) axis has been extensively studied in patients with T2DM.[3] In particular, some studies have found that these subjects have elevation of adrenocorticotrophic hormone (ACTH),[4] basal [5]and after dexamethasone test serum cortisol,[6] and late-night salivary cortisol levels.[7] This contrasts with other previous studies.[8] The presence of chronic complications of type 2 diabetes (i.e., macroangiopathy, retinopathy, and neuropathy) has been associated with HPA axis activity,[9] and recently an association has been found between the severity of various clinical measures of diabetes and cortisol secretion in type 2 diabetics with normal HPA activity.[10]

Working memory refers to the system or systems thought to be necessary to keep things in mind while performing complex tasks such as reasoning, understanding and learning. Working memory has been described by the multicomponent working memory model which performs the functions of short-term memory in the short-term storage of information, working memory is a multicomponent system that manipulates information storage for greater and more complex cognitive utility. The three subcomponents involved are the phonological loop (or verbal working memory), visuospatial sketchpad (visual-spatial working memory), and the central executive which involves the attentional control system.[11] and used the Corsi block tapping task (span) to study spatial WM and involves remembering a series of blocks (targets) touched by an experimenter.[12]

Diabetes Mellitus is an epidemic worldwide due to the increasing number of aging population and globalization. According to WHO, the number of diabetic patients will double in the next twenty years especially in developing countries in Asia.[13] Thailand is a country where the number of older people, aged 60 over increased rapidly in 2010. This number is expected to increase to 12.39 million (17.8%) by 2120.[14] However, it is not known whether Eye-Hand Coordinate improves Visuospatial Working Memory in Elderly with T2DM. If the effectiveness of the Brain Training with Eye-hand coordinate activities program of increasing visuospatial

working memory in elderly with diabetes mellitus type 2 in skills are widely applied among people in the community it may strengthen and benefit the health of people in both mental aspect, physical aspect and quality of life.

Therefore, our objectives were to: (1) develop the Eye-hand coordinate activity program to increase visuospatial working memory in the elderly with T2DM in Thailand, (2) create an activity test to apply the Eye- hand coordinate activity program to increase visuospatial working memory in the elderly with T2DM with a computer program suitable in Thailand, (3) to investigate the effect of the Eye- hand coordinate activity program to increase visuospatial working memory in the elderly with type 2 diabetes mellitus in Thailand as follows: (3.1) Comparison of the different accuracy scores in Working Memory before and after the experiment in the group receiving the Eye-hand coordinate activity program, and (3.2) Comparison of EEG with Working Memory before and after the experiment in the group receiving the Eye- hand coordinate activity program.

Research Methodology

Method and Design

This study was an experimental research utilizing two experimental techniques consisting of experimental conditions and controlled conditions. 1) The Eye-hand coordination activity program increase visuospatial working memory in elderly with T2DM, in which participants made eye movement during brain training of the eye-hand coordination activity (experimental conditions) 2) The psychosocial care and risk behavior, in which participants cannot participants in the Eye-hand coordination activity program but received regular medical treatment during psychosocial care and risk behavior (controlled conditions). While their EEG were simultaneously recorded to provide the participants with evidence to test the hypothesis, duration time was analyzed and compared, both between Eye-hand coordination activity program and medical conditions and experimental sessions. EEG recording and processing. An *Emotiv Epoc*+ EEG headset was used for the baseline EEG recordings and the Corsi Block-Tapping Task. It has 14 channels (AF3, AF4, F7, F3, F4, F8, FC5, FC6, T7, T8, P7, P8, O1 and O2, international 10–20 system) and uses passive saline sensors. The device is wireless and transmits data via Bluetooth through the 2.4 GHz band, has a battery autonomy of 12 hours and uses a built-in amplifier, as well as a CMS-DRL circuit to reduce external electrical noise. All analyses were carried out with MATLAB and EEGLAB.[15]

Participants

The population and participants were composed of 1) The population included all chronic T2DM elderly patients in elderly club and at Tharuea Hospital in Phra Nakhon Sri Ayutthaya Province, Thailand

who received services in the hospital in the academic year 2020. Through multi-stage random sampling 2) The sample were the elderly with T2DM in the community who received services in the hospital in Thailand. The 60 participants were randomly drawn by calculation according to the formula of Hair[16] 3) The participants were divided into two groups: 30 participants in the experimental group (brain training of eye-hand coordination activity), another 30 participants in the control group (medical treatment). and 4) The sample was selected by volunteer (Volunteer Sampling) so it would not affect the hospital services of the participants.

Data collection

In this study, there were two dependent variables namely decreasing ST5, MMSE, PHQ9, and increasing WHOQOL, Corsi Block-Tapping Task and EEG test due to brain training during Hands Boxes Activity (duration) of psychosocial care. The training curve for both groups was computed by recording participants' performance on the recognition task in each brain training session, for both the brain training of eye-hand coordination activity and control group conditions. The brain training of eye-hand coordination activities was presented to the participants in sessions, and intervention during the 3 session of 27 minutes sessions per week, including training for 2 weeks (14 time). In the first and last sessions, participants in both groups were measured with the Corsi Block-Tapping Task and EEG test recording. Physical activity results were tested and recorded for each session.

Data analysis

Training duration was compared and analyzed using standard scientific statistical tools. The Corsi Block-Tapping Task and the EEG test were analyzed and compared between the two groups and within sessions (first session and last session) and the results of the five sections of the questionnaires were analyzed using the t-test methodology.

Ethical considerations

The ethical aspects of this study were reviewed by the Burapha University Institutional Review Board (IRB) with Approval number IRB3-047/2564. Participants gave their informed consent verbally and in writing, which was confirmed with a signature.

Results

Sixty participants aged 64 to 75 were studied. The research found that at 66, age 70 was 43 percent and in general, participants report were 45% to be on the body; weigh centimetres 160-169, 53.33%; body mass index at 18.50-22.90, 56.67%; had primary education, participants had suffered from chronic diseases for a longer

period of time were 10 years; occupation of agriculture/work as an employee, 24%; most of them eat 3 meals, which was for 60%; participants were mostly sleep was 8 hours/day or 50%, not exercise 70%. Found that the older T2DM, 60 participants were divided into 2 groups: the experimental group. The group received brain training of eye-hand coordination program and not brain training of eye-hand coordination program of the control group (group B) was stress, QOL, PHQ-9 and MMSE level. For the experimental group and the control group (group B), the mean stress score was reduced to 1.66. The experiment before and after was mean stress scores before and after the experiment were 2.80 and 2.16, and were reduced stress and depression and quality of life and MMSE increased after the experimental group B after using eye-hand coordination activities program of increasing visuospatial working memory in elderly with T2DM.

Table 1 shows that the EEG examination after the experiment was higher than that before the experiment. The means were -2.76 and -.41, and the standard deviations were 1.36 and 1.05. A statistically significant difference was found at the .05 and that the control group had a score from the measure. Pre-experiment and Post-experiment. Their mean scores were -1.38 and -1.26 and their standard deviations were 1.38 and 1.27. The control group before and after using the eye-hand coordination activity program of Increasing Visuospatial Working Memory in Elderly with T2DM: EEG study. There was a statistically significant difference at .01. It was found that the experimental group with the MMSE test found that the Corsi block tapping task in memory span and the MMSE test had a higher mean score after than before the experiment. The mean score was 4.26, and 1.91 the standard deviation was 1.02 the standard deviation was .821. The MMSE mean score was 27.10 and 25.10, and the standard deviation was 4.53 and 4.61. The control group among the groups with MMSE test scores showed that the Corsi block tapping task memory on the memory span test had mean scores before the experiment was 2.76, the standard deviation was 1.23 after the experiment, and the mean score was 2.88, the standard deviation was 1.29. The MMSE test had a high post-experiment mean of 25.13, standard deviation was 4.62, and post-experiment mean of 26.13, standard deviation was 4.83. Corsi block-tapping task tests in the pretest and posttest experimental control group between the MMSE test group showed mean and standard deviations were not different.

Table 1 Comparison of Visuospatial Working Memory in the Corsi Block-Tapping Task with memory span measurement scores from the experimental and control groups.

Memory span	*M*	SD	df	t	p
Experimental group (A)					
Pre-test	-.41	1.05	30	-2.154*	.040
Post-test	-2.76	1.36	30		
Control group (B)					
Pre-test	-1.26	1.27	30	-5.429**	.000
Post-test	-1.38	1.38	30		

**p<.01 *p<.05

Table 2 revealed the experimental group found that males had higher mean EEG than females in the alpha brainwave and beta brainwave frequencies that respond to visual working memory during the experiment, it was found that males and females had no mean values for the alpha brainwave frequency band differently after the experiment, it was found that males and females had statistically significant differences in the .05 and beta brainwave frequency EEG responses to visual working memory in the experimental group before and after the experiment males had higher mean than females. Before the experiment, mean EEG in frequency beta brainwave was significantly different for males and females at .01 and after the experiment, males and females were significantly different frequency beta brainwave at the .05.

Table 2 Comparison electroencephalogram (EEG) of alpha brain wave and beta brain wave between gender in experimental group (group A) and control group (group B).

EEG	women (n=60)		men (n=60)		T	P
	M	SD	*M*	SD		
Experimental (group A)						
Alpha (μv^2)						
Pre-test	48.60	18.10	66.84	53.54	-1.250	.222
Post-test	53.50	14.33	267.77	387.87	-2.138*	.041
Beta (μv^2)						
Pre-test	84.81	35.96	328.61	344.57	-2.725**	.011
Post-test	122.21	25.54	274.06	280.91	-2.085*	.046
Control group (group B)						
Alpha (μv^2)						
Pre-test	46.51	19.85	119.01	172.12	-1.620	.116
Post-test	61.54	14.24	74.97	42.11	-1.171	.252

Table 2 Comparison electroencephalogram (EEG) of alpha brain wave and beta brain wave between gender in experimental group (group A) and control group (group B) (continue)

EEG	women (n=60)		men (n=60)		T	P
	M	SD	*M*	SD		
Beta (μv^2)						
Pre-test	109.15	26.69	128.46	83.90	-.850	.403
Post-test	122.21	25.54	274.08	280.91	-2.085*	.046

**p<.01 *p<.05

The mean EEG alpha and beta brain waves of the control group responding to visuospatial working memory with the Corsi block tapping task show that males in the pretest and posttest control groups have higher values than females. For the frequencies of alpha and beta brainwaves responding to visuospatial working memory during the experiment, it was found that the mean values for alpha brainwaves did not differ between men and women. After the experiment, it was found that men and women had statistically significant differences in the .05 and EEG responses beta brainwave to visual working memory of men had higher than women. Before the experiment, the beta brainwave was not different for males and females, and after the experiment, the mean value in the beta brainwave had males and females were statistically significantly different at the .05. Show electroencephalogram (EEG) of visuospatial working memory in the Corsi block tapping task with memory span of alpha brainwave between gender in the experimental group (Group A) and control group (Group B) in Table 2, Figure 2 and Figure 3.

Discussion

This study involved the development of an eye-hand coordination activity program to increase visuospatial working memory in elderly people with T2DM: EEG study. According to the results of the study, the EEG was different in the experimental group. The study examined the relationship between gender and visuospatial working memory before and after the Corsi block tapping task. In elderly people with type 2 diabetes mellitus, EEG was different in the experimental group and in the control group before and after the experiment in men and women.

Overall, it was found that before the experiment, men and women had no difference in alpha brain wave and after the experiment, it was found that men and women have EEG in beta alpha brain wave are differences responsive visuospatial working memory. Also, EEG alpha brain wave and EEG frequency beta brain wave in the position of AF3, F7, F8, P8, P7 and FC6 and the position of AF3, F7, F8, P7, P8 and FC6, and stress levels, depression and quality of life in the experimental group

using the eye-hand coordination activity program to increase visuospatial working memory in elderly people with type 2 diabetes mellitus and the control group, who did not use the eye-hand coordination activity program to increase visuospatial working memory in elderly with T2DM before and after the experiment found that alpha brain waves are different before and after treatment. By after experiment was lower than before EEG beta brain wave before and after treatment are different. The alpha brain wave corresponds to the efficiency increased memory. By found that the alpha brain waves have a function in transcription.[17] In addition, beta brain waves on the part of the occipital lobe and the temporal lobe, and consistent with the study analyzed the gender differences from the EEG to the attention and perception on the interaction of visual, age and gender with the establishment of neurons in the function of visuospatial working memory through the results, negative effects, such as depression, stress-induced decline in working memory all age groups, including the elderly, the will cognitive impairment found later in the elderly.[18]

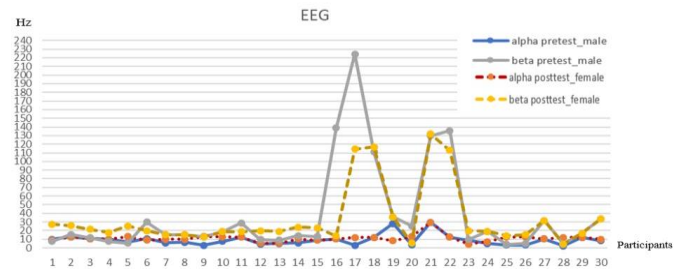

Figure 1. Comparison alpha brain wave and beta brain wave in experimental (group A).

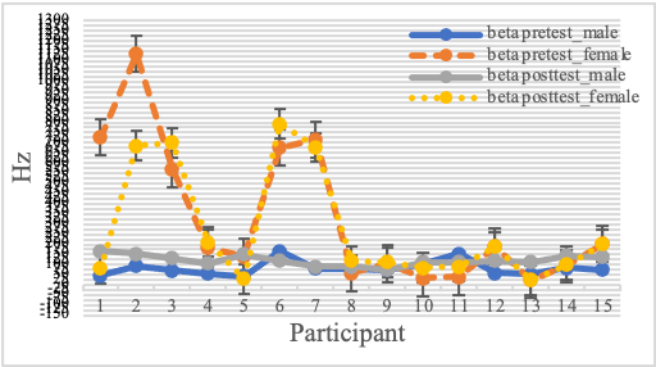

Figure 2. Comparison beta brain wave between male and female in control (group B)

Emotiv 2D alpha brain wave

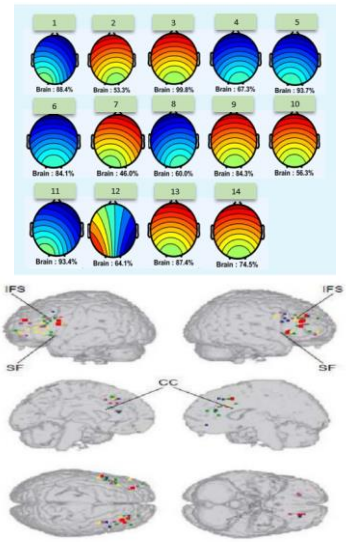

Figure 3 Comparison of brain regions stimulated by measuring the internal processes of the central executive which appears in the frontal lobe of the brain

Comparison of alpha brain waves between the experimental group (group A) and the control group (group B). Temporal evolution of relative individual upper alpha over twenty 3-minute periods of Corsi block-tapping task training (CBT, blue line) and

memory span (MS, orange dashed line) during the seven test sessions on four consecutive days. Relative alpha was determined by dividing the average amplitude of the single upper alpha band (approximately 10 to 13.5 Hz) by the average amplitude of the entire EEG band (i.e., 4 to 64 Hz). In addition, the relative alpha values were standardized with the first measurement (i.e., Fig. 1, Fig. 2, and Fig. 3).

However, decreased working memory was associated with negative effects such as stress, depression, quality of life, visuospatial working memory (VWM), possibly due to the decreased ability of VWM by physiological measurements, the negative effects are high, that is, the stress and depression are high. Therefore, the negative effects have a greater risk associated with less cognitive function. It affects the quality of life of the elderly.[19] Due to stress, anxiety and depression was associated with a decrease in cognitive memory measured n-back.[20] This led to a decrease in and dimensional memory, while there was a change in alpha frequency electrocardiogram (alpha) and frequency beta brain waves at positions AF3, F7, F8, P8, P7 and FC6, and at positions AF3, F7, F8, P7, P 8 and FC6. In addition, the study of mood and anxiety disorders in visuospatial working memory was used to evaluate the course of activity and biological responses. It was found that individuals with high level of mood and anxiety disorders had reduced ability to store visuospatial working memory or reduced ability, by the experimental group used eye-hand coordination stimulation program to improve thinking memory Visual and relational dimensions of the elderly, the T2DM has stress and depression and increased quality of life Visuospatial working memory decreases, and there is a change in alpha and beta EEG at the AF3, F7, F8, P8, P7 and FC6 positions and at the AF3, F7, F8, P7, P8 and FC6 position are in the cycle value of the frequency of the alpha brain waveband alpha with a frequency of about 8-13.9 cycles per second (Hz) and the EEG frequency beta brain wave with a frequency of about 14-30 cycles per second (Hertz : Hz).[21]

The finding was also consistent with the study of diabetes mellitus, physical activity, and longevity between the ages of 70 and 90 years from the Jerusalem Institute and found support for promoting regular physical activity with DM regardless of advancing age.[22] The researchers discovered that there is clear evidence from prospective cohort studies and controlled intervention trials that physical activity can help prevent T2DM.[23]

Limitations that may include additional issues, such as a room used to detect EEG intentions for water testing while simultaneously measuring EEG noise, and the ease of use and portability of the new

wireless EEG technology compared with laboratory-recorded EEG. The EEG-generated delta, theta, alpha, and beta bands were subjected to reliability testing (RP) of the EEG-derived delta, theta, alpha, and beta bands.

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