วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 15 ฉบับที่ 1, กรกฎาคม 2558
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นิพนธ์ต้นฉบับ (Original article)
สรีรวิทยาการออกกำลังกายและกีฬา (Sports and Exercise Physiology)

THE ACUTE EFFECTS OF EXERGAME ON BRAIN FUNCTIONS IN ELDERLY

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ABSTRACT

Although aging population in Thailand is expected to increase rapidly, only one-sixteenth of the elderly engage in regularly physical exercise. Inactivity in ageing found to be associated with an increased incident of many chronic diseases such as hypertension, diabetes, Alzheimer's disease etc. Therefore performing regular exercise should recommend since it can exert its positive effect on the ageing's physiological performance and brain functions. The purpose of this study was to investigate the acute effects of aerobic exercise by playing exergames on brain waves in sedentary elderly. Twenty volunteers aged 55 to 70 years (n=20; 10 male and 10 female) who did the exercise less than/equal two days per week and, no exergames experience. They were divided into two groups: control group (n=10) and exergames group (n=10). The exergames group was performed an aerobic exercise by playing exergames with moderate intensity (50% - 70% HRmax) for 20 minutes and recorded the EEG before and after playing games using NeXus-10 device. The results showed that in exergames group, beta wave was significantly increased (p<0.05) after exercise when compared with control group. These changes indicate the activating effect of exercise by increasing cortical activities in the cerebral cortex, which is related to the arousal. This mechanism may be related to an increase of the blood flow to the brain after exercise. In conclusion, playing exergames, as an aerobic exercise, has positive effects to increase arousal and improve brain functions, suggesting a useful method to slow down the degeneration of the brain functions in the elderly.

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KEY WORD: Electroencephalography (EEG), Exergames, Elderly

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ผลของการเล่นเกมแบบปฏิสัมพันธ์ที่ส่งผลต่อการทำงานของสมองโดยทันทีในผู้สูงอายุ

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บทคัดย่อ

เนื่องจากประเทศไทยกำลังจะก้าวไปเป็นสังคมผู้สูงอายุและจากรายงานของสำนักงานสถิติแห่งชาติพบว่ามีผู้สูงอายุเพียงหนึ่งในสิบหกส่วนเท่านั้นที่มีการออกกำลังกายเป็นประจำ ดังนั้นจึงทำให้เกิดโรคเรื้อรังต่างๆ เช่น ความดันโลหิตสูง โรคเบาหวาน โรคอัลไซเมอร์ เป็นต้น การวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาผลของการออกกำลังกายแบบแอโรบิคโดยการเล่นเกมแบบปฏิสัมพันธ์ ที่ส่งผลต่อคลื่นไฟฟ้าสมองในผู้สูงอายุที่ไม่ค่อยออกกำลังกาย กลุ่มตัวอย่างเป็นอาสาสมัครอายุระหว่าง 55-70 ปี จำนวน 20 คน (ชาย 10 คน หญิง 10 คน) ที่ออกกำลังกายน้อยกว่าหรือเท่ากับ 2 วันต่อสัปดาห์ และไม่เคยมีประสบการณ์การเล่นเกมแบบปฏิสัมพันธ์มาก่อน ผู้เข้าร่วมการวิจัยแบ่งออกเป็นกลุ่มทดสอบและกลุ่มควบคุม กลุ่มละ 10 คน โดยกลุ่มทดลอง จะให้ออกกำลังกายแบบแอโรบิคด้วยเครื่องเล่นเกมแบบปฏิสัมพันธ์ ด้วยระดับความหนักแบบปานกลาง (ร้อยละ 50- 70 ของอัตราการเต้นหัวใจสูงสุด) เป็นระยะเวลา 20 นาที และทำการบันทึกคลื่นไฟฟ้าสมองด้วยเครื่องมือ NeXus10 ในช่วงก่อนและหลังจากการเล่นออกกำลังกายในทันที ผลจากการศึกษา พบว่ากลุ่มทดสอบมีคลื่นเบต้าเพิ่มขึ้น ในช่วงหลังออกกำลังกายเมื่อเปรียบเทียบกับกลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ($P<0.05$) โดยการเปลี่ยนแปลงดังกล่าวน่าจะเป็นผลของการออกกำลังกายที่ช่วยไปเพิ่มการทำงานของเซลล์ประสาทในส่วนเปลือกสมองที่มีความสัมพันธ์กับความรู้สึกตื่นตัว ซึ่งกลไกนี้อาจจะเกี่ยวข้องกับการเพิ่มขึ้นของการไหลเวียนของเลือดที่ไปเลี้ยงสมองภายหลังการออกกำลังกาย จึงสรุปได้ว่าการออกกำลังกายแบบแอโรบิคโดยการเล่นเกมแบบปฏิสัมพันธ์ในผู้สูงอายุนั้นสามารถช่วยเพิ่มความตื่นตัว และช่วยเพิ่มการทำงานของสมองดังนั้นการออกกำลังกายในลักษณะนี้อาจจะนำมาใช้ในการชะลอความเสื่อมของระบบประสาทในผู้สูงอายุที่ไม่ค่อยออกกำลังกายได้

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คำสำคัญ :คลื่นไฟฟ้าสมอง, การออกกำลังกายแบบปฏิสัมพันธ์, ผู้สูงอายุ

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INTRODUCTION

In the year 2013, The National Statistics Office revealed that the elderly population in Thailand is continuously increasing. They estimated that approximately elderly population will increase about 1 in 5 of the total population in 2018. Therefore, Thailand becomes a completely aging society in the next 10 - 20 years ahead. Interestingly, the report of the surveyed behavior in sport, physical activity and mental health in the various age groups of the population in Thailand 2011 from the National Statistical Office, Ministry of Information and Communication Technology of Thailand found that only 1 in 16 of the elderly population in the country have physical activity. Most of the people do not exercise and spend long time with TV. Inactivity in aging found to be associated with an increased incident of many chronic diseases such as hypertension, diabetes, Alzheimer's disease etc.

Elderly has a lot of physical and mental changes. Their physical performances were reduced, according to the deterioration in body functions, which associated to higher risk of many diseases. Previous evidence showed that the functional changes occurred in the elderly brain was slow down such as poor memory, perception, thinking processes and decision. However, these deterioration changes depend on the lifestyle.[1] Therefore, good health and hygiene can reduce the risk of diseases or health problems in the elderly. Electroencephalography (EEG) is a non-invasive technique for analysis the frequencies of brain function. Theta waves (4-8 Hz) are slow wave associated with drowsiness, meditative, and creative states. Even though this wave is the most common found in young children, excess theta wave for elderly represents abnormal activity of brain function. Alpha wave (8-12 Hz) represents relaxation and mental exertion, reflect idle brain and relaxation. Beta wave (>12 Hz) is referred to the brain arousal, alert or anxious. This wave it associated to motor behavior and movements. Barry et al.,[2] recommended that although EEG provides information about the electrical activity of the brain, but due to the intervening media, the scalp-recorded signal can also provide a diffuse picture of that underlying activity, and calculate the relative of brain activity between the slow /fast wave ratio, which can be used to analyze the function and dysfunction of the brain. Then, the increase of theta/beta ratio is most reliably associated with attention deficit hyperactivity disorder (ADHD),[2] which finds in young children, however theta/beta ratio will decrease[3] when they grow up. On the other hand, the elderly may be at risk for the increasing of theta / beta ratio due to physiological change in aging, especially in the brain functions.[4] However, Hartikainen P., 1992[3] found that beta and alpha wave have tendency to decrease in elderly, but it not in healthy person.

The recommendations and guideline of the ACSM suggested that exercise become important for health because of it can slow down the changes of the brain in the elderly. The research of Colcombe et al., 2004[5] showed that exercise can increase cardiovascular, and cognitive functions in elderly. Recently Timinkul A. et al., 2010[6] studied the regional cerebral blood volume (rCBV) and brain wave by using NIRO 300 and EEG in nine adults healthy, they performed cycling for 10 min of at 40% and 60% VO2max. The result showed that exercise affected the increasing of the CBV which could affect higher frequency of the brain

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waves. According to the study of Moraes H., et al., 2007[7] found that beta power was higher at (FP1, F3 and F4) and central of the head (C4) after cycling ergometer until exhaustion. This result indicated that exercise until exhaustion can stimulate the increasing of cortical activity and improve cognitive function in sedentary elderly.

Currently with the development technology for exercise, Wii games or exergames is an interactive game by using the body movement or reaction to activate and control in play the game, in a studied the real time. This device is used for entertainment, and can play in all age. Many games of Wii such as Gold's Gym game, Your Shape game, Just Dance game and The Biggest Loser game were used to study how much the energy expenditure (EE) costs in each game. Haddock BL. et al., 2012 found that the average values of EE for all games were 1,005 kcals, which followed the ACSM recommendations for weekly.[8] Furthermore the average of heart rate in all the games was 125.4 $\pm$20 bpm, which was high enough to be considered as the moderate intensity exercise. While Pigford et al., 2010[9] studied effects of balance training using by Wii games (5 times/week for 2 weeks) in the elderly who have high risk of falling, after training they found that elderly had enhancement of stabilization of the balance. This was similar to the study of Karim H. et al, 2012 who found that the active balancing exercise with Wii games, subjects had 2-3 times increased of blood flow in the brain at superior temporal gyus.[10] Although various studies of the above found that exercise by exergames have effective effect to VO_2 and haemodynamic. However it is still unclear for exergames to affect brain functions of sedentary elderly.

This study aimed to investigate the aerobic exercise by exergames affected on brain wave (EEG) in sedentary elderly, and compared the amplitude of brain waves before and after exercise and compared between exercise by Wii games group and control group.

MATERIAL AND METHODS

Subjects

Twenty sedentary elderly volunteers with aged 50-70 years were participated in this study (n=20; 10 male and 10 female). The subjects have a physical activity or exercise less than 2 days/week. The female subjects were postmenopausal at least 5 years. Furthermore, the subjects have a right-handed predominant, never have experienced exergames before, and did not have any diseases, or ever had an accident on the nervous system and brain. The subjects were divided into two groups, control group (SC, n=10) and exergames (Wii) (SW, n=10) group.

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Data Collection

The researcher explained the purpose and procedure details about the research for elderly participants. All subjects signed the inform consent before started the experiment. This research was approved by the Central *Institutional Review* Board, Mahidol University.

To participate in this research, the subjects required to complete as following; the provided questionnaire, the health status and the fitness history. The handedness questionnaire (Oldfield, 1971) was used to screen only a right-handed dominant. The research was divided into two sessions, On the first day, the subjects came to the laboratory, the height, body weight, body fat, body mass, blood pressure, heart rate were recorded. Subjects were measured the cardiorespiratory fitness to divide the subjects for each groups according to the physical fitness. The peak of oxygen consumption (VO_{2peak}) was measured using O_2 and CO_2 gas analyzer (Oxycon mobile device). The subjects performed walking/running on a treadmill by a modified Bruce protocol and a constant speed with increasing grade increments of 2% every three minutes until volitional exhaustion. Physiological variables consist of heart rate, oxygen consumption and blood pressure were recorded in a real time during exercise. The rating of perceived exertion; RPE scale (Borg, 1970) was recorded every 3 min. Inclusion criteria of the sedentary groups have VO_{2peak} less than 20.3 ml/kg/min in female and VO_{2peak} less than 20.9 ml/kg/min in male.[11]The subjects were terminated the test immediately for any of the following conditions onset; angina or angina like symptoms, shortness of breath, wheezing and leg cramps, blood pressure (systolic pressure >250 mm Hg or diastolic pressure > 115 mm Hg, or drop in systolic blood pressure of >10 mm Hg from baseline of BP even though the workload was increased), light-headedness confusion, ataxia, pallor, cyanosis, nausea, or cold and clammy skin. When the respiratory exchange ratio (RER) of the subjects was 1.2 as well as RPE was at the level 18 (very hard) or subjects requested to stop.

All subjects were familiarized with 7 Wii games which consisted of Penguin, Football, Perfect10, Bird fly, Obstacle, Hula hoop and free running games. However, subjects were selected into groups on a voluntary basis.

On the second day of the experiment, the subjects came to the laboratory and measured EEG using NeXus-10 device at central of head (Cz) during eye-closed (EC) before and after the end of exercise. For exergames group, subjects were to exercise using exergames at the intensity 50%- 70% of maximum heart rate by warming up for 10 minutes and exercising for 20 minutes. Then the participants seated on the chair until heart rate return to 10% of pre-exercise value. After that they were measured EEG variables for 5 minutes. The subjects in control group were sit on the chair for 20 min instead of exercise with Wii games. The test periods between 1st and 2nd days will be apart for at least 5 days.

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Statistical

The analysis of data was used Kolmogorov-Smirnor test for normal distribution. Physical characteristic data was presented as mean and standard deviation (SD). The variable of brain waves were presented in mean and standard error of the mean (SEM). The comparison of the data between groups and within groups used unpaired *t-test* and paired *t-test*, respectively. The significant difference was at p <0.05. Use SPSS for windows Version 17 for analysis.

RESULT

General characteristics

General characteristics of subject were presented as mean and the standard deviations as shown in Tables 1. The age, weight, height, BMI, %body fat, % body fat free mass and VO_{2peak} were not significantly different between SW and SC group.

Tables 1 General characteristics of sedentary exergames (SW) and sedentary control (SC) group. Data are Mean ± Standard Deviation (SD).

Variables	SW group (n=10)	SC group (n=10)
Age (yrs.)	61.9±4.48	62.9±4.67
Weight (kg.)	59.49±3.12	62.1±6.87
Height (cm.)	158±6.26	162±6.01
Body Mass Index (kg. / $m.^2$)	23.67±2.55	24.24±4.2
Body fat (%)	23.15±8.3	22.5±7.16
Body mass (%)	25.58±4.22	26.28±3.55
VO_{2peak} (ml. /kg. /min)	20.05±1.16	19.93±2.04

Intensity of exercise by exergames

From Figure 1a, the intensity of exercise by exergames was represent as heart rate (HR). HR in SW group during in each game of the Penguin game, Football game, Perfect10 game, Bird fly game, Obstacle game, Hula hoop game and the free running games were 83±2.99, 79±2.39, 84±2.6, 89± 3.56, 92±3.61, 94±3.23 and 109±2.43 bpm, respectively. While that in SC group during sitting for 20 mins was 69± 2.3 to 71±2.12 bpm. As shown in Figure 1b.

Therefore, during exercise by exergames, the intensity was 53-70% of HRmax, whereas the SC group during sitting 20 min, the intensity of exercise was about 44 to 45% HRm

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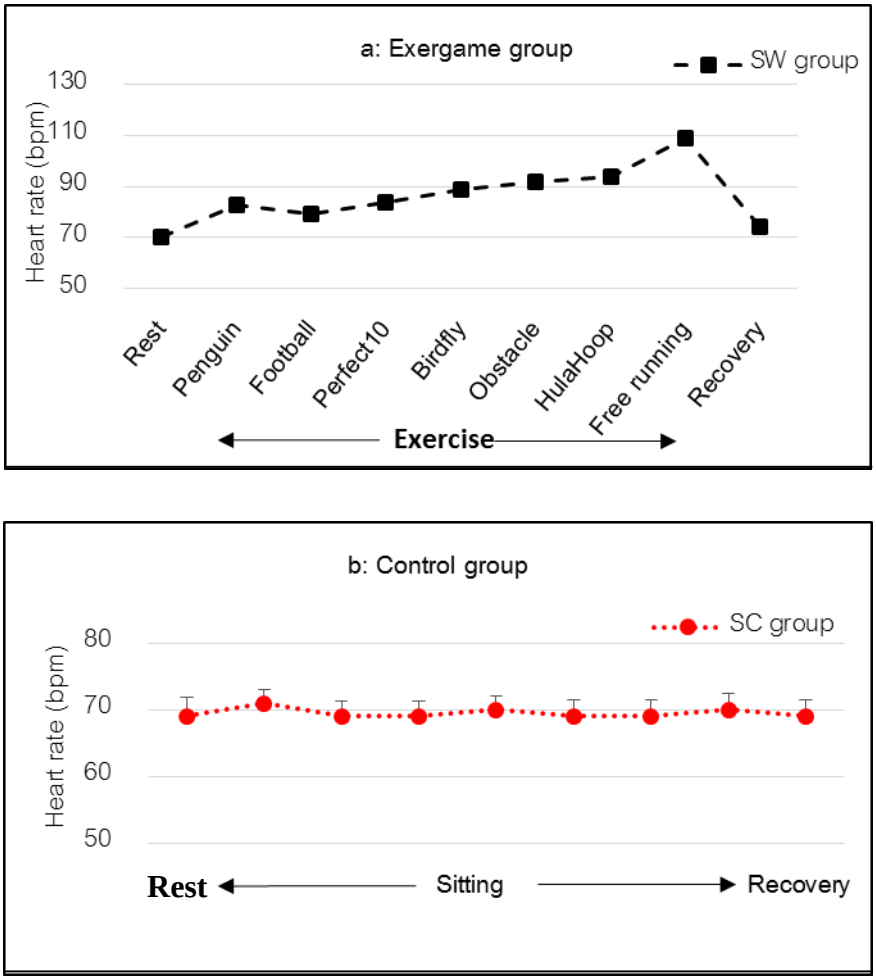
Figure: 1 Heart rate was shown at rest, during exercise and recovery in (a.) sedentary exergames; (SW) and (b.) sedentary control; (SC). Data were mean ±SEM



Comparison of the amplitude of brain waves

The amplitude of brain wave was measured during eyes closed at pre- and post- exercise in SW group and sitting in SC group. The results of the EEG at pre-exercise were not significant differences between both groups. At post-exercise, there was significant increase of the beta amplitude in SW group which shown higher than that in the SC group (Table 2).

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Table 2 The amplitude of brain wave. Data were mean± SEM. In exergames group (SW), data were corrected before and after exercise and in control group (SC), data were corrected before and after sitting 20 min.

Brain waves *(microvolt)*	Pre (baseline)		Post	
	SW group.	SC group.	SW group.	SC group.
Theta wave	11.7±1.07	9.6 ±0.71	12.25 ±1.28	10.59±0.92
Alpha wave	14.24±1.46	11.18 ±1.64	15.86±1.13	11.45±1.78
Beta wave	9.28±1.06	6.55±1.06	9.73 ±0.99 *	6.62±1.03*
Theta/Beta ratio	1.38±.019	1.68±0.18	1.36 ±0.2	1.85±0.26

*(p<0.05) Significantly different between exergames group and control group after experiment

DISCUSSION

In this studies the results of the EEG at resting period were not significantly (p<0.05) different between exergames and control groups. These data showed that brain activity at rest of both groups were similarly. However, the exergames group showed significantly increased in amplitude of the beta wave higher than that in the control group. This result suggests that the exercise using exergames can affect function of the brain.

Previous experiment reported that higher EEG of beta wave associated with the occurrence of function of nerve cells that located in the part of the cerebral cortex. Therefore our results demonstrates the exercise of this nature can increase the stimulating of the nerve cells in the cerebral cortex[12] and indicates the brain are increased arousal. This is consistency with study of Moraes H. at.el., 2007 [7] who found that beta wave increased at the frontal (FP1, F3 and F4) and middle of the head (C4) after exercise using the bicycle ergometer test. The research explained that the increase in beta waves may be relevant to an increase in function of the cerebral cortex. In addition, study of Timinkul A., el at. 2010[6] found that beta waves was increased after the exercise using the bicycle ergometer test at the intensities 40 and 60% of VO2max. This suggested that the increasing of volume of blood flow after exercise may be associated with brain arousal.[6] It was also found that beta waves increased after exercise may be associated with a higher attention, and may indicate changing in the activity of the brain.[13] Furthermore, the theta/beta ratio which is the one of indicator for diagnosis of ADHD. If this ratio is increased, it meant theta wave is active than beta wave which indicated the sign of ADHD. However, in the study we did not find the changes in theta/beta ratio in both groups. Colcombe SJ, et al., 2004 [14] found that exercise can retard the degeneration of brain function and cognitive processes in elderly.

CONCLUSION

An aerobic exercise using exergames at the intensity 53 -70% of VO2max can stimulates the beta wave in cerebral cortex indicating an increase in arousal, cognitive processes and slow down the degeneration of the brain function in the elderly.

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