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

THE ACUTE EFFECT OF EXERGAME ON HAEMODYNAMICS RESPONSES IN SEDENTARY AND ACTIVE YOUNG ADULTS

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ABSTRACT

The purpose of this study was to investigate the effects of exergame (Nintendo® Wii Fi™) on haemodynamics responses. Twenty participants with age 18-25 years old were participated in this study and were divided into two groups; active group (AG; n=10) and sedentary group (SG; n=10). On the experimental day, after resting for 10 min., participants performed exercise by using seven games of Nintendo Wii for 20 min. and recovery for 5 min. The haemodynamic variables including heart rate (HR), stroke volume (SV), cardiac output (CO), cardiac index (CI), ejection fraction (EF), and systemetic vascular resistance (SVR) were recorded in a real time on neck, sternum, rib closet to V6, and back by non-invasive technique (Physioflow®) throughout the experiment. The results showed that at rest, during exercise, and recovery period, the participants in AG had better blood circulation than those in SG, but no significant difference between groups. However, the value of EF in AG at recovery period was higher than that in SG and showed significant difference (p<0.05) between groups. Therefore, exercise by exergame can improve the cardiac function in young adults. The AG had more responses to exergames than SG in some haemodynamics parameters.

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KEYWORDS: Exergame, Heamodynamics responses, Young adults

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ผลของการเล่นเกมแบบปฏิสัมพันธ์แบบทันทีต่อระบบไหลเวียนเลือดของวัยรุ่นในกลุ่มที่ไม่ค่อยออกกำลังกายและออกกำลังกายเป็นประจำ

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บทคัดย่อ

การวิจัยครั้งนี้มีวัตถุประสงค์เพื่อศึกษาผลของการออกกำลังกายแบบปฏิสัมพันธ์ (นินเท็นโด วี ฟิต) ต่อระบบไหลเวียนเลือด ผู้เข้าร่วมวิจัยมีอายุระหว่าง 18 - 25 ปี และได้รับการแบ่งออกเป็น 2 กลุ่ม คือ กลุ่มที่ออกกำลังกายเป็นประจำ (n=10) และกลุ่มที่ไม่ค่อยได้ออกกำลังกาย (n=10) ในวันที่ทำการทดลองผู้เข้าร่วมวิจัยจะนั่งพัก 10 นาที เล่นเกมแบบปฏิสัมพันธ์ทั้งหมด 7 เกม เป็นระยะเวลา 20 นาที และพัก 5 นาที ตัวแปรของค่าการไหลเวียนเลือดที่วิจัย ได้แก่ อัตราการเต้นของหัวใจ, ปริมาณเลือดที่ออกจากหัวใจในหนึ่งครั้ง, ปริมาณเลือดที่ออกจากหัวใจในหนึ่งนาที, เปอร์เซ็นต์ของปริมาณเลือดที่สูบฉีดออกจากหัวใจในแต่ละครั้ง, อัตราการไหลเวียนของเลือดที่ออกจากหัวใจใน 1 นาทีต่อพื้นที่ผิวกาย, และความต้านทานรวมของหลอดเลือดส่วนปลาย โดยใช้เทคนิคแบบ non-invasive ด้วยเครื่อง Physioflow® โดยติดอิเลคโทรดที่บริเวณคอ, กระดูกกึ่งกลางหน้าอก, กระดูกระหว่างซี่โครงคู่ที่ 6 และกึ่งกลางหลังตลอดการทดลอง จากการศึกษาพบว่าในกลุ่มที่ออกกำลังกายเป็นประจำทั้งในขณะพัก, ระหว่างการเล่นเกมแบบปฏิสัมพันธ์, และภายหลังการเล่นเกมแบบปฏิสัมพันธ์ มีการไหลเวียนเลือดดีกว่ากลุ่มที่ไม่ค่อยได้ออกกำลังกาย แต่ไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติ อย่างไรก็ตามภายหลังการเล่นเกมแบบปฏิสัมพันธ์พบค่าเปอร์เซ็นต์ของปริมาณเลือดที่สูบฉีดออกจากหัวใจในแต่ละครั้งมีค่าสูงกว่ากลุ่มที่ไม่ค่อยได้ออกกำลังกายและมีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ (p<0.05) ดังนั้นการออกกำลังกายด้วยการเล่นเกมแบบปฏิสัมพันธ์สามารถช่วยพัฒนาการทำงานของหัวใจในวัยรุ่นได้ และผู้ที่มีค่าพื้นฐานการออกกำลังกายที่ดีจะตอบสนองต่อค่าการไหลเวียนเลือดดีกว่าผู้ที่ไม่ค่อยได้ออกกำลังกายเป็นประจำ

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คำสำคัญ: เกมแบบปฏิสัมพันธ์, การตอบสนองของระบบไหลเวียนเลือด, วัยรุ่น

วารสารวิทยาศาสตร์และเทคโนโลยีการกีฬา ปีที่ 15 ฉบับที่ 1, กรกฎาคม 2558

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INTRODUCTION

In recent years, development of advanced technologies affected young adults to have less exercise. They spend time mostly on screens for activities such as notebooks, tablets and smartphone. According to the report year 2013 by the Ministry of Culture and Ministry of Public Health[1], there are more than 2.7 million out of 18 million youths who addict in electronic games and social network such as Facebook. American College of Sports Medicine (ACSM) guideline suggests that people should have physical activity around 150 minutes per week (30 minutes per day, five days per week)[2]. National Statistical Office Thailand (NSO)[3] reported that there are only 15.1 million (26.1 percent) from 57.7 million people who exercise regularly. This showed that Thai population has less exercise which may be a cause of getting chronic diseases such as hypertension and diabetes mellitus.

Recently, exergaming becomes one of an alternative exercises which can cause our body to spend more energy. Therefore, it is suitable for people who dislike outdoor sport activities. Mongkol et al.,(2013)[4] investigated the effects of 4 weeks of Nintendo Wii game (dance game) on body mass index (BMI) and VO_{2max} . They found that the BMI of the participants who exercised with this Wii game were decreased and VO_2max were higher than those in non-exercise group. Graves et al., (2008)[5] found that the VO_2 during playing Wii sports was significantly higher than playing XBOX360. They recommended that exercised for 30 minutes a day, five days per week, could let an energy expenditure reached to 1005 kcals which is equivalent to ACSM's recommendation (Haskell et al., 2007)[6]. In addition, Bailey et al., (2011)[7] found that exergame supported more movement than three miles walking per hour. So, the purpose of this study was to investigate the effects of exergame on haemodynamic responses in active and sedentary young adults.

MATERIALS AND METHOD

Twenty healthy participants with age range 18-25 years old were recruited from students of Mahidol University. All participants wrote the informed consent which was approved by the Ethical Committee of Mahidol University. The participants were divided into two groups; the active group (AG; n=10) who had an experience of exercise 30 min/day, 3 days/week for at least 1 or 2 years and the sedentary group (SG; n=10) who were inactive or do the physical activity less than 2 days per week.

In this study, Nintendo game was used as the exergame. This game used a hand controller and a balance board for controlling movement and maintaining balance, respectively. Haemodynamics responses at rest, during exercise and recovery were measured by non-invasive technique (Physioflow®).

On the first day, general history and health information of all subjects were collected including weight, height, blood pressure, body mass index (BMI), percentage of fat and percentage of muscle mass. Physical activity readiness questionnaire (PAR-Q) was used for screening participants prior to starting the experiment. The participants were separated into two groups by using the peak of oxygen consumption (VO_{2peak})[16] which was modified by Bruce protocol. All participants practiced one time of the exergame which consisted of seven games that were Penguin, Football, Perfect10, Birdfly, Hulahoop, Obstacle and Free run for familiarization (Figure 1).

Examples of game

Figure 1: Example of exergame: Penguin (a), Football (b), Perfect10 (c), Birdfly (d), Hulahoop (e), Obstacle (f) and Free run (g). (http://www.wiifit.com)

On the second day, prior to the experiment, participants seated on the comfortable chair for 10 minutes, and their vital signs were recorded. Physioflow® was used to measure heart rate (HR), stroke volume (SV), cardiac output (CO), cardiac index (CI), ejection fraction (EF) and systemic vascular resistance (SVR). Before measured the haemodynamics variable by Physioflow®, the area of the skin was cleaned up by using an alcohol prep pad until it turned to bright pink color. The participants were attached the electrodes at 6 places on the body. White and blue leads were placed on participant's neck, red lead (sternum), orange lead (the rib closet to V6), green lead (xiphoid process) and black lead (laterally on the rib) as shown in Figure 2. Before exercising, all participants were seated on comfortable chair for 5 minutes. Then, they exercised by playing the exergame (7 games) for 20 minutes and recovery for 5 minutes on the comfortable chair. The haemodynamics variables were measured at rest, during exercise and recovery, respectively.

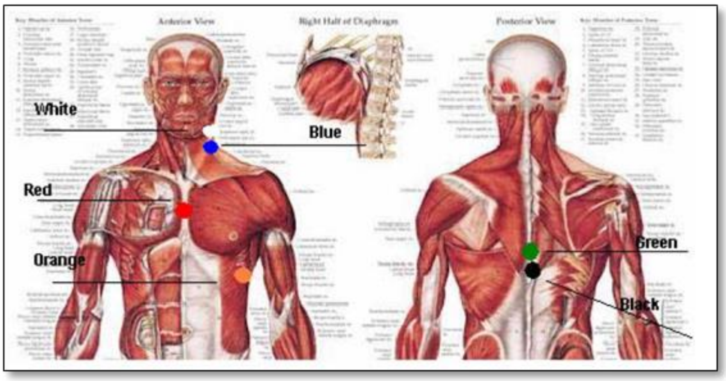


Figure 2: Electrode positions for haemodynamics measurement by Physioflow ®. White and blue lead placed on subject's neck, red lead (sternum), orange lead (the rib closet to V6), green lead (xiphoid process) and black lead (laterally on the rib). (Taken from User manual of Physioflow®)

STATISTICAL ANALYSIS

Characteristics of participants were presented as mean±SD. The haemodynamics responses presented as mean ± SEM. The Kolmogorov-Sminov test (K-S test) was used for normal distribution testing. Independent t-test was used to analyze the differences between the AG and the SG. Statistical significant will be accepted at $p<0.05$ level.

RESULTS

General characteristics

From Table 1, general characteristics; age, weight, height, body mass index (BMI), percentage of body fat and percentage of muscle mass were not significantly different between two groups. However, VO_{2peak} in the SG and the AG were 29.5 ± 1.1 ml/kg/min and 40.8 ± 1.2 ml/kg/min, respectively. There were significantly different between the groups ($p<0.05$).

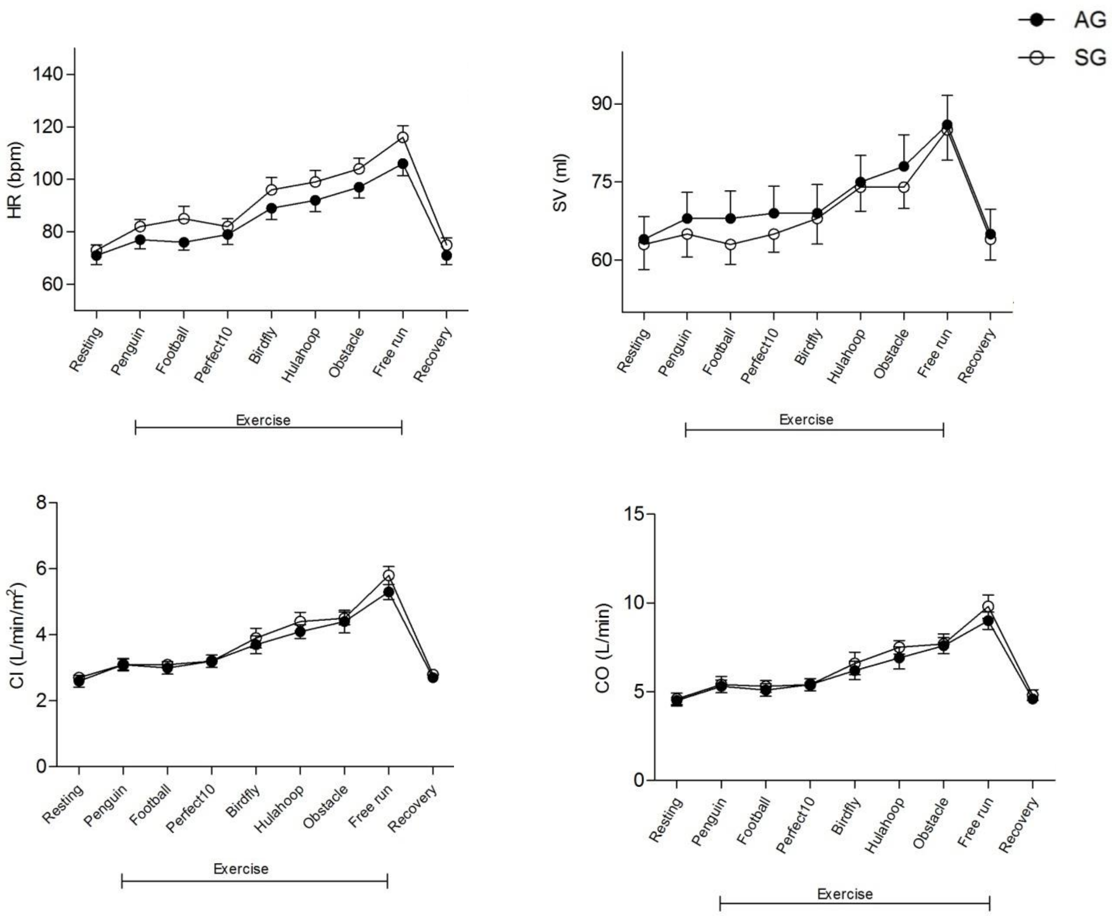
Table1 Characteristics of participants in the active group (AG) and sedentary groups (SG). Values are mean ± SD.

Variables	AG (n=10)	SG (n=10)
Age (yrs.)	21.7 ± 2.1	21.6 ± 2.4
Weight (kg)	63.1 ± 10.3	60.0 ± 7.9
Height (cm)	168.1 ± 8.8	167.3 ± 7.2
BMI (kg/m^2)	22.3 ± 2.1	21.4 ± 2.6
Body Fat (%)	17.4 ± 6.2	17.6 ± 6.7
Muscle mass (%)	32.4 ± 4.1	31.7 ± 4.7
VO_2peak (ml/kg/min)	40.8 ± 1.2*	29.5 ± 1.1

* Significant difference between the SG and the AG ($p < 0.05$).

CARDIOVASCULAR RESPONSES

The HR, SV, CO, EF, CI, and SVR were measured at rest, during exercise and recovery.



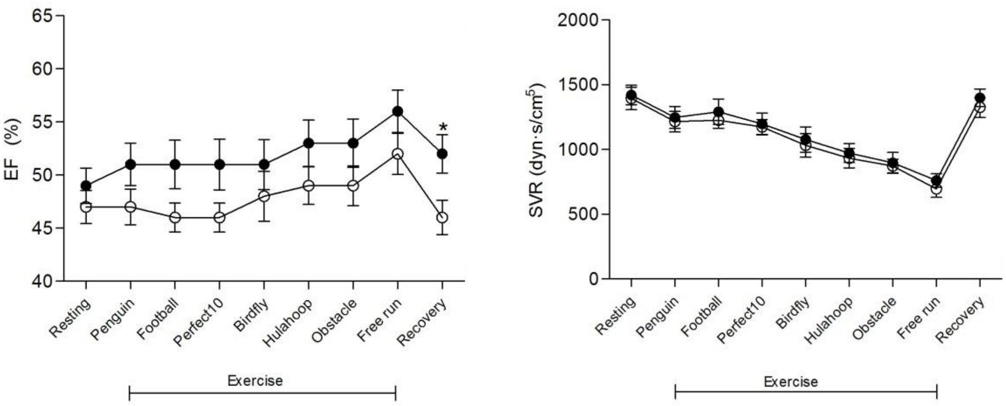


Figure3: The haemodynamic variables; of heart rate (HR), stroke volume (SV), cardiac output (CO), ejection fraction (EF), cardiac index (CI) and systemic vascular resistance (SVR) at resting, during exercise and recovery in active (AG) and sedentary (SG) groups. Value are mean ± SEM. * significant difference between groups (*p*<0.05).

Resting period

In the resting period, the values of HR in AG and SG were 71.2 ± 3.41 and 72.9 ± 2.10 bpm, respectively. Those of SV were 63.9 ± 4.38 and 63.1 ± 4.77 ml, CO were 4.54 ± 0.29 and 4.64 ± 0.32 L/mins, CI were 2.63 ± 0.18 and 2.72 ± 0.13 L/min/m^2, EF were 49 ± 1.65 and 47.1 ± 1.57 %, SVR were 1420.9 ± 74.9 and 1393.5 ± 87.0 dyn·s/cm^5, respectively. These results showed that the HR, CO, CI, and SVR in AG were less than those in SG. It is clearly that the SV and EF in AG were higher than those in the SG. However, there was no significant difference between the groups.

During exercise

Figure 3 showed the HR, SV, CO, CI, EF, and SVR of the AG compared to those in the SG. At the peak of exercise, the HR of AG and SG were (106.4 ± 4.58 and 116.3 ± 4.54 bpm), SV (85.5 ± 5.66 and 84.5 ± 5.78 ml), CO (9.03 ± 0.47 and 9.83 ± 0.66 L/min), CI (5.26 ± 0.23 and 5.77 ± 0.27 L/min/m^2), EF (56.0 ± 2.00 % and 51.8 ± 1.95%) and SVR (760.3 ± 53.11 and 696.0 ± 64.62 dyn·s/cm^5), respectively. There was no significant difference between the two groups during exercise.

Recovery period

Recovery period (5 minutes after exercise), the values of HR in AG and SG were 70.70 ± 3.42 and 75.30 ± 2.70 bpm, respectively. Those of SV were 64.90 ± 4.78 and 63.60 ± 3.98 ml, CO were 4.63 ± 0.24 and 4.81 ± 0.30 L/mins, CI were 2.69 ± 0.15 and 2.83 ± 0.13 L/min/m^2, EF were 51.60 ± 1.82 and 46.10 ± 1.61 %

and SVR were 1399.30 ± 68.42 and 1325.20 ± 77.11 dyn·s/cm[5]. It was found that, the EF in the AG and the SG were significantly different between groups at the recovery period.

DISCUSSION

In this study, it is clearly that the VO_{2max} in AG (40.8 ± 1.2 ml/kg/min) was significantly higher than that in the SG (29.5 ± 1.1 ml/kg/min) indicating the cardiorespiratory system in active people can enhance better physical performance while doing regularly physical activities than that in sedentary people. Although, the haemodynamics variables in this study did not show significant difference at rest, during exercise and recover, but the EF, which is an indicator of cardiac function in the AG was higher than that in the SG during exercise. It was consistent with Bello et al, 1996[8] who found that the value of EF after maximum exercise in athletes was increased more than that in sedentary which followed through the Frank-Starling mechanism. Furthermore, Granger et al., 1985[12] reported that athletes have higher EF than in untrained subjects, but no significant difference between groups. In addition, 12-week progressive exercise training showed the improvement of EF in obese male subjects (Schrauwen-Hinderling et al., 2010)[10]. This may be explained by the effect of exercise training decreases resting and submaximal exercise HR and increase SV, which improves functional capacity and cardiac efficiency. However, it was not affected on CO directly, but affected on the HR and SV. In 2000, Pluim et al.[11] also found that the left ventricular wall thickness in control subjects was smaller than athletes. Therefore, the athletes should have a powerful cardiac muscle to eject the blood more than sedentary people. It is clearly in this study that HR in the AG was lower than that in the SG at rest, during exercise and recovery. The SV in the AG was higher than that in SG during exercise. The possible mechanism of the increase of SV during exercise may be due to increase of preload reserve (Frank-starling). Furthermore, systemic vascular resistance (SVR) was decreased during exercise in both groups.

Due to the exergame have many type of the games, previous studies had examined 22 of 68 activities in Wii Fit Plus and Wii sports which classified the games as moderate intensity of activities on the basis of METs [9]. However, the results showed that during exercise, the HR in each game of both groups were not significantly different (106.4 ± 4.58 bpm in AG, while the SG 116.3 ± 4.54 bpm). Our study tried to set the game from light to moderate intensity based on the HR, followed the ACSM guideline. In addition, Monteiro-Junior et al., (2014)[14] found that the HR was increased from pre-exercise (75.0 ± 9 bpm) until the end of exercise (176 ± 15 bpm) after playing the game Free-run for 10 min, it showed the upper-limit of the aerobic zone, which is recommended for the gain and maintenance of cardiorespiratory fitness[15]. Furthermore, Douris et al., (2012)[13] compared exercise on the treadmill and Free run for 30 min on physiological responses. The results showed that HR response during Free-run was 142.4 ± 20.5 bpm, while treadmill exercise was 123.2 ± 13.7 bpm. This meant that exergames have various intensity of the game which we can select for appropriate the intensity for the health promotion followed the ACSM guideline.

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The present study showed that the haemodynamics variables in the AG and the SG were not significantly different at the resting period, except the VO_{2peak}. However, during exercise with the exergame the EF in the AG revealed that the efficiency of the cardiac functions was higher than that in the SG. This indicated that the regular physical exercise by using the exergame with light to moderate intensity exercise can improve the cardiac functions. Furthermore, the exergame is also one of the alternative exercises for health promotion.

CONCLUSION

In this study, the acute effect of the exergame affected the haemodynamics variables in young adults, although there were no significant difference between the AG and the SG. This may be caused by the intensity of the exergame which was high to moderate level. However, the effect of the regular exercise in the AG revealed that the efficiency of the cardiac functions were more than those in the SG. For further study, the exergame intensity should be higher than moderate level for investigating the cardiovascular functions.

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