INTRODUCTION

A sedentary lifestyle is an activity that requires little or no additional energy expenditure beyond the resting metabolic rate. Generally, many people around the world spend several times in this behavior because of new modern technology.1 A previous study showed that the lack of physical activity and high sedentary behavior is one of the main causes of non-communicable diseases at a young age, contributing to future ailments. According to WHO estimation, 6 out of 10 deaths are caused by non-communicable diseases.1 It was also discovered that approximately 31% of the global population above 15 years has a sedentary lifestyle. The most significant factor that improves lifestyle inactivity is an increase in “screen time,” the duration spent in front of the television, computer, and video games.2,3 The young population can spend more than 60% of the time, namely 16 hours watching television, sitting in front of the computer at work and home, talking on the phone, and in the car. Moreover, insufficient weekly physical activity at a young age will be ineffective in adulthood when the sedentary lifestyle continues.4

Exergaming is a type of exercise that integrates different modes of digital games into physical activities.5,6 This term comprises “exercise” and “gaming,” defined as any video game requiring the movement of the player’s entire body.7,8 The users are also specifically engaged in coordination with the video system. Furthermore, active playing has become a tool to improve or maintain cardiovascular fitness, balance, and strength, which makes it a viable mechanism for reducing a physically inactive lifestyle.9 Although exergaming comes from the entertainment industry, it has become a new alternative for fitness training, education, and health maintenance. The game also offers a novel method to perform physical activity at

The effect of boxing exergame on blood lactate and VO\textsubscript{2max} in non-athlete healthy young men

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ABSTRACT

Background: The lack of physical activity and high sedentary behavior is among the main causes of non-communicable diseases at a young age. Moreover, exergaming (EXG) is a type of exercise that integrates different modes of digital games into physical activities. Since several young men spend a significant amount of time on sedentary games, it is believed that replacement with exergames will improve physical activity levels. Therefore, this study was carried out to evaluate the effectiveness of exercise by measuring blood lactate (BLa) and VO\textsubscript{2max} in non-athlete healthy young men. This study aims to analyze the effect of exercise using Nintendo\textsuperscript{TM} switch “Fitness Boxing 2” on BLa and VO\textsubscript{2max} in non-athlete healthy young men.

Methods: Experimental series with repeated measures on healthy young men of 20-40 years by the health worker at Dr. Soetomo Hospital Surabaya. This research was based on the exercise using Nintendo Switch\textsuperscript{TM} “Fitness Boxing 2” with the hard or high-intensity mode at a duration of 38 minutes consisting of warm-up, core training which included variations of Straight Hook, and Uppercut strokes, and cooling down three times a week for one month. The BLa examination was carried out 3 times before and after exercises I, VI, and XII during the exercise. VO\textsubscript{2max} was examined using the 6-minutes walking test based on the Nusdwinuringtyas formula one day before and after exercises I and XII, respectively.

Results: This study included 13 healthy young men, with an average age of 30.77± 3.632. The mean BLa before and after exercise was 2.03 and 3.02, respectively, with an increase of 0.99. The three p-values were carried out by the Wilcoxon Signed Rank Test, where a p-value = 0.001 was obtained, indicating a significant increase in post-exercise BLa levels. The VO\textsubscript{2max} before and after treatment obtained an average of 23.39± 2.82 (mL/kg/minute) and 30.69 ± 4.95 (mL/kg/minute), respectively. Furthermore, the comparison of VO\textsubscript{2max} examination before and after treatment with an average of 7.30±4.04 (mL/kg/min) obtained a significant difference with a p-value = 0.000.

Conclusion: The effect of high-intensity exercise using Nintendo Switch\textsuperscript{TM} “Fitness Boxing 2” increases the BLa levels and VO\textsubscript{2max} in non-athlete healthy young men.

Keywords: BLa level, VO\textsubscript{2max}, high-intensity exercise, Nintendo Switch\textsuperscript{TM}, Fitness Boxing 2, non-athlete, healthy young.

home without space restrictions.5,6

The Nintendo Wii gaming console is popular for sports games and aims to develop new franchises based on fitness. This game includes the Wii Fit, a popular exergame for Wii with several activities using the Balance Board, which has been used for physiotherapy rehabilitation.8 Nintendo Switch™ is the latest generation and a hybrid video game console released to the public in March 2017.11 Fitness Boxing is an exergame for the company and was commercially marketed in December 2018.12

Several studies examined the benefits of exergaming and its impact on health. However, it is unclear whether boxing exergame is an appropriate strategy to improve the health of non-athlete healthy young men. Since several young men spend a considerable amount of time using sedentary games, it is argued that replacing them with exergames can enhance physical activity levels. Therefore, this study was carried out to evaluate the effectiveness of exercise by measuring blood lactate (BLa) and VO2max in non-athlete healthy young men.

METHODS

Study Design

This randomized prospective study lasted four weeks, and the participants were voluntarily recruited from health workers at Dr. Soetomo Hospital Surabaya. The screening was carried out by a collection of basic data (age, weight, height), medical history and physical examination, filling out the International Physical Activity Questionnaire (IPAQ), Physical Activity Readiness Questionnaire (PAR-Q), One Leg Stance (OLS) tests, Electrocardiography (ECG), Montreal Cognitive Assessment Indonesia Version (MoCA-Ina), visual examination, and COVID-19 screening. Before this study was conducted, the participants were provided with a comprehensive explanation of the content, and those willing to participate provided written informed consent. Subsequently, all data were collected, analyzed, and stored anonymously. The Ethics Committee of Dr. Soetomo Academic Hospital, Surabaya, Indonesia, approved this research with approval number 0309/KEPK/XI/2021.

Participants

The study period was from November 2021 to February 2022; the inclusion criteria were (1) healthy men aged 25-44 years, (2) Body Mass Index (BMI) of 18.5-22.9 kg/m², and (3) willingness to be the study subject by participating in the entire series of and signing informed consent.

Sample and Randomization

After sending a broadcast message, 4 out of the 21 volunteers who enrolled for this study were rejected because they were included in the exclusion criteria. Subsequently, randomization using the simple random sampling method with 13 participants.

Intervention

This study was carried out during the COVID-19 pandemic, and all interventions strictly adhered to protocols such as using masks, washing hands, and keeping a social distance. Familiarization was carried out before the workout program started until the exercise’s final target score was 80. This movement consists of types of punch, namely Jab, straight, Left and Right Hook, as well as Uppercut. The participants were required to exercise using Nintendo Switch™ “Fitness Boxing 2” for about 36 minutes per week for one month in a daily workout with heavy or high-intensity mode. Each daily workout consists of Stretching (low intensity, for 2 minutes and 33 seconds), Straight combo (High intensity, for 8 minutes and 32 seconds), Hook combo (High intensity, for 8 minutes and 37 seconds), Uppercut combo (High intensity, for 11 minutes and 45 seconds), and Cooling down (Low intensity, for 2 minutes and 45 seconds). The final score of each workout session was recorded to assess the accuracy and compliance of participants. Furthermore, all participants continue daily activities without engaging in heavy duties or other sports outside the exergame schedule.

The workout will be stopped when the medical or non-medical conditions make it impossible to continue this study. Medical criteria were based on American College of Sport Medicine (ACSM)’s guideline 2018,13 which include (1) the onset of angina or angina-like symptoms, arrhythmias, (2) a decrease in SBP 10 mmHg with increasing work rate or when it reduces below the value obtained at the same position before the test, (3) excessively elevated blood pressure (elevated systole blood pressure (SBP) >250 mmHg and/or diastole blood pressure (DBP) >115 mmHg), (3) shortness of breath, wheezing, leg cramps, or claudication, (4) signs of poor perfusion such as dizziness, confusion, ataxia, pallor, cyanosis, nausea, or cold, clammy skin, (5) Physical or verbal manifestations of severe fatigue, (6) failure to increase heart rate (HR) with increasing exercise intensity, (7) changes in heart rhythm by palpation or auscultation, and (8) other medical conditions such as musculoskeletal injuries including strains, sprains. Meanwhile, non-medical criteria were (1) participant is not willing to continue this study and (2) does not come three times in a row.

Measurements

Blood Lactate (BLa)

The BLa levels of participants were measured before and directly after exercise, specifically in exercises first, sixth, and twelfth, using a portable BLa analyzer, namely accutrend®. The tool will calculate the concentration in whole blood from the measured value in plasma.

VO2max

The Sub-maximal VO2max examination was carried out using the 6-minute walking test (6-MWT). Age, height, weight, and gender greatly affect the distance traveled during the 6-MWT. Based on the American Thoracic Society (ATS), it is recommended that each country has a reference price standardization to formulate the right formula and measure the predicted VO2max.14 Therefore, Nury’s formula was used to calculate VO2max in healthy adults in Indonesia. The formula is expressed as follows:15

\[ \text{VO2max} = 0.053 \times \text{WD} + 0.022 \times \text{A} + 0.032 \times (\text{BH} - 0.164 \times \text{BW}) - 2.228 \times \text{sex}^* - 2.287 \]

Explanation: walking distance (WD) in meters, age (A) in years old, (year), Body height (BH) in centimeters, Bodyweight (BW) in kilogram, and sex* (0=male and 1=female)15

Pre-intervention 6-MWT was taken 1 day before the 1st workout and Post-
intervention 6-MWT was taken 1 day after the 12th workout.

**Statistical Analysis**

The basic data and parameters are shown descriptively in tabular form. The normality of the data distribution was tested using the Shapiro-Wilk. The data were analyzed by comparing lactate levels before and after treatment using paired t-tests when they were normally distributed. The Wilcoxon signed-rank test was used when the data were not normally distributed; meanwhile, all the data analysis was conducted using SPSS version 23.

**RESULTS**

**Participant Demographics**

This study included 13 healthy young men aged 26 to 37 years with a bodyweight between 50.0-74.2 kg and a height of 160.0-183.0 cm. All study subjects (n = 13 or 100%) had a normal body mass index (18.5 – 22.9 kg.m⁻²) ranging from 18.82 to 22.9. There was no significant difference in the participants’ age, body weight, height, and mass index (Table 1). Furthermore, none of the participants was smoking, drinking alcohol, or exercising regularly.

**Intervention Outcomes**

All subjects completed the exercise program according to the schedule, and none of the participants experienced side effects or dropped out. The effectiveness of the exercise was monitored through the scores achieved at the end of the training session. Meanwhile, the final treatment score was obtained with an average of 98.34 ± 1.07 (Table 2).

**Blood Lactate (BLa) Level**

BLa examination was carried out before and after the first, sixth, and twelfth exercises. The normality test using Shapiro-Wilk obtained a normally distribution (p > 0.05) on the variables of examinations I pre-exercise (p = 0.059), II pre-exercise (p = 0.519), II post-exercise (p = 0.685), III pre-exercise (p = 0.072), and III post-exercise (p = 0.811). For the examination I post-exercise, the data were not normally distributed (p = 0.040); therefore, the parametric test was carried out (Table 3).

In the parametric test, there was a significant difference between pre- and post-exercise, where the p-value in examinations I, II, and III were (p=0.000), (p=0.005), and (p=0.007), respectively (Table 4). The mean BLa before and after exercise was 2.03 and 3.02, with an increase of 0.99. The three p-values, carried out with the Wilcoxon Signed Rank Test, obtained a p-value = 0.001. This result showed that there was a significant increase in post-exercise BLa levels.

**VO₂max**

The VO₂max was examined using the 6-minutes walking test based on Nury’s formula. Meanwhile, the examination of VO₂max one day before the 1st exercise obtained an average of 23.39 ± 2.82 (mL/kg/minute). The normality test was conducted using Shapiro-Wilk, and the p-value before treatment was 0.352, which indicated that the data was normally distributed (p > 0.05). The post-treatment examination of VO₂max was carried out one day after the 12th exercise, and an average value of 30.69 ± 4.95 (mL/kg/minute) was obtained. The normality test was carried out with Shapiro-Wilk, and the p-value after treatment was 0.383, which showed that the data is normally distributed (p > 0.05) (Table 5).

The comparison of VO₂max examination pre- and post-exercise obtained an average difference of 7.30 ± 4.04 (mL/kg/minute). Based on the two normality tests, VO₂max
before and after treatment obtained a p-value > 0.05. This was followed by the parametric test, where a significant difference between the examination of VO<sub>2max</sub> obtained a p-value = 0.000 (Table 6).

**DISCUSSION**

Based on previous reports, this is the first study to assess the Nintendo<sup>TM</sup> switch “Fitness Boxing 2” on BLa and VO<sub>2max</sub> in non-athlete healthy young men. All subjects participated in an exercise program by playing Nintendo<sup>TM</sup> switch “Fitness Boxing 2” with high-intensity mode. They also attended all training sessions according to a set schedule, and no subject was dropped out or experienced side effects, which showed this study’s high compliance and safety. Based on the results, the average final score for each exercise was 98.34±1.07, which is expected to reach the target according to the high-intensity exercise mode. This result indicated that the exercise using Nintendo<sup>TM</sup> switch “Fitness Boxing 2” is easy and acceptable. In 2018, Valenzuela et al. assessed the adherence and acceptance of technology-based exercise interventions in old age (67-86 years). The results showed that technology-based interventions have a higher adherence level than regular traditional exercise. 16

**Blood Lactate (BLa)**

The level of BLa at rest is around 1-2 mmol/L. 17 In this study, the mean before exercise was 2.03 mmol/L, slightly higher than the normal value. This result can be caused by the rest of the subject’s activities before the exercise test, although the training test protocol has been explained to avoid strenuous activity at least 24 hours before the test. Moreover, an increase in BLa levels at rest slightly above the normal value occurs due to the production of lactate in the body of healthy individuals who are well oxygenated. 18 The lactate accumulation in the blood test can indicate whether an exercise is aerobic or anaerobic. 19,20 In this study, the average BLa level after exercise was 3.02 mmol/L, which increased by 0.99 mmol/L compared to before exercise. The anaerobic threshold for lactate in the blood or point of lactate accumulation in the blood (OBLA: onset of BLa accumulation) is 4 mmol/L. 21-23 Therefore, the average increase in BLa has not yet reached the anaerobic threshold.

Another opinion that opposes the above theory explains that anaerobic conditions do not occur in the muscles during submaximal exercise. The lactate value in the blood is above 4 mmol/L due to an imbalance in the production of lactate, which is higher than the process of removing (catabolism) it during an exercise. 18 Previous reports on experimental animals stated that lactate formation in dogs’ gastrocnemius and gracilis muscles during contraction was not caused by hypoxic stimulation from anaerobic glycolysis but due to a temporary imbalance between pyruvate formation during aerobic glycolysis and the use of pyruvate in the Krebs cycle. 24 Based on the investigation of human lower extremity muscles with biopsy, it was discovered that lactate accumulation in muscle persists, even when oxygen levels in the mitochondria are sufficient. 25 It showed that an average increase in BLa can reach the anaerobic threshold.

Currently, there is a debate on the theoretical differences between the anaerobic threshold of 4 mmol/L, 19,21,22 with the theory that states that the threshold does not exist. 18,25-27 Therefore, the exercise using Nintendo<sup>TM</sup> switch “Fitness Boxing 2” with high-intensity mode cannot be determined whether it is aerobic or anaerobic.

**VO<sub>2max</sub>**

VO<sub>2max</sub> is examined directly; however, this method requires more cost, time, and effort to achieve maximum HR. The ability to test VO<sub>2max</sub> is also usually limited because it is carried out in certain laboratories, which demand expensive equipment. 28 This study used a submaximal VO<sub>2max</sub> examination carried out during the COVID-19 pandemic; therefore, testing with aerosol potential is difficult and requires special conditions. The submaximal exercise test was used because examination of maximal exercise is always applied to determine VO<sub>2max</sub>. 13 In this study, a 6-minute walk test (6-MWT) using the formula from Nusdwinuringtyas and the predicted VO<sub>2max</sub> value was in line with the characteristics of Indonesians with the Mongolian race. 27 The race factor is significantly affected by the genetic influence on VO<sub>2max</sub> reaching 25-40%. Although there is a significant influence of genetic factors on endurance, its effect on VO<sub>2max</sub> is lower than other indicators. 29

The pre-treatment examination of VO<sub>2max</sub> was carried out one day before exercise I, and an average of 23.39 ± 2.82 (mL/kg/minute) was obtained. Jang et al. conducted a study on a healthy young male population in the Asian population represented by Korea. VO<sub>2max</sub> was measured using the treadmill method with the Bruce protocol and obtained a reference value of 42.3 ± 6.3 (mL/kg/min) for ages 19-29 years, while age 30-39 is 42.0 ± 5.0 (mL/kg/min). 30 Currently, the reference value of VO<sub>2max</sub> in young men for the population in Indonesia has not been discovered. Based on this study, the VO<sub>2max</sub> in healthy young men is lower than the reference value in Asia and Europe. This difference is due to the variation in the examination methods. Furthermore, the post-treatment VO<sub>2max</sub> examination was carried out 1 day after exercise XII, where an average of 30.69 ± 4.95 (mL/kg/minute) was obtained. The average increase in the examination before and after treatment was 7.30 ± 4.04 (mL/kg/minute). It showed a significant increase in VO<sub>2max</sub> before and after the exercise using the Nintendo<sup>TM</sup> switch “Fitness Boxing 2”. According to Huang et al., the average change in VO<sub>2max</sub> will give the maximum value of 3.78 ml/kg/ min with exercise between 8-52 weeks. 31 Rabsamen et al. also showed that a four-week high-intensity exercise intervention could increase VO<sub>2max</sub> by 2.6 ml/kg/min. 32 Berg et al. revealed that two times per week sessions for two months with exergame could improve cardiorespiratory fitness in healthy adults, but not for trained adults. 33 It also discovered that exercise skills and fitness do not affect enjoyment or changes in VO<sub>2max</sub>. It indicated that the sporting platform could be enjoyed by adults regardless of their exercise skills.

**CONCLUSION**

The effect of high-intensity exercise using Nintendo Switch<sup>TM</sup> “Fitness Boxing 2” increases the levels of BLa and VO<sub>2max</sub> in non-athlete healthy young men.
REFERENCES