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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF CONTINUOUS-EXERCISE AND MODIFICATION INTERVAL-EXERCISE ON DECREASING MALONDIALDEHYDE AND BLOOD LACTATE LEVELS IN NON-PROFESSIONAL SHORINJI KEMPO ATHLETES

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

The study purpose was to analyze the effect of continuous exercise and modification interval exercise on decreasing malondialdehyde (MDA) and blood lactate levels in non-professional Shorinji Kempo athletes.

Materials and methods. This study used a quasi-experimental method with a randomized pretest posttest-only group design. Subjects were 16 male adolescents aged 18-20, body mass index (BMI) 20-24 kg/m^2, who had normal blood pressure, normal resting heart rate, and no history of chronic disease. The subjects were randomly divided into two groups: CEG (n = 8, continuous exercise group) and MIEG (n = 8, modification interval exercise group). Continuous and modification interval exercises were carried out in 30 minutes/exercise sessions, with an intensity of 75% HRmax and 75% RM, as often as 3 times/week, for one week. Measurements of resting heart rate, blood lactate and MDA levels were performed 30 minutes pre-exercise and 10 minutes post-exercise. The data analysis technique used the Paired Sample T-Test and the independent T-test with SPSS software version 21.

Results. The results showed significant differences in resting heart rate, blood lactate and MDA levels pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). A difference was also observed in Delta (Δ) heart rate pre-exercise vs. post-exercise on CEG (–3.88 ± 3.36 bpm) and MIEG (–15.25 ± 3.45 bpm) ($p \leq 0.001$), but no differences were observed in the Delta (Δ) blood lactate and MDA levels in both groups.

Conclusion. Based on the study results, it was shown that continuous exercise and modification interval exercise increase blood lactate and MDA levels shortly after intervention but both exercises could reduce acute stress, which was indicated by a decrease in resting heart rate.

Keywords: continuous exercise, modification interval exercise, Shorinji Kempo, healthy life style.

Introduction

Shorinji kempo was founded by Doshin in 1947 in Japan to be a training and self-development system based on Shaolin kung fu. Shorinji kempo is a martial arts sport with competition numbers consisting of embu and randori. The embu competition consists of combined movements such as punches, kicks, blocks, and slams performed by two Kenshi (Kempo athletes) in pairs or four to eight Kenshi in a team. To support achievement in a match, of course, requires a healthy and fit physical condition to maintain performance when competing and increase the fatigue threshold (Edwards et al., 2018). During the match, there will be repeated muscle contractions, and physiologically, this will trigger a response to oxidative stress (Steinbacher & Eckl, 2015). In addition, blood lactate levels and heart rate will also in-

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crease as a sign that athletes use submaximal to maximum intensity when competing (Stojanović et al., 2018). The high intensity of movement demands and physiological stress on athletes during competition can accumulate during the match, presenting as signs of fatigue that lead to decreased performance and even the risk of injury (Kristie-Lee Taylor, 2012). Of course, this should not happen, so action is needed to maintain physical condition and fatigue levels and prevent oxidative stress (Edwards et al., 2018).

Oxidative stress conditions characterized by increased production of reactive oxygen species (ROS) have implications for various acute and chronic pathological processes such as cardiovascular disease (CVDs), neurodegenerative diseases (NDs), acute and chronic kidney disease (CKD), macular degeneration (MD), biliary diseases and cancer (Liguori et al., 2018). This is due to the high level of inflammation characterized by ROS-mediated increases in IL-1α, IL-6, and IL-8, and this condition usually occurs in individuals with obesity, diabetes, hypertension, and atherosclerosis (Liguori et al., 2018; Andarianto et al., 2022). In addition, the inflammatory process has a role in the pathogenesis of breast cancer (Rejeki et al., 2021). Then the high level of lactate is also a sign of hypoxia in body tissues (Uyar et al., 2020), an increase in blood lactate caused by the high intensity of muscle work characterized by an increase in heart rate. Hypoxia is one of the factors that can cause an increase in ROS, leading to oxidative stress conditions through reperfusion injury mechanisms (Ferrari & Andrade, 2015). Oxidative stress levels can be determined by looking at changes in malondialdehyde (MDA) levels (Yosika et al., 2020). The reaction between ROS and polyunsaturated fatty acids (on the cell wall) will result in the formation of aldehydes, such as MDA, through the lipid peroxidation process (Su et al., 2019). An important new strategy is to reduce oxidative stress, characterized by an increase in MDA levels. It is known that the body has a natural antioxidant system that helps reduce oxidative stress and this system can be improved with exercise (Park & Kwak, 2016).

Bouzid et al. (2015) found that MDA levels increased by 5 minutes after ergocycle exercise to experience fatigue. However, a study conducted by Yosika et al. (2020) revealed that moderate continuous exercise in testing in humans could lower MDA levels. Bishop et al. (2008) has revealed that exercise for 5 weeks can reduce blood lactate levels. In his research, Zhao et al. (2021) stated that exercises performed for 4 weeks did not affect the concentration of basal blood lactate. Rahayu et al. (2019) in his study reported that there was a significant difference in heart rate recovery between 60 and 90 minutes after exercise. Therefore, how the fundamental impact of exercise on blood MDA and lactate levels remains controversial. On this basis, the *purpose of this study* was to analyze the influence of continuous exercise and modification interval exercise on the reduction of blood MDA and lactate levels in non-professional athletes with ages 18-20 years and body mass index (BMI) 20-24 kg/m^2.

Material and Methods

Study participants

This study was a quasi-experiment with a randomized pretest posttest-only group design. The subjects were 16 teenage boys aged 18-20 years, body mass index (BMI) 20-24 kg/m^2, had normal blood pressure, normal resting heart rate, and no history of chronic disease. All subjects obtained information both orally and in writing about the study and agreed to sign informed consent. These research procedures have been approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Airlangga Surabaya Number: 125/EC/KEPK/FKUA/2015.

Study organization

The training program was conducted and supervised by professionals from the Faculty of Sport Science, State University of Surabaya. Subjects were randomly divided into two groups, namely CEG (n = 8, continuous exercise group), MIEG (n = 8, modification interval exercise group). Continous exercise was done by jogging for 30 minutes with an intensity of 75% HRmax for 30 minutes followed by warming up and cooling for 5 minutes each, while modification interval exercise was done with three stages, including warming up (jogging for 5 minutes), core exercises (Knee up, Knee up twist out, Knee up twist in, Hip twist, Hooping, Jumping Jack, Front Jumping Jack) which was done continuously, 3 sets of 15 reps each type of movement, and followed by active rest between intervals (jogging, side step and backward jogging for 30 seconds), and cooling (jogging and PNF stretching for 5 minutes). Intervention of continuous exercise and modification interval exercise were carried out for one week with a frequency of 3x/week and continued with embu (pattern of movement shorinji kempo (punch, kick, tank, slam, lockdown, catch and throw)) paired for 2 minutes, subaxial intensity, at the end of each exercise intervention. Heart rate during exercise monitored using polar heart rate monitor (Polar H10 Heart Rate Sensor, Inc., USA).

Height measurement using a stadiometer (accuracy of 0.5 cm) (SECA, Chino, CA). Weight measurement using an electronic scale (Tech 05®, China). BMI is measured by calculating weight (kg) divided by height in square meters (m2). Blood pressure tests are performed using OMRON digital meter tension (OMRON Model HEM-7130L, Omron Co., Osaka, Japan) on the non-dominant arm 3 times in a row at 1-2 minutes between two measurements, then the average value of the measurement is taken. Resting heart rate is measured using a Pulse Oximeter (PO 30 Pulse Oximeter, Beurer North America LP, 900 N Federal Highway, Suite 300, Hallandale Beach, FL 33009).

Blood collection was done 30 minutes pre-exercise and 10 minutes post-exercise (Rejeki et al., 2021). Blood was checked for 15 minutes at a speed of 3000 rpm. Plasma was separated and stored at a temperature of –80°C for analysis of MDA levels the next day. MDA level was measured using the thiobarbituric acid reactive substance (TBARs) (Esgalhado et al., 2015) with a concentration unit of ng/mL. Measurement of lactic acid levels using Accutrend Plus Meter (Accutrend® lactate meter, Roche Diagnostics, Mannheim, Germany) (Perez et al., 2008) with mmol/L concentration units.

Statistical analysis

Statistical analysis using Statistic Package for Social Science (SPSS) version 21 (SPSS Inc., Chicago, IL, USA). The normality test uses the Shapiro-Wilk test, while the other test uses the Paired Sample T-Test and the Independent Samples T-Test. All data is displayed with Mean ± Standard Deviation (SD). All statistical analyses use significant levels ($p \leq 0.05$).

Results

The results of descriptive analysis of the characteristic data of the research subjects in each group can be seen in Table 1.

Table 1. Results of analysis of characteristics of research subjects

Parameter	Group		Independent Samples T-Test p-value
	CEG (n=8)	MIEG (n=8)	
Age (years)	19.88±0.83	19.50±1.20	0.480
Height (m)	60.50±6.91	59.38±3.96	0.697
Weight (kg)	1.68±0.05	1.67±0.05	0.801
BMI (kg/m^2)	21.44±1.52	21.25±0.97	0.778
SBP (mmHg)	116.38±3.38	114.75±3.88	0.387
DBP (mmHg)	79.25±5.47	75.13±3.80	0.104

Description: BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Independent Samples T-Test. All data is displayed with the mean ± standard deviation (SD).

Based on Table 1, the Independent Samples T-Test results showed no significant difference in average data on the characteristics of the study subjects in each group ($p \geq 0.05$). The results of the analysis of pre-exercise vs. post-exercise MDA levels in each group can be seen in Figure 1.

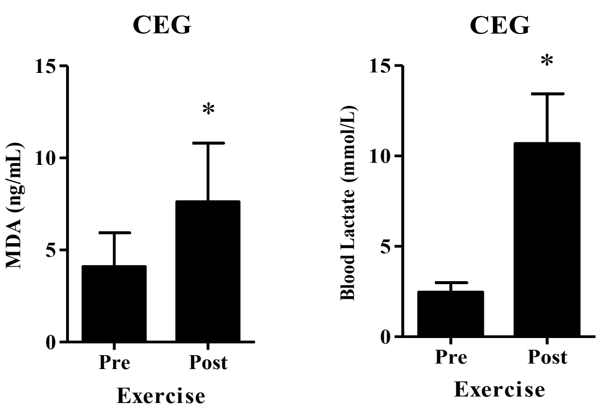

Figure 1. Average MDA pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean±SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

Based on Figure 1, there was an increase in post-exercise MDA levels in each group. The Paired Sample T-Test showed a significant difference in average increase in MDA levels between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The results of the average analysis of blood lactate

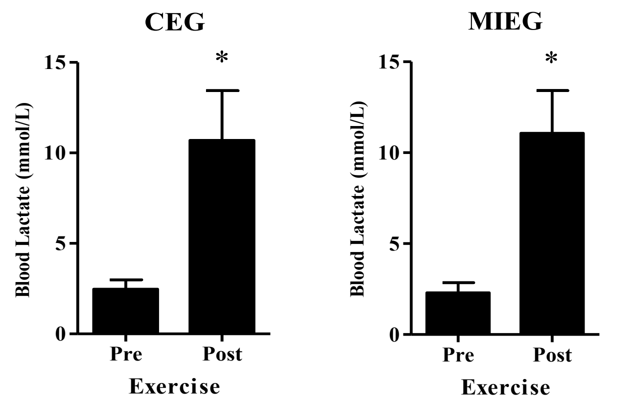

Figure 2. Average blood lactate pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean±SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

between pre-exercise vs. post-exercise on CEG and MIEG are presented in Figure 2.

Based on Figure 2, there was an increase in post-exercise blood lactate in each group. Paired Sample T-Test results showed a significant difference in average increase in blood lactate between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The average resting heart rate analysis results between pre-exercise vs. post-exercise on CEG and MIEG are presented in Figure 3.

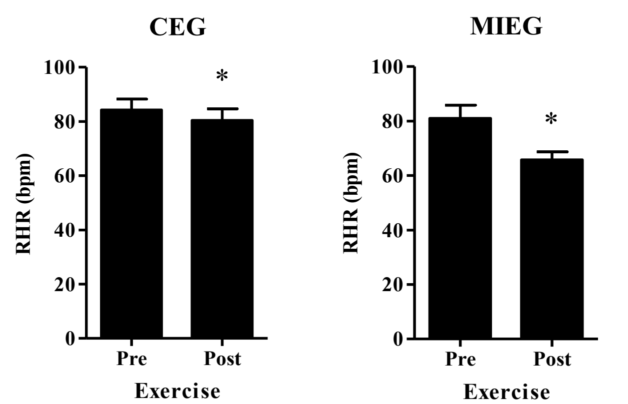

Figure 3. Average resting heart rate pre-exercise vs. post-exercise on each group. Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Paired Sample T-Test. All data is displayed mean±SD. (*) Significant vs. Pre-exercise ($p \leq 0.05$).

Based on Figure 3, there was a decrease in resting heart rate post-exercise in each group. Paired Sample T-Test results showed a significant difference in average resting heart rate reduction between pre-exercise vs. post-exercise on CEG and MIEG ($p \leq 0.05$). The results of the analysis of the average levels of MDA, blood lactate, and resting heart rate based on the examination time are presented in Table 2.

Based on Table 2, the independent samples T-Test showed no significant difference in average resting heart rate pre-exercise between CEG and MIEG ($p \geq 0.05$). In

Table 2. Results of RHR, blood lactate, and MDA analysis based on examination time

Time	Group		Independent Samples T-Test p-value
	CEG (n=8)	MIEG (n=8)	
Resting Heart Rate (bpm)			
Pre-exercise	84.25±4.03	81.00±4.87	0.168
Post-exercise	80.38±4.27	65.75±2.96*	0.000
Delta (Δ)	-3.88±3.36	-15.25±3.45*	0.000
Laktat Darah (mmol/L)			
Pre-exercise	2.48±0.52	2.30±0.55	0.524
Post-exercise	10.70±2.74	11.08±2.33	0.773
Delta (Δ)	8.23±2.82	8.78±2.46	0.684
Malondialdehyde (ng/mL)			
Pre-exercise	4.10±1.83	6.84±1.87	0.070
Post-exercise	7.62±3.18	10.15±2.27	0.091
Delta (Δ)	3.53±3.48	3.31±2.55	0.891

Description: CEG: Continuous exercise group; MIEG: Modification interval exercise group. p-Value is obtained using the Independent Samples T-Test. All data is displayed mean±SD. (*) Significant vs. CEG ($p \leq 0.05$).

contrast, the average resting heart rate post-exercise and delta (Δ) showed significant differences ($p \leq 0.05$). Likewise, the results of the Independent Samples T-Test showed that there was no significant difference in average blood lactate pre-exercise, post-exercise, and delta (Δ) between CEG and MIEG ($p \geq 0.05$). Independent Samples T-Test results also showed that there was no significant difference in average levels of MDA pre-exercise, post-exercise, and delta (Δ) between CEG and MIEG ($p \leq 0.05$).

Discussion

Based on the results of the Independent Samples T-Test test showed a significant difference in average resting heart rate (RHR) between pretest vs. posttest in continuous exercise group and modification of exercise group interval ($p \leq 0.05$). The findings in this study were a decrease in RHR after doing CEG and MIEG and an increase after continuing with embu. This proves that both exercises have the same effect on RHR decline. Bahrainy et al. (2016) showed that increased and decreased parasympathetic tone of resting responses to beta-adrenergic stimulation contributed to a decrease in RHR after regular exercise or physical activity in humans. Silva et al. (2018) explained that increased cardiorespiratory during exercise is associated with an increase in diameter/thickness in the left ventricle and an increase in the final systolic volume, leading to an increase in the stroke volume. An increase in the volume of stroke volume resulted in a decrease in the number of heartbeats, a reduction in the heart's metabolic load, and contributed to the decline of RHR (Silva et al., 2018). In the case of a decrease in RHR after CEG and MIEG it may also result from an increase in output from parasympathetic. In comparison, the rise in RHR after paired embu may be due to decreased parasympathetic activity and an increase in sympathizer output (Tyagi & Cohen, 2016). The results of this study are similar to systematic reviews and meta-analyses conducted by Reimers et al. (2018), reporting that endurance training and yoga decrease RHR. After endurance exercise, the average RHR of exercise participants decreased compared to those who did not exercise (4.5% to 9.0% and 2.7 to 5.8 bpm).

The main findings in the study related to the degree of oxidative stress measured through parameters of blood lactate levels and the MDA showed a 5-minute increase in post CEG dab MIEG followed by paired embu. Based on the Independent Samples T-Test, the average blood lactate level and MDA showed a significant difference ($p \leq 0.05$) between pre-exercise vs. post-exercise. This is possible because, at the time of doing embu paired, there is a hypoxia moment due to high intensity (sub-maxim), so the predominant energy metabolism used is anaerobic. High blood lactate levels after CEG and MIEG are also considered to be associated with hypoxic conditions, and this is because hypoxia increases the expression of hypoxia-inducible factor 1 α (HIF1α) which then stimulates the glycolysis process and increases lactic acid dehydrogenase (LDH) activity so that lactate is produced higher (Ivashkiv, 2020). These results are similar to the study conducted by Lesmana et al. (2016) showed that treadmill exercise 5 times/week increased blood lactate levels 25 minutes post-exercise. Kato et al. (2013) have also proven that 5 minutes after moderate-intensity treadmill exercise and swimming for 10 minutes showed that blood lactate levels increased.

When the body undergoes hypoxia, it will also cause electron leakage in the mitochondria during oxygen reperfusion. During oxidative phosphorylation in mitochondria, oxygen is reduced by the mitochondrial electron transport system to form adenosine triphosphate (ATP) and water (H2O) (Mrakic-Sposta et al., 2015). This explanation is supported by the explanation (Arsana et al., 2013) that when oxidative phosphorylation (electron transport) as much as 2-5% of the total oxygen demand can be converted into free radicals, resulting in ROS. The high ROS will result in a reaction with polyunsaturated fatty acids (on the cell wall), resulting in the formation of aldehydes, such as MDA, through the lipid peroxidation process (Su et al., 2019). Therefore, the level of MDA after CEG dab MIEG followed by paired embu increased. The study's findings are similar to the research results conducted by Ilyas et al. (2017), which stated that moderate-intensity exercise training in mice increased MDA levels. Moflehi et al. (2012), in their study, also proved that treadmill exercise, low, moderate, and high intensity was shown to increase MDA levels compared to subjects who did not do exercise. It is also supported by Huang et al. (2015) that acute exercise can cause oxidative stress, in contrast to chronic exercise, which can provide a stimulus for beneficial oxidative adaptation and improve physiological performance and physical health.

Limitations of this study include (1) Lack of inflammatory parameters as a marker of generality due to oxidative stress, (2) Absence of control groups, (3) Absence of measurement of the body's internal antioxidant parameters, (4) This study only conducted acute exercises. First, in this study, we only measured blood lactate levels and MDA as oxidative stress markers. Therefore, future studies should include more in-depth parameters as a sign of the discharge from oxidative stress, such as inflammatory parameters

(IL-6). Second, the absence of a control group that did not intervene was exercised. Therefore, further research needs to be added to control groups as a comparison with groups given exercise interventions. Third, measurement of MDA levels is only a marker of high levels of oxidative stress, but the balance between antioxidants and oxidative stress is not yet known. Therefore, further research is recommended to take measurements of antioxidant activity (SOD, GPX). Fourth, the study only conducted acute intervention (exercise), so more research is needed to find out the effects of chronic intervention (training) in non-professional athletes. The results are expected to be useful for leteration in creating a pre-condition training program before the athlete's games.

Conclusion

Based on the results of the study, it was concluded that the provision of continuous exercise and modification interval exercise which was carried out for 30 minutes/exercise session with an intensity of 75% HRmax and 75% RM, a frequency of 3x/week for one week was able to reduce acute stress which was characterized by a decrease in RHR, but not yet able to reduce blood lactate and oxidative stress which is indicated by MDA levels.

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Conflict of interest

The authors declare that they have no competing interests.

References

Edwards, T., Spiteri, T., Piggott, B., Bonhotal, J., Haff, G. G., & Joyce, C. (2018). Monitoring and Managing Fatigue in Basketball. *Sports (Basel, Switzerland), 6*(1), 19. https://doi.org/10.3390/sports6010019

Steinbacher, P., & Eckl, P. (2015). Impact of oxidative stress on exercising skeletal muscle. *Biomolecules, 5*(2), 356-377. https://doi.org/10.3390/biom5020356

Stojanović, E., Stojiljković, N., Scanlan, A. T., Dalbo, V. J., Berkelmans, D. M., & Milanović, Z. (2018). The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. *Sports Medicine, 48*(1), 111-135. https://doi.org/10.1007/s40279-017-0794-z

Kristie-Lee Taylor. (2012). *Monitoring neuromuscular fatigue in high performance athletes.* https://doi.org/10.13140/RG.2.2.36468.55685

Liguori, I., Russo, G., Curcio, F., Bulli, G., Aran, L., Della-Morte, D., Gargiulo, G., Testa, G., Cacciatore, F., Bonaduce, D., & Abete, P. (2018). Oxidative stress, aging, and diseases. *Clinical Interventions in Aging,* 13, 757-772. https://doi.org/10.2147/CIA.S158513

Andarianto, A., Rejeki, P.S., Sakina, Pranoto, A., Seputra, T.W.A., Sugiharto, & Miftahussurur, M. (2022). Inflammatory markers in response to interval and continuous exercise in obese women. *Comparative Exercise Physiology, 18*(2), 135-142. https://doi.org/10.3920/CEP210038

Rejeki, P.S., Utami, D.M., Izzatunnisa, N., Pranoto,A., Sukarno, D.A., & Fasitasari, M. (2021). A high-fat diet decreases serum TNF-alpha and breast tumor area on benzopyrene induced mice (Mus musculus). *Chiang Mai University Journal of Natural Sciences, 20*(4), e2021089. https://doi.org/10.12982/CMUJNS.2021.089

Uyar, H., Yesil, E., Karadeniz, M., Orscelik, O., Ozkan, B., Ozcan, T., Cicek Yilmaz, D., & Celik, A. (2020). The Effect of High Lactate Level on Mortality in Acute Heart Failure Patients With Reduced Ejection Fraction Without Cardiogenic Shock. *Cardiovascular Toxicology, 20*(4), 361-369. https://doi.org/10.1007/s12012-020-09563-9

Ferrari, R. S., & Andrade, C. F. (2015). Oxidative Stress and Lung Ischemia-Reperfusion Injury. *Oxidative Medicine and Cellular Longevity,* 1-14. https://doi.org/10.1155/2015/590987

Firsta Yosika, G., Sukoco, P., Pranoto, A., & Purwoto, S. P. (2020). Penurunan malondialdehyde serum setelah latihan interval dan continuous di pagi hari pada perempuan obesitas. Jurnal SPORTIF : Jurnal Penelitian Pembelajaran, 6(2), 288–303. https://doi.org/10.29407/js_unpgri.vi.14289

Su, L. J., Zhang, J. H., Gomez, H., Murugan, R., Hong, X., Xu, D., Jiang, F., & Peng, Z. Y. (2019). Reactive Oxygen Species-Induced Lipid Peroxidation in Apoptosis, Autophagy, and Ferroptosis. *Oxidative Medicine and Cellular Longevity,* 5080843. https://doi.org/10.1155/2019/5080843

Park, S.Y., & Kwak, Y.S. (2016). Impact of aerobic and anaerobic exercise training on oxidative stress and antioxidant defense in athletes. *Journal of Exercise Rehabilitation, 12*(2), 113-118. https://doi.org/10.12965/jer.1632598.299

Bouzid, M. A., Hammouda, O., Matran, R., Robin, S., & Fabre, C. (2015). Influence of physical fitness on antioxidant activity and malondialdehyde level in healthy older adults. *Applied Physiology, Nutrition, and Metabolism, 40*(6), 582-589. https://doi.org/10.1139/apnm-2014-0417

Bishop, D., Edge, J., Thomas, C., & Mercier, J. (2008). Effects of high-intensity training on muscle lactate transporters and postexercise recovery of muscle lactate and hydrogen ions in women. American journal of physiology. *Regulatory, Integrative and Comparative Physiology, 295*(6), R1991-R1998. https://doi.org/10.1152/ajpregu.00863.2007

Zhao, T., Le, S., Freitag, N., Schumann, M., Wang, X., & Cheng, S. (2021). Effect of Chronic Exercise Training on Blood Lactate Metabolism Among Patients With Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. *Frontiers in Physiology,* 12, 652023. https://doi.org/10.3389/fphys.2021.652023

Rahayu, T., Aprilawati, D., Mahmud, J., Purwanto, B., & Herawati L. (2019). Both Upper and Lower Extremity-Only Video Game-Based Exercise (Exergaming) Affect Blood Glucose Serum Levels and Heart Rates but Not Oxygen Saturation in Teenagers. *Journal of Physical Education and Sport, 19*(3), 802-807. https://doi.org/10.7752/jpes.2019.s3114

Rejeki, P.S., Pranoto, A., Prasetya, R.E., & Sugiharto. (2021). Irisin serum increasing pattern is higher at moderate-intensity continuous exercise than at moderate-intensity interval exercise in obese females. *Comparative Exercise Physiology, 17*(5), 475-484. https://doi.org/10.3920/CEP200050

Esgalhado, M., Stockler-Pinto, M.B., de França Cardozo, L.F.M., Costa, C., Barboza, J.E. & Mafra, D. (2015). Effect of acute intradialytic strength physical exercise on oxidative stress and inflammatory responses in hemodialysis patients. *Kidney Res Clin Pract,* 34, 35-40. https://doi.org/10.1016/j.krcp.2015.02.004

Perez, E.H., Dawood, H., Chetty, U., Esterhuizen, T.M. and Bizaare, M. (2008). Validation of the Accutrend Lactate Meter for Hyperlactatemia Screening During Antiretroviral Therapy in a Resource-Poor Setting. *International Journal of Infectious Diseases, 12*(5), 553-556. https://doi.org/10.1016/j.ijid.2008.03.007

Bahrainy, S., Levy, W. C., Busey, J. M., Caldwell, J. H., & Stratton, J. R. (2016). Exercise training bradycardia is largely explained by reduced intrinsic heart rate. *International Journal of Cardiology,* 222, 213-216. https://doi.org/10.1016/j.ijcard.2016.07.203

Silva, D. A. S., de Lima, T. R., & Tremblay, M. S. (2018). Association between Resting Heart Rate and Health-Related Physical Fitness in Brazilian Adolescents. *BioMed Research International,* 3812197. https://doi.org/10.1155/2018/3812197

Tyagi, A., & Cohen, M. (2016). Yoga and heart rate variability: A comprehensive review of the literature. *International Journal of Yoga, 9*(2), 97-113. https://doi.org/10.4103/0973-6131.183712

Reimers, A. K., Knapp, G., & Reimers, C. D. (2018). Effects of Exercise on the Resting Heart Rate: A Systematic Review and Meta-Analysis of Interventional Studies. *Journal of Clinical Medicine, 7*(12), 503. https://doi.org/10.3390/jcm7120503

Ivashkiv, L. B. (2020). The hypoxia-lactate axis tempers inflammation. Nature Reviews. *Immunology, 20*(2), 85-86. https://doi.org/10.1038/s41577-019-0259-8

Lesmana, R., Iwasaki, T., Iizuka, Y., Amano, I., Shimokawa, N., & Koibuchi, N. (2016). The change in thyroid hormone signaling by altered training intensity in male rat skeletal muscle. *Endocrine Journal, 63*(8), 727-738. https://doi.org/10.1507/endocrj.EJ16-0126

Kato, M., Kurakane, S., Nishina, A., Park, J., & Chang, H. (2013). The blood lactate increase in high intensity exercise is depressed by Acanthopanax sieboldianus. *Nutrients, 5*(10), 4134-4144. https://doi.org/10.3390/nu5104134

Mrakic-Sposta, S., Gussoni, M., Porcelli, S., Pugliese, L., Pavei, G., Bellistri, G., Montorsi, M., Tacchini, P., & Vezzoli, A. (2015). Training effects on ROS production determined by electron paramagnetic resonance in master swimmers. *Oxidative Medicine and Cellular Longevity,* 804794. https://doi.org/10.1155/2015/804794

Arsana, I.N., Adiputra, N., Pangkahila, J.A. and Putra-Manuaba, I.B. 2013. Garcinia Mangostana L. Rind Extract and Physical Training Reduce Oxidative Stress in Wistar Rats During Maximal Physical Activity. *Indonesian Journal of Biomedical Sciences, 7*(2), 63-68.

Ilyas, E.I.I., Utami, T.P., Siagian, M., Santoso, D.I.S., & Prijanti., A.R. (2017). Effect Moderate Intensity Exercise Training on Stress Oxidative Marker: Malondialdehyde and Superoxide Dismutase Acticity in Abdominal Aorta of Juvenile Rats. *International Journal of Research-Granthaalayah, 5*(12), 99-105. https://doi.org/10.5281/zenodo.1133607

Moflehi, D., Kok, L. Y., Tengku-Kamalden, T. F., & Amri, S. (2012). Effect of single-session aerobic exercise with varying intensities on lipid peroxidation and muscle-damage markers in sedentary males. *Global Journal of Health Science, 4*(4), 48-54. https://doi.org/10.5539/gjhs.v4n4p48

Huang, C-J., McAllister, M.J., Slusher, A.L., Webb, H.E., Mock, T. & Acevedo, E.O. (2015). Obesity-Related Oxidative Stress: the Impact of Physical Activity and Diet Manipulation. *Sports Medicine – Open, 1*(32), 1-12. https://doi.org/10.1186/s40798-015-0031-y

ВПЛИВ БЕЗПЕРЕРВНОЇ ВПРАВИ ТА МОДИФІКОВАНОЇ ІНТЕРВАЛЬНОЇ ВПРАВИ НА ЗНИЖЕННЯ РІВНІВ МАЛОНОВОГО ДІАЛЬДЕГІДУ ТА ЛАКТАТУ В КРОВІ В НЕПРОФЕСІЙНИХ СПОРТСМЕНІВ, ЯКІ ЗАЙМАЮТЬСЯ СЬОРІНДЗІ-КЕМПО

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Реферат. Стаття: 7 с., 3 табл., 3 рис., 31 джерело.

Метою дослідження було проаналізувати вплив безперервної вправи та модифікованої інтервальної вправи на зниження рівнів малонового діальдегіду (МДА) та лактату в крові в непрофесійних спортсменів, які займаються сьоріндзі-кемпо.

Матеріали та методи. У цьому дослідженні використовували квазіекспериментальний метод, при цьому план проведення дослідження включає лише попереднє та заключне дослідження в рамках двох експериментальних груп із випадковою вибіркою учасників. Учасниками були

16 підлітків і юнаків чоловічої статі віком 18–20 років, індекс маси тіла (ІМТ) 20–24 кг/м^2, з нормальним кров'яним тиском, нормальною частотою серцевих скорочень (ЧСС) у стані спокою та без хронічних захворювань. Учасників випадково розподілили на дві групи: CEG (n = 8, група безперервної вправи) та MIEG (n = 8, група модифікованої інтервальної вправи). Безперервні та модифіковані інтервальні вправи проводили по 30 хвилин/заняття вправами, з інтенсивністю 75% максимальної ЧСС (HRmax) та 75% повторного максимуму (RM), із частотою 3 рази/тиждень, протягом одного тижня. Вимірювання показників ЧСС у стані спокою, рівнів малонового діальдегіду (МДА) та лактату в крові проводили за 30 хвилин до початку тренування та через 10 хвилин після завершення тренування. Як метод аналізу даних використовували t-критерій Стьюдента для парних вибірок та t-критерій Стьюдента для незалежних вибірок із застосуванням програмного забезпечення SPSS версії 21.

Результати. Результати показали значні відмінності в показниках ЧСС у стані спокою, рівнів малонового діальдегіду (МДА) та лактату в крові до початку тренування та після завершення тренування в групі безперервної вправи (CEG) та в групі модифікованої інтервальної вправи (MIEG) ($p \leq 0,05$). Також зафіксована відмінність у різниці (Δ) показників ЧСС до початку тренування та після завершення тренування в CEG (−3,88 ± 3,36 уд./хв) та в MIEG (−15,25 ± 3,45 уд./хв) ($p \leq 0,001$), але в обох групах не зафіксовано жодних відмінностей у різниці (Δ) рівнів малонового діальдегіду (МДА) та лактату в крові.

Висновки. На підставі одержаних результатів дослідження було показано, що безперервна вправа та модифікована інтервальна вправа підвищують рівні МДА та лактату в крові незабаром після втручання, але обидва види вправ можуть зменшувати гострий стрес, на що вказувало зниження ЧСС у стані спокою.

Ключові слова: безперервна вправа, модифікована інтервальна вправа, сьоріндзі-кемпо, здоровий спосіб життя.

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