The Attenuation of Physical-Physiological Stresses through Musical-High Intensity Exercise Co-Treatment in Non-Athlete Individual

Sugiharto¹*, Desiana Merawati¹, Rias Gesang Kinanti¹, Hendra Susanto², Ahmad Taufiq³, Sunaryono³

¹Department of Sports Science, Faculty of Sports Science, Universitas Negeri Malang, Jl. Semarang 5 Malang 65145, Indonesia.
²Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Jl. Semarang 5 Malang 65145, Indonesia.
³Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Malang, Jl. Semarang 5 Malang 65145, Indonesia.

*Corresponding author's email: sugiharto@um.ac.id

Abstract. Exercise is a very effective strategy to improve people’s health. However, the unwell managed exercise potentially causes distress and decreases the health. Therefore, this research aimed to know the correlation of exercise combined with music to control stress/tissue injury by using physical-physiological neurohormonal paradigm approach. This study used randomized control group pre-test and post-test design with the sample of 30 non-athlete individuals randomly selected with the age range of 19-23 years old, the body mass index (BMI) of 19-23, VO₂ Max of 46-56 ml/kg/BB, and they do not smoke. The experiment group was divided into high-intensity exercise by listening to hard beat music, high-intensity-exercise by listening to slow beat music, high-intensity exercise without listening to the music. The high intensity, in this research, means the intensity with 85% load of maximum working capacity with the multilevel load test using ergometer. The measurement of distress level was performed by taking the sample of 10 ccs of the blood of cube vein and the measurement of heart rate before and after doing an exercise. The distress level was determined using a biomaterial secretion indicator in the form of cortisol hormone, endorphin, cytokine interleukin-6 (IL-6), and the heart work. The method that was used to check the blood sample to know the cortisol, endorphin, and IL-6 content was ELISA (Enzyme-Linked Immunosorbent Assay), while the measurement of heart work was carried out using polar heart rate monitor. The research results showed that there was a significant difference in circulating level of endorphin and IL-6 (P < 0.05) after treatment by listening to slow beat music compared to the other experimental groups. Nevertheless, there was no significant difference in the circulating levels of cortisol (P > 0.05). In summary, giving co-treatment of high-intensity exercise with slow beat music could decrease the physical-physiological stress of non-athlete individual. It is suggested that the treatment could decrease the inflammatory within the skeletal muscle and improve the decrease in physiological stress by modulating the anti-physiological stress neurohormonal secretion.

Keywords: High-intensity exercise, music, stress, muscle, non-athlete, endocrine.
1. Introduction
Physical exercise is a fundamental effort to improve the health of children, adult, and elderly people. Exercise supports the increase in fat oxidation and the ability of muscle in using the fat as the energy source [1]. Therefore, exercise is a very effective strategy to improve people’s health, prevent and treat metabolic syndrome [2], and prevent as well as decrease the stress since it is related to the increase in physical and spiritual fitness [3]. However, the high-intensity exercise is a stressor possibly causing physical, physiological, and psychological stresses as well as oxidative stress [4]. Interestingly, until now, the success of the exercise is in line with the getting higher exercise intensity given so that it is riskier to the increase in muscular stress [5]. Hence, the change of physical-physiological interaction and internal stress with a physio-neurohormonal indicator is vital. However, the information regarding this case is very rarely available so that an in-depth study is necessary through a molecular approach.

The previous research results explained that exercise is an essential thing in enhancing and maintaining the happiness through the healthy lifestyle [6]. Besides, the high-intensity exercise is regarded as beneficial to manage obesity since it can improve the metabolism rate and lipolysis as well as enhance the insulin sensitivity [1]. In contrary, exercise is also a stressor for a body that can impact on physical, physiological, and psychological stresses. This case is indicated by the increase in cortisol secretion and the decrease in testosterone hormone, endorphin hormone, and the other hormones [7]. In the high-intensity exercise, the muscle will be more active, need much more energy, improve the metabolism, and the inflammatory cytokine secretion results in the inflammatory of muscle due to the increase in IL-6 [8,9]. Importantly, exercise can influence the neurohormonal function related to the effort to face the exercise stressor [10]. The exercise with 60% intensity of VO2 will improve the cortisol secretion and the higher the exercise intensity; the cortisol secretion will be higher as well. It is proven by the anaerobic sport which can enhance the cortisol secretion [11].

The research results in the last decades showed that listening to the music could prevent the cortisol hormone secretion during the exercise and avert the stress [12]. The exercise while listening to the music could enhance the mood, motivation, reduce the anxiety, stress response, blood pressure, heart rate, and stress hormone [13]. The rhythm, beat, and color of music physiologically influenced the convenience during exercise and could distract the attention of tiredness [14]. As a consequence, the physical performance increased, the tiredness sensation decreased, and people could enjoy and avoid distress [15]. The effect of music on the body was influenced by not only the exercise intensity but also the suitability of exercise intensity for the music beat, habitual factor, culture, and the music rhythm [16]. Classical music that was listened to during exercise had been proven to be able to provide relaxation compared to rock music [12]. Interestingly, the exercise while listening to the rock music for 30 minutes could increase the heart rate, blood pressure, and cortisol compared to listening to classical music [17]. Even though several previous studies have been done with the preliminary investigation related to musical-exercise combination model, the basic molecular profile linked cytokine, and hormonal alteration in high-intensity exercise combined with serial beat musical treatment are still not fully elucidated.

2. Experimental Methods
This study was an experimental research aiming at uncovering the physical-physiological response and muscle inflammatory to the musical beat combined with the high-intensity exercise. This research used a randomized control group pre-test and post-test design, with three experimental groups consisting of high-intensity exercise with hard beat music, high-intensity exercise with slow beat music, and high-intensity exercise without music. Slow beat music was decided about 130-140 beats/minute while hard beat music was selected on 150-170 beats/minute.

The human samples were selected from 30 healthy subjects with several criteria namely male, 19-23 years old, normal body mass index or it is about 19-23, heart rate, normal rest, VO2 Max 46-56 ml/kg/BB, not smoking, non-athlete, and do not have the habit of drinking alcohol beverage, normal blood pressure, and willing to be the sample (informed content). The ethical clearance has been approved by ethic committee of Faculty of Medicine, Universitas Brawijaya, Indonesia No.
100/EC/KEPK/04/2018. The data collection was conducted by asking people to do warming up for five minutes by pedaling an ergometer bicycle with low intensity continued by pedaling the ergometer bicycle for 15 minutes with 85% intensity of maximum working capacity and ended by the cooling for five minutes with low intensity. The measurement of stress level was by using marker of neuroendocrine and cytokine included cortisol, endorphin, and IL-6. The heart rate performance was measured pre and post treatment. Taking 10 ccs blood sample was to measure the cortisol hormone, endorphin, and IL-6 of the cube vein, while the measurement of heart performance used polar heart rate monitor set in the chest and the monitor set in the ergometer bicycle. Checking the blood sample was to measure the cortisol hormone, endorphin, and IL-6 using the ELISA method; the data analysis was by one way ANOVA with a 5% significance level.

3. Results and Discussion

The research results of the physical condition of the samples related to anthropometric and baseline characteristics are presented in Table 1.

| Groups               | Age (years) | Resting Heart Beat (beats/minute) | BMI (kg/m²) | Sistolic Blood Pressure (mmHg) | Diastolic Blood Pressure (mmHg) | VO₂ max (L) |
|----------------------|-------------|----------------------------------|-------------|--------------------------------|---------------------------------|-------------|
| HIE + HBM (n = 10)   | 20          | 74                               | 21          | 110                            | 90                              | 51          |
| HIE + SBM (n = 10)   | 20          | 69                               | 22          | 120                            | 90                              | 52          |
| HIE (n = 10)         | 19          | 68                               | 21          | 120                            | 90                              | 49          |

HIE + HBM (High-Intensity Exercise + Hard Beat Music), HIE + SBM (High-Intensity Exercise + Slow Beat Music), HIE (High-Intensity Exercise); BMI (Body Mass Index)

Based on Table 1, the physical condition from the anthropometric aspect and physiological condition of each group were good, and the physical and physiological conditions of each group were not significantly different (P < 0.05). The research subjects were then given high-intensity exercise using music, and their stress level was measured using heart performance indicator, and the results are presented in Table 2. The high-intensity exercise without listening to the music caused the enhancement of heart performance than the high-intensity exercise while listening to the music. To know the stress level was by using a marker of cortisol hormone, endorphin, and IL-6 presented in Table 3. Based on the ANOVA (Table 3), there was a significant difference in endorphin content and interleukin-6 (IL-6) of the group given high-intensity exercise with slow beat music compared to control group (p < 0.05). However, there was no significant difference in circulating cortisol content in all experimental groups (p > 0.05).

| Groups               | Heart Beat (beats/minute) | Resting | Post Exercise |
|----------------------|---------------------------|---------|---------------|
| HIE + HBM (n = 10)   | 73                        | 189     |               |
| HIE + SBM (n = 10)   | 69                        | 185     |               |
| HIE (n = 10)         | 67                        | 194     |               |

HIE + HBM (High-Intensity Exercise + Hard Beat Music), HIE + SBM (High-Intensity Exercise + Slow Beat Music), HIE (High-Intensity Exercise)

Physio-neurohormonal, music can increase the enjoyable feeling, mood, pleasure, decrease the emotion, as well as physical, physiological, and psychological stresses [18]. Besides, music can also reduce the perception of tiredness, mood, and pain suppression [19]. Exercise is a stressor that potentially disturbs body homeostatic and causes distress [11]. Hence, the well and right, as well as regulated and measured sports management, were by shifting the stress perception by using music is very important to improve the coping mechanism in the body in building the body adaptation. Music is a non-pharmacological approach to decrease the stress related to central nerve regulation in the...
hypothalamus-pituitary-adrenal axis (HPA axis) and sympathetic nervous system (SNS). Treatment using music could enhance the enjoyable feeling for the condition related to physical stress, emotional/mental stress, distress change to eustress through control of psychological and physiological aspects [20]. The stress level related to physical and physiological changes in this research used the marker of cortisol hormone, endorphin, cytokine IL-6, and heart performance. The heart performance used heart rate parameter as the distress indicator [5]. The research results showed that the high-intensity exercise without listening to the music caused the heart performance higher than the high-intensity exercise while listening to the music. Based on the variant test, there was a significant difference (P < 0.05). The improvement of higher heart performance in high-intensity exercise without listening to the music was the effect of sympathetic nerve stimulation that was more active than parasympathetic nerve. The research of [21] concluded that listening to the music during exercise could increase the parasympathetic nerve activity stimulation giving effect on the stress decrease in heart muscle. Moreover, the increase in heart rate was found in the exercise without music compared to the exercise with music [18]. This case was because music contributes to control and reduce the sympathetic nerve stimulation and increase the parasympathetic nerve stimulation. The parasympathetic nerve stimulation could decrease the stress of heart so that the heart performance decreased. Besides, music could also control the emotion level and decrease the anxiety level decreasing the heart performance [21]. The decrease in heart performance in the exercise with music was also influenced by the stressor level. The exercise with music caused the stress hormone activity lower so that that the anxiety level reduced, the relaxation and enjoyment while doing exercise increased [13]. The decrease in heart performance in the exercise while listening to music was caused by the music listened to is a voice wave of which stimulation arrives at the auditorious cortex in celebri cortex 41, stimulates to limbic system through cerebral cortex ring (limbic cortex), to the hypothalamus, then Hypothalamus does the secretion of some hormones related to the emotional behavior setting [22]. Besides, the voice wave of music continues to formati retikularis giving the impulse to the autonomy nerve namely sympathetic and parasympathetic nerves. Both nerves are responsible for the heart performance setting [23].

| Groups                  | Endorphin (ng/mL) | Cortisol (ng/mL) | IL-6 (ng/mL) |
|-------------------------|-------------------|------------------|--------------|
|                         | Pre HIE | Post HIE | Pre HIE | Post HIE | Pre HIE | Post HIE |
| HIE + HBM (n = 10)      | 301.0384 | 244.538  | 908.700 | 764.4000 | 359.7500 | 327.5000 |
| HIE + SBM (n = 10)      | 192.4615 | 233.9230* | 819.3000 | 1113.2000 | 337.00 | 298.000* |
| HIE (n = 10)            | 212.3077 | 251.385  | 790.600 | 878.8000 | 287.7500 | 294.2500 |

HIE + HBM (High-Intensity Exercise + Hard Beat Music), HIE + SBM (High-Intensity Exercise + Slow Beat Music), HIE (High-Intensity Exercise). *Significant difference with p < 0.05

The increase in heart rate in the high-intensity exercise with hard beat music was higher than the high-intensity exercise with slow beat music. The difference in heart performance of both groups was possibly caused by the difference in music beat, sympathetic and parasympathetic nerves. The hard beat music caused the sympathetic nerve oscillator stimulation in the brain more active. The stimulation level of sympathetic and parasympathetic nerves system to the respiration system as the consequence of hard beat music could increase the respiration frequency of 1:8, while the respiration frequency of the slow beat music was only 1:4 [24]. This case was assumed that listening to the hard beat music enhance the sympathetic nerve response and stimulate the high contraction of heart muscle so that the heartbeat content increased. Such enhancement was also caused by the active sympathetic nerve in doing secretion of catecholamine hormone of medulla adrenal, or the increase in venous return through frank starling mechanism. Besides, doing exercise while listening to the hard beat music also could improve the skeletal muscle performance influencing the increase in energy need. To fulfill the energy need, the heart performance was enhanced in order there is no homeostatic disturbance impacting on the distress increase. On the contrary, the slow music decreases the
physiological and psychological responses, increase the resilience, motivation, decrease the tiredness, become more relax, reduce the stress of muscle, and prevent the working perception [25].

Based on the results of this research, the secretion of cortisol hormone in the group of high-intensity exercise with slow beat music and the high-intensity exercise without music tended to increase but the increase was responded by the increase in endorphin secretion. On the contrary, the high-intensity exercise with the hard beat music, the cortisol decrease occurred that was also responded by the decrease in endorphin secretion. Endorphin is an oped hormone secreted from adrenal pituitary gland to face distress, while if the body undergoes distress, it will stimulate corticotrophin releasing hormone (CRH) from hypothalamus and also stimulate the endorphin secretion and Adrenocorticotropic Hormone (ACTH) as well as α-Melanocyte Stimulating Hormone (α-MSH) from pituitary anterior gland as the stimulator of the increase in cortisol hormone secretion [26]. Interestingly, the enhancement of cortisol secretion was responded by the endorphin increase. This case was caused by the exercise intensity done, the training level, and the type of music used. Exercise gives an opportunity for body to overcome stress that can cause the pleasure, happiness, but to adapt needs time to face the stress [6]. Therefore, the trained people could be able to do adaptation to the stress caused by exercise so that the exercise can improve the pleasure feeling supported by music that will influence neurohormonal system [27]. Listening to the music during exercise could change the depression level function, cognitive system, and endocrine glands [28]. The previous research proved that the rhythm and music melody influence human’s endocrine nerve system that the impulse is started from limbic system, thalamus, and reticular activity system (RAS). However, the hard beat music influences the neuroendocrine, improves the heart performance, noradrenalin hormone secretion, cortisol, and adrenotrophic hormone causing the stress increase, arrhythmia, the high heart rate and blood pressure [27].

The increase in body response to do endorphin secretion when cortisol increases or decreases in all groups was possibly caused by the training level of the research subjects used so that it could prevent the stress of muscle and physiology. The endorphin secretion is an indicator of enjoyable feeling, pleasure, and relaxation in the body system, also as the anti-pain. Exercise can increase the brain-derived neurogenic factor (BDNF) [29], while the response of cortisol secretion is related to cortisol hormone function in maintaining the glucose equilibrium in fulfilling the energy needed by muscle to do high-intensity exercise [5]. Cortisol is human’s glucocorticoid. It is a catabolic hormone secreted from adrenal cortex because it was responded from exercise and psychological stresses, exercise with 60% intensity of maximum oxygen is one of the stressors that can cause the cortisol discretion. The cortisol secretion influences the metabolism to help the maintenance of blood glucose during exercise. This case is the part of activities in the skeletal muscle of adipose tissue to increase the amino acid and fat metabolism [30].

The high-intensity exercise without listening to the music caused the increase in IL-6 secretion higher than the other two groups. This case showed that exercise without listening to the music, the stress level was higher directing to distress. One of the differences was caused by the effect of music as the anti-inflammatory, anti-pain, as well as more relaxes muscle, and avoided the damage caused by the endorphin effect. Since the music causes the endorphin secretion, while the endorphin is hormone that causes not only enjoyment and relaxation, but also anti-pain hormone or oped system [26]. Endorphin secretion is very dominant with agonist μ and δ as the опед receptor. Such stimulation impacts on the decrease in Ca²⁺ ion concentration, while the decrease in Ca²⁺ ion causes the decrease in contraction and skeletal muscle relaxation that can prevent the inflammatory and stress of muscle [26]. The increase in inflammatory level indicated the distress of muscle signed by IL-6 secretion in the high-intensity exercise without music was higher than the exercise with listening to the music. This enhancement is related to the muscle performance that also caused the increase in heart performance by the epinephrine hormone and glucocorticoid hormones stimulation secreted during exercise (Pedersen, 2009). This case proved that music decreases the physiological and psychological stresses and increases the resilience ability, motivates to improve the performance, prevents the tiredness, and causes the relaxation so that it can prevent pain, adds the attention, and reduces the stress of muscle [25].
4. Conclusion
Based on the research results, it can be concluded that the high-intensity exercise while listening to the music could prevent the physical-physiology stress confirmed by neurohormonal and marker inflammatory. Giving the co-treatment of high-intensity exercise with music could suppress the muscle inflammatory and physiology stress. Hence, giving regular exercise combined with music could possibly reduce the metabolic disease progression. However, a further research is needed related to the suitability between the type of music, the number of beat, the type/color of music for the exercise in sport and recreation model.

Acknowledgments
We thank KEMENRISTEKDIKTI and Universitas Negeri Malang for Supporting research funding for this work.

References
[1] Jabbour G and Iancu H-D 2017 High-intensity exercise training does not influence body weight but improves lipid oxidation in obese adults: a 6-week RCT BMJ Open Sport Exerc. Med. 3 e000283
[2] Blizzard LeBlanc D R, Rioux B V, Pelech C, Moffatt T L, Kimber D E, Duhamel T A, Dolinsky V W, McGavock J M and Sénéchal M 2017 Exercise-induced irisin release as a determinant of the metabolic response to exercise training in obese youth: the EXIT trial Physiol. Rep. 5
[3] Mastorakos G, Pavlatou M, Diamanti-Kandarakis E and Chrousos G P 2005 Exercise and the stress system Horm. Athens Greece 4 73–89
[4] Brondani L de A, Assmann T S, Duarte G C K, Gross J L, Canani L H and Crispim D 2012 The role of the uncoupling protein 1 (UCP1) on the development of obesity and type 2 diabetes mellitus Arq. Bras. Endocrinol. Metabol. 56 215–25
[5] Aizawa K, Nakahori C, Akimoto T, Kimura F, Hayashi K, Kono I and Mesaki N 2006 Changes of pituitary, adrenal and gonadal hormones during competition among female soccer players J. Sports Med. Phys. Fitness 46 322–7
[6] Bhavsar D S D, S. Abhange D R and Afroz D S 2014 Effect of Different Musical Tempo on Post-Exercise Recovery in young adults IOSR J. Dent. Med. Sci. 13 60–4
[7] Jarraya M, Chtourou H, Aloui A, Hammouda O, Chamari K, Chaouachi A and Souissi N 2012 The Effects of Music on High-intensity Short-term Exercise in Well Trained Athletes Asian J. Sports Med. 3 233–8
[8] Gleeson M 2004 Immune function and exercise Eur. J. Sport Sci. 4 52–66
[9] Elkington L J, Gleeson M, Pyne D B, Callister R and Wood L G 2015 Inflammation and Immune Function: Can Antioxidants Help the Endurance Athlete? Antioxidants in Sport Nutrition ed M Lamprecht (Boca Raton (FL): CRC Press/Taylor & Francis)
[10] Hackney A C 2006 Exercise as a stressor to the human neuroendocrine system Med. Kaunas Lith. 42 788–97
[11] Minetto M A, Paccotti P, Borrione P, Massazza G, Ventura M, Termine A, Di Luigi L, Pigozzi F and Angeli A 2006 Effects of the training status on the hormonal response and recovery from high-intensity isokinetic exercise: comparisons between endurance-trained athletes and sedentary subjects J. Sports Med. Phys. Fitness 46 494–500
[12] Hebert S, Béland R, Dionne-Fournelle O, Crête M and Lupien S J 2005 Physiological stress response to video-game playing: the contribution of built-in music Life Sci. 76 2371–80
[13] Clark M, Isaacks-Downton G, Wells N, Redlin-Frazier S, Eck C, Hepworth J T and Chakravarthy B 2006 Use of preferred music to reduce emotional distress and symptom
activity during radiation therapy J. Music Ther. 43 247–65

[14] Savitha D, Sejil T V, Rao S, Roshan C J and Roshan C J 2013 The effect of vocal and instrumental music on cardio respiratory variables, energy expenditure and exertion levels during sub maximal treadmill exercise Indian J. Physiol. Pharmacol. 57 159–68

[15] Szabo A, Small A and Leigh M 1999 The effects of slow- and fast-rhythm classical music on progressive physical voluntary physical exhaustion J. Sports Med. Phys. Fitness 39 220–5

[16] Bernardi L 2005 Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence Heart 92 445–52

[17] Priest D L, Karageorghis C I and Sharp N C C 2004 The characteristics and effects of motivational music in exercise settings: the possible influence of gender, age, frequency of attendance, and time of attendance J. Sports Med. Phys. Fitness 44 77–86

[18] Yamashita S, Iwai K, Akimoto T, Sugawara J and Kono I 2006 Effects of music during exercise on RPE, heart rate and the autonomic nervous system J. Sports Med. Phys. Fitness 46 425–30

[19] Fukui H and Yamashita M 2003 The effects of music and visual stress on testosterone and cortisol in men and women Neuro Endocrinol. Lett. 24 173–80

[20] Jucău R and Jucău I 2012 Influenţa terapiei prin muzică asupra stării de anxietate şi a cortizolului salivar, în stresul indus de efortul fizic intens şi de scurtă durată 5

[21] Jia T, Ogawa Y, Miura M, Ito O and Kohzuki M 2016 Music Attenuated a Decrease in Parasympathetic Nervous System Activity after Exercise PloS One 11 e0148648

[22] Hall J E 2016 Guyton and Hall textbook of medical physiology (Philadelphia, PA: Elsevier)

[23] Stefano G B, Zhu W, Cadet P, Salamon E and Mantione K J 2004 Music alters constitutively expressed opiate and cytokine processes in listeners Med. Sci. Monit. Int. Med. J. Exp. Clin. Res. 10 MS18-27

[24] Larsen P D 2005 The sound of silence is music to the heart Heart 92 433–4

[25] Ghavam-Bakhtiar R, Nikbakht H, Ziaee N and Mohammadi M 2012 The effect of relaxing music on changes in blood lactate level during recovery following a maximal exercise session in young female athletes 4

[26] Nandhra T S and Carson R J 2000 beta-endorphin inhibits the production of interleukin-8 by human chorio-decidual cells in culture Mol. Hum. Reprod. 6 555–60

[27] Amaral J A T, Nogueira M L, Roque A L, Guida H L, De Abreu L C, Raimundo R D, Vanderlei L C M, Ribeiro V L, Ferreira C and Valenti V E 2014 Cardiac autonomic regulation during exposure to auditory stimulation with classical baroque or heavy metal music of different intensities Turk Kardiyl. Dernegi Arsivi Turk Kardiyl. Derneginin Yayin Organidir 42 139–46

[28] Satoh M, Ogawa J, Tokita T, Nakaguchi N, Nakao K, Kida H and Tomimoto H 2014 The Effects of Physical Exercise with Music on Cognitive Function of Elderly People: Mihama-Kiho Project ed C J Stam PLoS ONE 9 e95230

[29] Yeh S-H, Lin L-W, Chuang Y K, Liu C-L, Tsai L-J, Tsuei F-S, Lee M-T, Hsiao C-Y and Yang K D 2015 Effects of Music Aerobic Exercise on Depression and Brain-Derived Neurotrophic Factor Levels in Community Dwelling Women BioMed Res. Int. 2015 1–10

[30] Brownlee K K, Moore A W and Hackney A C 2005 Relationship between circulating cortisol and testosterone: influence of physical exercise J. Sports Sci. Med. 4 76–83