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## The Effect of Tempo of Musical Treatment and Acute Exercise on Vascular Tension and Cardiovascular Performance: A Case Study on Trained Non-Athletes

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# The Effect of Tempo of Musical Treatment and Acute Exercise on Vascular Tension and Cardiovascular Performance: A Case Study on Trained Non-Athletes

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**Abstract.** The higher incidence of hypertension strongly and significantly associated with unhealthy lifestyle and lack of physical exercise. This study aimed to investigate the fundamental correlation between musical tempo and physiological response particularly on vascular tension and cardiorespiratory activity in the nonathletes. This pre-posttest randomized design study involving non-athletes with age ranged from 19-21 years old, resting cardiac 60-80 beat/minute, maximal oxygen consumption ( $\text{VO}_2 \text{ max}$ ) 37- 49 ml/KgBW, average body mass index (BMI) and hemoglobin level (Hb), and without smoking history. The experimental data were collected from 60 participants that divided into four criteria. The placebo was treated with high exercise in the acute model while another group was exposed by moderate exercise with fast and slow musical tempo during treatment for 20 minutes. The monitoring of vascular tension and cardiovascular performance were done by using standardized clinical test. Importantly, the slow tempo of musical beat and acute moderate exercise model significantly decreased the vascular tension in cardiovascular activity without significant alteration in the lung activity. The pre-treatment with slow beat of musical tempo strongly correlated to vascular wall pressure. The systolic and diastolic pressure was significantly different among the group ( $P < 0.05$ ). Moreover, the combination treatment in our study improved the primary effect of musical tempo and muscular stretch on heart rate and cardiovascular performance. Our preliminary study suggests that co-treatment of slow beat musical and acute moderate exercise can reduce the progression of hypertension in the trained non-athletes.

**Keywords:** Musical tempo, vascular tension, cardiovascular, acute moderate intensity exercise



## 1. Introduction

High blood pressure is one of the universal heart diseases in the society, which is recently the prevalence rate experiences a significant increase and became an epidemic not only in developed countries but also in the developing countries [1]. Importantly, in 2025, it is predicted that the prevalence rate will reach 42% [2]. High blood pressure related disease ranks 3<sup>rd</sup> as one of the causes of morbidity [3] and mortality in the world [4]. In the community mortality incidence, for 8 death cases, one of them is caused by high blood pressure, while 3 out of 10 deaths is caused by a heart disease [1]. Besides that, high blood pressure is a predictor of some other diseases such as stroke, coronary heart disease, congestive heart failure, and liver disease [5]. The increase of high blood pressure disease prevalence is related to behaviors and passive lifestyle problems [6], lack of physical activity and exercise as well as the inability of stress management [7]. This will be a threat in the effort in improving the quality of health and human resources.

A passive lifestyle and the lack of exercise correlated with the increase of some diseases such as type-2 diabetes mellitus (T2DM), sarcopenia, osteoporosis and heart diseases [8], and high blood pressure [9]. On the contrary, the active lifestyle by doing regular and fun exercise does not only prevent the prevalence in heart disease but also decrease the risk of heart disease, DM 2 and high blood pressure disease (hypertension) [7]. It is proven that the exercise performed dynamically and regularly decreasing the high blood pressure and metabolic syndrome disease [2]. Therefore, an exercise with the right intensity will be responded well by the body, which generates an adaptation on the body. On the other hand, the intensity of exercise which is unable to be responded by the body will disrupt homeostasis and can have a negative impact on the body [10]. It is because physiologically, the exercise performed will be responded by the body in increasing the pressure and performance of the heart [8]. Also, the heart is the source of information to predict the intensity received by the body related to the increase of metabolism and body needs during the exercise [11]. The increase which exceeds the ability can be dangerous and trigger the incident of sudden death which often occurs during the exercise. More than 5 million people died related to exercise, allegedly due to the excessive exercise intensity, the heart cannot respond load. Therefore heart failure occurs [4]. Thus, exercise must be performed regularly with the intensity according to the ability, as well as can be performed aerobically and anaerobically [10]. Aerobic exercise is considered responsible for increasing the heart functions whose effects are similar to pharmacology medication and affecting on the improvement or decreasing the high blood pressure as well as enhancing the heart function in encountering a sudden change [11]. Exercise can be a stressor for the body which can disrupt homeostasis and increase the incidence during exercising [4]. Accordingly, to prevent the increase of prevalence of heart disease, high blood pressure, decrease the exercise incidence and increase more pleasing relaxation both physically and psychologically then music collaborates with exercise [12]. Music has a role in making the metabolism process effective, altering the fatigue perception, increasing the coordination of motion in the muscles and reducing the activity of the hypothalamus-pituitary axis (HPA) and sympathetic adrenal axis (SAM axis) [13]. The decrease of sympathetic nerve activity, SAM axis, and HPA axis affects the increase of relaxation and pleasure [3], decreases cortisol secretion [14], the music being listened to stimulates the autonomic nerve system, [15], affects the increase of heart performance function and the decrease of blood [16]. Music also plays a role in increasing fat metabolism and accelerating the elimination of lactic acid after exercise, which can increase the speed of recovery and prevent hypertension and improve cardiovascular performance [17]. Based on those above, then this research studied on the effect of listening to moderate and fast musical tempo during acute exercise with high and moderate intensity on the blood pressure and cardiovascular performance in trained non-athlete subjects.

## 2. Methods

The research aimed to investigate the effect of exercise and listening to music on the blood pressure and cardiorespiratory performance on the trained non-athletes, by using Randomized Control Group pretest-posttest design, consisting of 4-group treatment. The four treatment groups were the high-intensity exercise without listening to music, moderate intensity exercise without listening to music, moderate intensity exercise with listening to moderate musical tempo and moderate exercise with listening to fast musical tempo. Listening to music was performed during the exercise and recovery, listening to music using a handphone and earphones set on both ears. The music being listened to was chosen by the sample based on their preferred music according to the type group of moderate and fast musical tempo.

The population used in this research was 250 students in Faculty of sports science Universitas Negeri Malang, batch 2015-2017, while the samples were 60 students. The sampling was with the criteria of trained nonathletes, male gender, 19-21 years old, IMT 19-23,  $\text{VO}_2$  Max 37-49 (milliliter/kilogram body/minute) ml/kg bb/minute, not smoking, non-alcoholic, normal blood pressure, normal resting heart rate, normal Hb, and willing to sign the informed consent. The exercise in this research was performed by the samples run in the treadmill with high and moderate intensity for 20 minutes. The high-intensity exercise was performed by running on a treadmill with an intensity of 80-85% from HR max, and moderate intensity exercise was conducted by samples running on a treadmill with an intensity of 70-75% from HR max. Before carrying out the exercise, warming up and cooling down were performed with low intensity, each for 5 minutes. During performing the exercise, the samples listened to music according to the group. The fast musical tempo being listened is music with the beat frequency of 120-168 beat/minute (bpm), while the moderate musical tempo has the beat frequency of beat 109-120 bpm.

The data collection, an indicator of heart rate measurement was used for cardiorespiratory performance. Meanwhile, for the blood pressure, systolic and diastolic blood pressure indicators were employed. The measurements of heart rate were conducted pre, post-exercise, and after 5 minutes of recovery. Measuring the heart rate by using the polar heart rate, with a heart rate lead mounted on the chest, where the sensor is placed right at the heart position (left chest) and the heart rate monitor (the same size as the watch) mounted on the arm. Measuring blood pressure in systole and diastole is also done before, after exercise and after 5 minutes of recovery. The measurement of systolic and diastolic blood pressure was conducted by the samples sitting on the provided chair, and then the measurement of blood pressure was performed by the medical staff. The data analysis employed ANOVA difference test with a significant level of 1%.

## 3. Results and Discussion

This research used the samples of 60 trained nonathletes divided into 4 groups with the general characteristics of the samples presented in Table 1. Based on the ANOVA analysis, there is no significant difference between the general characteristics of the samples ( $P > 0.01$ ).

**Table 1:** Baseline characteristics of the study participant

Group	BMI (kg/m <sup>2</sup> )	Resting Heart Rate (rate/minute)	Hemoglobin (g/dL)	$\text{VO}_2$ max (ml/kgbb/minutes)
1	21.5	73	16.8	41.6
2	21.8	70	16.5	40.9
3	20.9	69	15.4	40.9
4	21.5	72	15.5	40.9

Group 1 (High intensity exercise); Group 2 (Moderate intensity exercise); Group 3 (Moderate intensity exercise + moderate musical tempo); Group 4 (Moderate intensity exercise + fast musical tempo)

The effects of listening to music during acute exercise on cardiovascular performance with the indicator of heart rate per minute showed an increase of heart rate average on each group (Table 2).

**Table 2.** The average heart rate of each group

Group	Heart Rate (rate/minute)			
	Resting	Warm-up	Exercise	Recovery
1	73	122	175	104
2	70	122	152	107
3	69	121	154	107
4	72	116	150	106

Group 1 (High intensity exercise); Group 2 (Moderate intensity exercise); Group 3 (Moderate intensity exercise + moderate musical tempo); Group 4 (Moderate intensity exercise + fast musical tempo)

Based on the research results, there is a significant difference in heart performance between the treatment groups. The heart rate average per minute on Group 3 and 4 is lower as compared with Group 2 and 1 ( $P < 0.01$ ). The difference is affected by the exercise intensity and musical tempo [18]. The previous research also found that a significant difference in heart performance between the exercises given fast, moderate, and without music [19]. This difference is caused by the effects of music on the neurotransmitter, sympathetic and parasympathetic nervous system, which affects changes in cardiac performance, energy metabolism efficiency, and systemic contraction in the skeletal muscles [20]. The another prove shows that exercise with listening to music affects the lower heart performance compared to the exercise without listening to music [21]. The average heart rate on the exercise without music co-treatment is significantly increased compared to the exercise with music. The research employed a meta-analysis approach found that the intervention by using music lower the systolic, diastolic pressures, and heart rate, in which also found in the patients with coronary heart disease [22]. This shows that music in the exercise decreases the level of activity of the HPA axis and the SAM axis, thus increasing pleasure, improving mood, and reducing anxiety, [23], on the contrary, exercise without music collaboration activate the HPA Axis and SAM axis to secrete cortisol and catecholamine hormones [24]. Both hormones cause an increase a heart performance [25]. The increase in heart performance is also caused by the emotional stimulus from the cardiac accelerator in the bottom lobe of the brain and limbic lobe stimulus on the cortex and hypothalamus, which are caused by the activation of sympathetic nerves and decreases the activity of parasympathetic nerves [26]. On the other hand, the heat performance on the exercise collaborated with music resulting from the music effect which acts anti-anxiety, body high-intensity exercise work efficiency and effectiveness of metabolism [27].

Music can direct a pleasant emotional condition so that it can trigger physical and mental relaxation, which raises the positive emotion through limbic system which then releases endorphin [22] holding responsible on the regulation of cardiorespiratory performance and also can decrease the activity of HPA axis [17], which can decrease the secretion of stress hormone (cortisol) [28]. [29] It has been proven that listening to music increases  $\beta$ -endorphin secretion, growth hormone, norepinephrine and decreases adrenocorticotrophic hormone (ACTH) secretion, cortisol, and decreases inflammation [24]. Accordingly it increases relaxation and decreases the stress level, particularly the stress in muscles. The music collaboration during exercise does not only cause pleasure but also increase mood during the exercise [20], regulating metabolism and energy balance [17]. Listening to music during exercise will increase the body's system performance, metabolic efficiency and causes muscle relaxation, which results in an efficiency of

energy expenditure, and also decreases fatigue perception [29]. However, it depends on the intensity of the exercise and music related to the rhythm, type, and even tempo. The fast musical tempo with 120-130 beat/minute increases anxiety, blood pressure, and heart rate, while the slow musical tempo with 50-60 beat/minute causes the opposite [12].

The average of heart performance is higher on the exercise collaborated with fast musical tempo compared to the exercise collaborated with moderate musical tempo. Listening to music with slow and fast tempo on a high-intensity exercise revealed an increase in higher heart rate in the high-intensity exercise by listening to fast musical tempo compared to slow musical tempo [30]. This is because the exercise by listening to fast music activates more significant to increase the sympathetic nerve stimulation, which causes the discretion of epinephrine hormone from medulla adrenal. It has been widely known that increasing the secretion of these hormones causes an increase in the speed and strength of the heart's performance. Music will affect the heart and the respiratory system, but the musical tempo influences the level of response, music habits that are listened to, the type of music, the musician and the intensity of the exercise performed [31]. The fast musical tempo causes the increase in blood pressure, heart rate, and respiratory rate as well as the decrease in baroreflex sensitivity [32], increases parasympathetic stimuli, and decreases sympathetic nerve stimuli, eventually lowers the heart rate and blood pressure [22]. The fast rhythm music increases the speed in the heart rate and respiratory frequency, on the other hand, the slow musical tempo significantly decreases the heart rate and respiratory frequency [31]. It proves that the musical tempo has different effects in the exercise, proven by the alteration of musical tempo from slow to fast has a significant physiology change [33].

According to this preliminary study, it also found that the primary effect of music during acute exercise on systolic, and diastolic blood pressures as shown in Table 3.

**Table 3.** The average of blood pressure on each group

Group	Systolic Pressure (mmHg)			Diastolic Pressure (mmHg)		
	Resting	Exercise	Recovery	Resting	Exercise	Recovery
1	122	145	121	83	81	85
2	113	140	114	78	81	79
3	117	139	116	79	81	79
4	105	135	113	77	82	81

Group 1 (High intensity exercise); Group 2 (Moderate intensity exercise); Group 3 (Moderate intensity exercise + moderate musical tempo); Group 4 (Moderate intensity exercise + fast musical tempo)

Based on statistical data, the systolic blood pressure in the pre-treatment stage was not significantly different among the group ( $P > 0.01$ ). However, there was a significant difference in systolic pressure during the exercise and recovery stage ( $P < 0.01$ ). On the contrary, there was no significant difference in diastolic blood pressure before treatment, after treatment, and recovery ( $P > 0.01$ ). Blood pressure increases correlatively with the increase of energy and oxygen needs. The increase of the blood pressure is caused by general vasoconstriction as the effect of the increase in sympathetic stimulation. The exercise related to the cardiorespiratory change and increases psychological stress, while music acts as a good distractor which will positively perceive, affects skeletal muscle system, eventually decreases the muscle tension and maintaining motivation [34]. The difference in the increase of cardiorespiratory pressure on systole and diastole besides caused by the effect of exercise intensity, it is also affected by music, which is proven by a significant difference of systolic artery pressure between patients who listen and do not listen to music [35].

The activities of sympathetic nerve stimulation significantly influenced the difference of cardiorespiratory pressure on systolic pressure. The activation of the sympathetic nervous system will induce the cardiorespiratory pressure will be high compared to in the homeostasis condition.

Meanwhile, physiologically stresses during exercise with the increase of energy, oxygen needs, and muscle contractions, stimulates the increase of sympathetic nerve activities to be more active than parasympathetic nerves stimulus to improve the heart performance and blood pressure. [36]. The increase in the average cardiorespiratory pressure on exercise with music collaboration was lower than that with music-free exercise. Its caused by the influence of, music being listened to, being able to control sympathetic nerve activity, and increase the activation of the parasympathetic nerves [5]. The stimulus of the music being listened to affects the neurotransmitter and neurohormone which release the anti-stress. Accordingly, it increases excitement, regulating emotions, happiness, activity, calmness, the effects of which are like sedatives [18]. It is proven with Zumba dance on lowering blood pressure; it can be concluded that Zumba dance can lower blood pressure [37]. The lowering blood pressure is caused by the increase of neurotransmitter released by the activation of parasympathetic nerve performance. Therefore, it causes a decrease in stress, modulates relaxation and causes a reduction in systolic blood pressure [1]. Listening to music gives rise to a relaxation response, thus lowering blood pressure, which is caused by an increase in dopamine levels in the brain through the system of calmodulin. Increased levels of dopamine will inhibit sympathetic activity through dopamine-2 receptors which in turn reduce blood pressure. Besides, music can also direct a pleasant emotional state, therefore triggering physical and mental relaxation, the possibility of music also raises positive emotions through the limbic system, which will release endorphins [22]. However, the effect is also influenced by musical tempo which is slow and fast musical tempo during exercise can generate a different physiological effect, proven on the slow musical tempo it can prevent the increase of stress, lowering systolic blood pressure and heart rate in teenagers during the recovery period [34]. Other studies also prove that the sample given acute exercise with high intensity by pedaling an ergometer bike while listening to music fast and slow tempo on stress level. It concludes that exercise with high intensity and listening to slow musical tempo releases more endorphin hormone as an anti-stress hormone than on the group listening to fast musical tempo [30].

The musical tempo being listened to during exercise tends to have a different response to systolic blood pressure. Based on the research results, there is a tendency of the average difference in systolic blood pressure. The previous investigation also found that there were no significant differences in pressure systole in listening to slow musical tempo compared to fast musical tempo (fast) [38]. Another research also reported there is a higher increase in blood pressure after listening to fast musical tempo, but not listening to slow musical tempo. When listening to fast musical tempo, on average the systolic blood pressure increases as much as 6.42 mmHg, and the diastolic pressure decreases as much as 3.92 mmHg. In contrary, listening to slow musical tempo, on average systolic blood pressure decreases as much as 7.12 mmHg and the diastolic pressure decreases as much as 3.86 mmHg [12]. In addition, classical music decreases heart rate and blood pressure, whereas hip-hop music and rap music with fast tempo increase blood pressure and heart rate. Fast and loud musical tempo automatically stimulates the central nervous system, this causes an increase in heart rate, blood pressure, body temperature, skin creativity, and muscle tension [18]. The proof shows that by listening to music for 22 minutes decreases systolic and diastolic blood pressure as well as the speed of respiratory [5]. The research using Mozart music also concluded that it could decrease blood pressure followed by the change of dopamine [16]. By contrast, the increase in heart rate in exercise collaborated with fast musical tempo is caused by the oscillator of sympathetic nerves in the brain [15]. Exercise while listening to fast musical tempo increases the respiratory frequency of 1:8, on the other hand, the exercises accompanied by slow musical tempo the increase of the frequency is 1:4, the increase also occurs by the increase of heart rate in which both are controlled by autonomic nerves [39]. Based on the results of this study, the use of musical tempo during exercise should be adjusted to the intensity of the exercise performed. Exercise with moderate intensity will better hear moderate musical tempo. The exercise with moderate intensity while listening to slow musical tempo results in the lower heart

rate and blood pressure. Thus, the exercise is safe and pleasurable enough so that it can lower the blood pressure disease.

#### 4. Conclusion

In summary, listening music with lower tempo/beat during acute moderate intensity exercise could be more effective on cardiovascular performance and systolic blood pressure. Moreover, to reduce the physio-psychological stresses, it is recommended to manage the musical beat/tempo exposure in particular for an non-athlete with hypertension symptom to avoid cardiovascular injury stress during the exercise.

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