PHYSIOLOGICAL EFFECTS OF MUSIC DURING EXERCISE SECRETION OF HORMONES CORTISOL AND ENDORPHINS

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ABSTRACT

This study is a randomized experimental design with control group pre test - post test design, which aims to uncover the physiological effects of listening to music during exercise on the secretion of the hormone cortisol and endorphins. The sample is majoring in Sport Science students some 24 people chosen at random based on the criteria established, and then divided into three groups consisting of sports, without listening to music, sports by listening to slow music (slow music) and sports by listening to loud music (hard music). Data collecting was done by pedaling a bicycle ergometer exercise for 10 minutes with sub maximal intensity while listening to music. Listening to music during the workout using five multiplayer (MP5) and head sets. Blood sampling for hormone cortisol and endorphins examination performed before and after exercise. The analysis anova data using different test, with significance level 5%. Results of data analysis revealed that there is no significant difference between the exercise without music, sports by listening to music, whether slow or music on loud music on the secretion of the hormone cortisol and endorphin (P <0.05). Sports without the music tends to have increased secretion of the hormone cortisol and also hormone endorphin, contrary to the exercise by listening to loud music and there is a tendency slow decline in secretion of the hormone cortisol, whereas the hormone endorphin in both groups are still fluctuative. It can be concluded that sub maximal intensity exercise, by listening to music for 10 minutes tends to lower the hormone cortisol and increases endorphins, which can inhibit the stress and make sense of music as well. Therefore it is advisable to inhibit the increase in cortisol during exercise can be done by listening to music, which according to the intensity of exercise.

Keywords: Exercise, stress, Cortisol, Endorphin, loud music (hard music), slow music (music slow)

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INTRODUCTION

During this community understand that the sport is an activity that manarik and fun, is also beneficial for promoting health, physical fitness and performance (Challem 1997). But sports also have an increased risk of declining quality of health and physical fitness (Rost 1993), both exercise with maximum intensity and the intensity sub maximal (Gervino 1993). Because physical exercise can cause stress, chemistry, physiology or spikologis (Uchakin, 2003). Associated with increased stress hormone cortisol, so more heavy intensity exercise, the higher the secretion of the hormone cortisol (Kurosawa, 1998, Minetto 2006). Hormone cortisol can serve as immunosupresive (Roitt, 1995) that may cause disruption of homeostasis, so the potential neglect of health conditions (Sulton 1975; Bouchard 1993). But this still seems have less attention.

During and after exercise the body will experience a change in metabolism (Kelkar 2008), which can cause stressors to the body (X-ray 2002). These stressors can disrupt homeostasis (Minetto 2006), so it causes health problems (Hebert 2005) suppress the immune response, causing upper respiratory infections (ARI), depression (Farzanaki 2008). Incident stressors can also cause tissue damage both at the cellular level or at the enzymatic (Minetto 2006). Sugiharto (2006a) reported no increase in enzyme creatine kinase in rats given pool exercises regularly and irregularly. In other studies Sugiharto (2006b) that compared between aerobic and anaerobic exercise on the guinea pig rat finds the osmotic fragility of erythrocytes. Creatine kinase enzyme elevations and osmotic fragility of erythrocytes, caused by increasing free radical (MDA/ malondialdehyde) during the workout lasts (Halliwel, 1999; Sugiharto 2000). Stressors related sports as X-ray (2002) reported an increase in cortisol after exercise. Increased cortisol can suppress protein synthesis, reducing the population of eosinophils, lymphocytes and macrophages / monocytes, causing antropi lymphoid tissue, thymus, spleen and lymph nodes. Cortisol also has a role to prevent the production of IL-1 from macrophages, IL-2 on Th cells (Bernardi 2006) and increased levels of cytokine (IL1 and TNF) of peripheral blood, sitotosik activate NK cells and
Macrophages (IL-1, IL-6, TNF α) (Mackinon 1992). In addition, secretion of cortisol can also increase plasminogen activator inhibitor -1 (PAI-1), which is a biomarker of inflammation that allegedly also due to exercise (Clark 2006).

The hormone cortisol has a dual function, as well as an immunomodulator, it also can function as a suppressor, which can cause stress and even become destres (Aizawa, 2006). Reported that the music has a role in reducing stress and inhibit the secretion of cortisol (Hebert, 2005). According to Clark (2006), listening to music can improve mood, reduce anxiety, decrease stress response, blood pressure, heart rate and decrease stress hormones. Mohammadzadeh (2008) reported listening to music during exercise can decrease stress hormone secretion, decreased secretion of cortisol, which is faster than with exercise without music, it is also found decrease of sympathetic nerve stimulation during the workout by listening to music.

Szabo (1999) examined the effects of classical music with slow rhythms (slow) and fast tempo music (fast) on the sport by using multilevel load on a bicycle until exhaustion, slow rhythms of classical music find very efficient in improving the work ability more than with fast rhythm classical music. The response depends on the dose of music sports, custom options, musicians, the rhythm of music and culture as well as pleasure (Karageorghis 2006). However this is still unclear types of music, sport and the intensity of the response mechanisms are also impacted by the music of body systems (Yasmashita, 2006). On the basis of the background of these problems in this research aims to reveal the physiological effects of listening to music during the workout intensity sub maximal on the secretion of the hormone cortisol and endorphins. This is very necessary to reduce the stressors of sports, so sports are done can have a positive impact on the increase, health, physical fitness, and achievement of optimal physiological conditions, as well as improving sports motivation. In addition research is also useful for the development of molecular-based sports concept.

**Materials and Methods**

This research was experimental, using a randomized control group design pre-test-post test design, which consists of three groups: exercise without listening to music, sports by listening to slow music (slow music) and sports by listening to loud music (hard music). Slower music is music with 130-140 beats / min, while loud music with 150-170 beats / min.

Samples in this study were students majoring in sports science, State University of Malang force in 2006, a total of 24 people chosen at random with the following criteria: gender men, ages 19-21 yr, healthy based on medical examination, do not smoke, have eating patterns well, maximal oxygen capacity (VO2 max), 40 ml / kg / min - 45 ml / kg / min. BMI 18-22, and were willing to participate in research as evidenced by a letter signed and acknowledged by the willingness of parents or guardians of students. Then the sample was divided into three treatment groups consisting of the sport without listening to music, sports by listening to slow music (slow music), and sports by listening to loud music (hard music).

Sport is done by pedaling a bicycle ergometer-Gambettola Technogym brand-Italy, during 10 minutes with intensity sub maximal. Exercise intensity based on the determination of test loading sub maximal maximal work capacity, which was conducted before the research goes. The data collection was carried out by pedaling a bicycle ergometer exercise with sub maximal load for 10 minutes while listening to music. In this study, to listen to the music using MP5 and head sets are mounted on either ear samples. Music you listen to a sample selected in accordance with the pleasures and habits, both on the kind of slow and loud music. Blood sampling for the measurement of hormones cortisol and endorphin and heart rate measurements performed before and after exercise. Venous blood sampling from cubeti, whereas the method of analysis of hormonal Inmunosorbat Enzyme Linked Assay (ELISA) in the laboratory of Physiology Faculty of Medicine Brawijaya University. To measure your heart rate using Polar Hear Rate monitor. Analysis of data using different test ANOVA with significance level 5%.

**Results**

Based on the calculated average exercise without music, sports by listening to slow music and sports by listening to loud music on the variables heart rate, hormone cortisol and endorphins submitted in Table 1. Based on average results calculated show that there is a rise in heart rate between before and after exercise in all groups. There was an increase of hormones cortisol and endorphin hormone in sports without music, sports contrary to listen to music instead there is a decrease, while the hormone endorphin is still volatile. The analysis shows no significant differences in heart rate between before and after, both sports without music and sports to music (P <0.05), while for the hormones cortisol and endorphins difference are not significant (P> 0.05). To prove the physiological effects of exercise without music by listening to slow music and loud
music during exercise on the secretion of the hormone cortisol, endorphins and heart rate, indicated that there were no significant differences (P> 0.05). (Table 2)

Table 1. Average Count in Each Group of Variables

<table>
<thead>
<tr>
<th>No</th>
<th>Group</th>
<th>Heart Rate</th>
<th>Cortisol</th>
<th>Endorphin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pre test</td>
<td>Post test</td>
<td>Pre test</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>72</td>
<td>172</td>
<td>11.127</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>73.286</td>
<td>160.33</td>
<td>33.997</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>77.833</td>
<td>173.5</td>
<td>28.881</td>
</tr>
</tbody>
</table>

Description:
1 = control group (exercise without musical accompaniment)
2 = Symbol, accompanied by slow music (slow music)
3 = Sports, accompanied by loud music (hard music)

Table 2. Test of Differences Between Groups

<table>
<thead>
<tr>
<th>No</th>
<th>Variable</th>
<th>F. hit</th>
<th>sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart rate</td>
<td>2.980</td>
<td>0.081</td>
</tr>
<tr>
<td>2</td>
<td>Cortisol</td>
<td>0.128</td>
<td>0.880</td>
</tr>
<tr>
<td>3</td>
<td>Endorphin</td>
<td>2.289</td>
<td>0.136</td>
</tr>
</tbody>
</table>

DISCUSSION

This study aims to reveal the physiological responses of listening to loud music, slow music during the workout intensity sub maximal on the secretion of the hormone cortisol and endorphins. Based on this research there are no significant differences in secretion of the hormone cortisol and endorphins between before exercise and after exercise both in sports and exercise without music by listening to music (P> 0.05). Similarly, the difference test between groups on the secretion of the hormone cortisol and endorphin (P <0.05). However, when viewed from an average value between the sport without listening to music, sports by listening to slow music, and sports by listening to music loud on the secretion of the hormone cortisol and endorphin showed no inclination difference.

The results show no increase in the average value of the secretion of cortisol and endorphins at the gym which performed for 10 minutes with intensity sub maximal without listening to music. Marce (2000) also found an increase of the hormone cortisol and ACTH treatment in horses fed a treadmill, using multilevel load test. Filmic (2003) reported no increase in cortisol in marathon runners, bike racing and jumping, after conducting tests with multilevel load treadmill for 10 minutes. Viru (2001) reported no increase in the hormone cortisol, testosterone and growth hormone in athletes ski 12 ice, after pedaling a bicycle ergometer intensity of 70% of VO2 max for 10 minutes. During the hormone cortisol is used as a parameter of stress on the body (Gordon, 2005), both physical and psychological stress (Wilson 1992, Filmic, 2003).

The trend increase in the secretion of the hormone cortisol, on sports without listening to music, proving that exercise is the cause of stress for the body. Stress is not only a physiological stress, but also psychological stress, which can affect the endocrine-related neuro immunosuppressive (Uchakin, 2003). Increased cortisol during exercise, is actually the body's efforts in maintaining homeostasis of the loads are received. Body's response mechanisms to exercise load according to Dunn (1995) made the hypothalamus and pituitary peptide, which is a product of the sympathetic branch of autonomic nerves. These factors through coticotropin releasing factor (CRF), endoefin, ACTH, substance P, epineprin, dopamine, serotonin, histamine, growth hormone, intestinal polypeptide vasoactive, beta-endorphin, methionine, enkefalin and somatostatin. CRF is the main mediator of the changes caused by the stress of exercise.

Because one role as an initiator of CRF is the biologic response in the brain to respond to stress, which causes activation of HPA flow and autonomic nervous system (nerves Autonomic System / ANS), the suppression
Physiological Effects of Music During Exercise

Secretion of Hormones Cortisol and Endorphins (Sugiharto)

A physiological effect occurs directly and indirectly (Martce, 2000). According Minetto (2006) response to the increasing burden of cortisol sport through the mechanism of neurons in the paraventricular nucleus in the hypothalamus, which secrete corticotrophin-releasing hormone and vasopressin, and then activate the HPA axis and subsequent increased spending cortisol from the adrenal glands.

Sports without listening to music increases the hormone cortisol and endorphins, proving that exercise in addition to causing stress also causes a sense of fun and enjoy. Has been widely known that the hormone is endorphin opied systems of the body which when removed make the mood more relaxed, fun and raises motivation, and feelings of "enjoy" (Debruille, 1999). Stes caused by intensity exercise may still be eustres sub maximal who are encouraged to develop coping mechanisms in the body (Harte, 1995). This may be different from the heavy load, the stress caused may result in distress (Goldstein, 2003). Besides increased cortisol secretion during exercise related efforts in maintaining homeostasis due to increased energy needs during exercise under way (Debruille, 1999). Therefore, the more severe the intensity and duration of exercise that will be performed higher secretion of the hormone cortisol (Marce, 2000, Jill 2001).

Increased hormone cortisol and also the hormone endorphin in exercise intensity sub maximal without music, is also influenced by the physical condition of exercise samples and samples with an average with a VO2 max of 40-45 ml / kg BW. Told by Lamb (1984) factors affecting the response to the intensity of exercise the body is a physical condition, age and gender and environment. Farzanaki (2008) states that the factors of age, physical ability, athletic type, intensity of exercise affect the secretion of the hormone cortisol. The lower one's physical abilities will be facing a more stressful exercise intensity, which is described by an excessive increase in cortisol, hormones that suppress the secretion of endorphins.

As already explained earlier that the sport is basically a stressor that can be conditioned and regulated, thereby becoming a stimulator (Brook, 1984). Stimulator in response to stressors and intensity of exercise, is dependent on the level of physical condition (physical fitness), exercise level, age, gender, intensity and type of exercise (Rushall, 1992). Because the exercise habit forming behavior neurohormonal responses that are influenced by the limbic system of the HPA Axis, which causes the flow of conditioning stimuli on limbic-hypothalamic pituitary-adrenal-axis (LHPA). Then, and hormonal causes of motor behavior and cause a feedback mechanism on the central nervous system through chemical and metabolic somatosensory (Carlson, 1994). Secretion of the hormone cortisol in the sport is intended to mobilize the energy and adaptation reactions of the body systems (Viru, 2001). In addition, as a mediation in maintaining homeostasis the body (Bouchard, 1993). Increased endorphin hormone cortisol and increased by an average heart rate significantly (P <0.05) (Figure 1).

Increased heart rate between before and after exercise is a physiological response in an effort to prevent the occurrence of homeostasis disorders (Minetto, 2006). Because during exercise can increase oxygen demand, up to 15 times (Ji, 1999), even up to 20 times than usual (Kelkar, 2008), so the higher oxygen demand and energy, the higher the response by the heart, with increased speed and strength cardiac contraction.
Increased heart rate caused by increased activity of skeletal muscle which is also followed by an increase in metabolism in muscle cells (Rushall, 1992). The increase resulted in the accumulation of metabolic vasodilator substances locally in muscle tissue, and increased heat production due to increase in metabolism that occur in muscles (Mc. Ardle, 2000). Vasodilator causes capillary vasodilation in skeletal muscle tissue that is being actively worked. This leads to skeletal muscle vascular pressure drop, and the resulting pressure decrease total peripheral resistance. During the compensation had not occurred, arterial blood pressure decreased, thus stimulating baroreseptor and provide information to the center in the medulla oblongata cardiovascular (Guyton, 1997).

At the beginning of the acceleration sports seem work of the heart, this is caused by nerve reflexes from contracting muscles or joints. Cardiac response during exercise and rest is determined by the autonomic nerves (Behavior of the autonomic nervous system). Activity was controlled by two mechanisms namely a central mechanism (Central COMAND) and peripheral mechanisms (neural reflex mechanism). The central mechanism causing changes in sympathetic and parasympathetic nerve activity. Peripheral mechanisms also affect activities through ergoreseptor (Mekano receptor, and metaboreseptor). (Dampney, 2006). Listening to music during exercise have different effects on employment heart. Sports by listening to music there is an increase that is lower than the exercise without music.

The results also prove the existence of differences between the cardiac response to exercise with slow music and loud music. Sports by listening to loud music have increased heart rate is higher with exercise compared to slow music listening. Both types of music you listen to while doing exercise also influence the behavior of the hormone cortisol and endorphins. Hormone secretion of the hormone cortisol and endorphins on the basis of average values show the difference. Average picture of these two hormones in all groups can be seen in pictures 2 and 3.

Listening to slow music during the workout, as evidenced lowering hormone cortisol secretion was higher than by hearing loud music (Figure 2). But the decline in the secretion of the hormone cortisol is high on the exercise by listening to slow music, not followed by increase in the average value of hormone secretion of endorphins (Figure 3). Instead listen to loud music during exercise tends to increase the secretion of the hormone endorphin and cortisol also decreases. From both of these prove that the type of music you listen to influence the behavior of hormones during exercise (Dyrlund, 2008). Behavior is influenced by the type of hormones in addition to music, also influenced by the intensity of exercise, thus decreasing the secretion of the hormone cortisol, which is not accompanied by increased secretion of the hormone endorphin in sports by listening to slow music, probably due to lack of blend between the beats in music with the intensity of exercise performed. Therefore, slow music is heard during the workout intensity sub maximal, can only reduce stress, have not been able to make happy, relaxed, mood and enjoy.

Decrease stress that has not been followed by a sense of relaxed, enjoy and fun in sports by listening to slow music, also caused by the beat (rhythm), low music does...
not fit with the rhythm of woods on the pedal a bicycle ergometer used in the retrieval of data. However, according to Meeks (2002), music can cause a sense of mood, improve physical performance and reduce perception of fatigue, if the music you listen to the rhythm or intensity of the pedal, otherwise if the music is heard not in accordance with the intensity / rhythm of the pedals, causing dishinchronization, so that happen "psychology complex". Maybe it will be different when listening to slow music during low-intensity exercise or under conditions relaxed (relaxed) or not working. Could be better suited for slow music relaxed atmosphere, not to encourage the spirit of work. From the results of the study decreased hormone cortisol is higher in slow compared with the music loud music, slow music that is able to reduce your stress better, but has not been able to encourage morale.

According to Hebert (2005) more slow music makes the atmosphere relaxed and fun, and relaxing atmosphere, is different when the work that requires increased energy, higher oxygen and the involvement of all body systems to work together in facing the pressures of work intensity (Yamashita, 2006). According Nugroho (2006) in music, the main elements that make humans respond directly is the element of rhythm. So the music has a rhythm equivalent to "body rhythm" in their work can make sense of joy and calm, do not cause disturbance of the body homeostasis. If the harmony of music or rhythm of music equivalent to the internal demands of the body then the music will be fun, so it can reduce stress and prevent depression (Monty, 2008). Ritmit listen to music can reduce stress response, decrease anxiety, blood pressure, heart rate, and decrease stress hormones. When the harmonious relationship between body rhythm with the music maintained, then the stressor can be muted (Yamamoto, 2003). Karageorghis (2006) conducted a study on the role of music in sport reported no relevance to music with the intensity of exercise performed. In a report explaining intensity of more than 60% VO2 max, the music should be heard is 120-140 bpm (beats / min), while for the sport with the intensity of 75% of VO2 max is the music you listen to music that has a 140 minute beat, on the contrary sports with low-intensity music you listen to slow music (slow music). When the intensity of exercise in accordance with the rhythm of the music heard. causes more work morale, lower fatigue perception and fun.

Results show the average value of the differences in hormones during exercise behavior by listening to slow music and loud music. Listening to loud music during exercise reduce the tendency to increase the hormone cortisol and endorphins. It means listening to loud music during the workout in addition to reducing stress, also makes sense of pleasure and enjoy. This is probably due to suitability intensity exercise with music you listen to the rhythm. As presented by Meeks (2008) music appropriate to the workload may increase the perception of fatigue, improve mood and physical performance in dealing with the workload of the stretcher. Choice of music you listen to during exercise may also contribute to decrease stress and increase a sense of happy and relaxed. It really depends on the culture, age, musicians and intensity of exercise performed. Dyrlund (2008) who examined the effects of some types of music with exercise intensity on the perception of fatigue and reported feeling enjoy listening to music will cause the music as if there was interested in music, which according to the rhythm of exercise intensity used.

![Figure 3: Average endorphin hormone](image)

Behavioral changes with hormones in sports and sports to music without music, many factors influence. According Pakalakonis (1994) increased cortisol hormone is not something that stands alone and
separate, but interdependent systems, and is determined by several factors. These factors are individual characteristics, intensity of activity used, duration of stressor, the perception of stress, appraisal, ability to cope and adapt to stress. In accordance with the tastes of music listeners to affect the limbic and autonomic nervous system, creating a sense of relaxed, safe and enjoyable, thus stimulating the central sense of satisfaction and release of gamma amino butyric chemical substrate acid (GABA), enkephalin and beta endorphin, which will eliminate neurotransmitter pain or sense of anxiety, thus causing a sense of calm and improve the sense of mood (Prasetyo, 2005). This mechanism is also done by the body when accepting response from the sport that according to his ability (Rushall, 1992). According to Clark (2006) there are four factors that affect the body's response to music, including rhythm, musical, cultural habits. Rhythm related to the rhythm of music and music speed beat / min. In addition to these factors also influenced by the level regularity of exercise. Sports are conducted on a regular basis is antidepressant, this mechanism was inferred from a neuro-muscular stimulation in hyperactive HPA axis (Viru 1995; Oliver 2007).

Higher cortisol decline during the workout listening to music is slow, followed by increased heart rate increase was lower than that sport to listen to loud music and no music in sports (figure 1). Even the sport without listening to music increased the heart rate higher compared with two other groups. The increase in heart rate was lower in slow sport with music because music is more stimulating work slow parasympathetic nerves compared with the sympathetic nerves, so it can reduce heart work (Sirait 2007). The results of this study together with studies conducted by the Schie (2008) that compared exercise with music and sports without music, shows an increase in heart rate was lower in sports with music, compared with exercise without music. Associated with slow and loud music there are differences in heart rate, but there is no clarity of how music affects their heart in their work, only suspected that music affects the working of the sympathetic nerves and the sympathetic.

The research results also show there is an increased heart rate was higher in sport with loud music than sports with slow music. This is caused by sympathetic nerve responsiveness is higher in the gym with loud music, thereby increasing the secretion of hormones epinephrin. Epinephrin have known that the function to improve the speed and strength of the heart (Guyton, 1997). Larsen (2007) who analyzed the influence of music on the frequency of respiration, concluded that loud music can increase respiratory frequency of 1:8, whereas slow music that only can increase the respiratory frequency of 1:4, the increase is due to stimulation of the sympathetic nervous oscillators in the brain and also by the stimuli sympathetic nerves in the organs of respiration, which is analogous to the system of the heart. Because music has the effect of parasympathetic nerve growth in employment, so the work is more dominant parasympathetic nerves from the sympathetic nerve (Urakawa (2005). In addition, the rhythm of loud music and fast rhythm has stimulative properties (Karageorghis, 2006), music also has a stimulative to the perception feeling tired. Yamashita (in 2006) in the study reported that music lowered the speed of fatigue during moderate intensity exercise. Therefore when the exercise intensity of 50% of HRR (Heart Rate Reserve) showed that there was a difference of reducing the speed of exhaustion, but in sports with intensity 80 % no difference. But this is still unclear the mechanism involved the effect of different rhythms of music with the decrease in speed and fatigue on cardiac autonomic nervous, so how the physiological response to music is not something simple. Similarly, the effects of music during exercise on the hormone cortisol and endorphin, other than compliance issues intensity exercise with music, suspected the existence of differences between the hormone cortisol secretion path with the hormone endorphin caused by physical stress such as exercise and hormonal response differences caused by the music, so that molecular research is needed to sharpen analysis.

CONCLUSIONS

Based on the results, it can disimpukan that exercise is a stressor to the body, but on submaksimal intensity exercise for the already trained can reduce stress, and increase the sense of pleasure and enjoy. By providing musical accompaniment on submaksimal intensity exercise for 10 minutes have a tendency to reduce the secretion of cortisol, whereas the hormone endorphin response continues to be volatile. Listening to slow music during the workout intensity tends to decrease the hormone cortisol submaksimal, while listening to loud music during sports also tend to decrease cortisol, and tends to increase the endorphin hormone. Based on this research there is an increased heart rate is lower on the exercise by listening to the music compared with exercise without music.

Based on the findings and conclusions can be suggested, that the stress of sport should be managed well, using the groove music accompaniment in accordance with the intensity of exercise. It is also to promote the spirit of exercise in improving health and fitness, and achievement.
REFERENCES


Bernard L, Porta C, Sleight P, 2006. Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians; The importance of silence.


Larsen Pd, Galletly. 2007. The Sound of Silence is Music to the Heart: The underlying tempo of different types of music may have an effect on heart rate and blood pressure. Heart 92 :433-434 (akses 18 September 2008)

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Nugroho A, 2006. Anda Pilih Musik Mana? Pikiran Rayat, Minggu 12 Februari


Sugiharto, 2006 A. The effect of aerobic exercise on the erythrocyte osmotic fragility of the wistar white rats. Vol 42 no 3 Juli-September ISSN 0303-793


Yamamoto T; Ohkuwa T; Itoh H; Terasawa J; Tsuda S, 2003. Effect of pre-exercise listening to slow music and fast rhythm music on supramaximal cycle Performance and Selected Metabolic variables. Archives of physiology and Biochemistry, Volume 111, issue 2.