

# The Effect of Listening to Brain Waves' Relaxing and Exciting Music during Intense Endurance Training on Blood Cortisol Levels of Adult Men

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**Abstract Objectives:** Listening to music during exercise could be used to counteract reduced immune function in endurance athletes. The aim of this study was to determine the effect of listening to music, with relaxing and stimulating effect on the brain waves, during intense endurance exercise on blood cortisol levels of adult men. **Methods:** In this study, eight healthy men (n=8) with mean age of (23.25±1.83 years) were asked to perform four different protocols in a crossover design, after pre-test determination of their cortisol levels. Protocols included: intense endurance training (control) (A), intense endurance training with relaxing music (B), intense endurance training with exciting music (C), and intense endurance training with music stimulating their brain waves in four non-consecutive days (D). Their post-test cortisol levels were determined. To analyze data, the statistical tests ANOVA R.M and LSD were used. **Results:** A significant increase was observed in cortisol levels in protocols A and B, compared to pre-test (P≤0.05). While changes of the other two protocols, C and D, were not significant. (P>0.05). **Conclusion:** The findings show that listening to exciting music and music stimulating brain waves counteracts cortisol rise during intense endurance exercise.

**Keywords:** hypothalamic-pituitary-adrenal axis, immune system, vitality, stress

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## 1. Introduction

Studying the correlation of music and medicine is rapidly growing. Previously, music as a complementary therapy was the focus of many researches. It has been shown that music has a positive effect on variables such as stress, relaxation, pain, neurological cognition, cardiac function, etc. [1-5]. Recently, attention has been driven to understanding the physiologic mechanisms related to the effect and role of music on metabolic responses. Research has proven the regulatory effect of music on Hypothalamic-Pituitary-Adrenal axis (HPA), Sympathetic Nervous System (SNS), and the immune system; all of which with key functions in the regulation of metabolism and energy balance. New findings have also shown the role of music in metabolic recovery from stress, increasing lipid metabolism, and lactic acid elimination after physical activity.

Recent studies focus on a deeper understanding of the impact of music on complex human stress response by the HPA, SNS, and immune system. HPA axis activity is monitored by measuring the serum level of cortisol, adrenocorticotropic hormone, growth hormone (GH), insulin-like growth factor, and oxytocin. Cortisol is

released from adrenal glands in response to adrenocorticotropic hormone, an anterior pituitary gland hormone. Cortisol initiates metabolic response by stimulating gluconeogenesis, both general and hepatic. It also suppresses the immune system secondary to the negative feedback of cytokine production. Increased catabolic state through metabolism of proteins, fats, and carbohydrates in muscle, fat tissue, connective tissue, and lymphatic tissue is another effect of this hormone. Thus, the HPA axis plays an important role in the regulation of metabolic responses and balance of energy.

Several studies have shown the role of music in reducing cortisol levels in surgical environments. Patients who had listened to music after surgery had significantly reduced cortisol levels, compared to control group (patients without music exposure) [6,7,8]. In a study by Nilsson et al [8], patients who received postoperative music therapy revealed 206 mmol per liter reduction of cortisol levels after two hours in intensive care unit, while the reduction in the control group was 72 mmol per liter. Similarly, Lord and his colleagues reported decrease in cortisol levels in patients receiving music before and after surgery. A significant reduction was observed in post-surgical cortisol levels of patients who were able to choose their music type. Koolesh and colleagues [9] demonstrated that patients who listened to music during

surgery had lower cortisol levels than patients who received no such intervention. In another study, performed to determine the relaxing effect of peaceful music after stressful work, salivary cortisol ceased to increase in the group who listened to music, while its' increment continued for 30 minutes in the control group [10]. Hajizadeh and colleagues [11] found that cortisol levels in a group of patients who had music intervention during surgery did not increase, unlike the other groups. Foucault and Yamashita [12] also concluded that regardless of the gender differences, listening to music for thirty minutes reduces levels of cortisol in saliva.

Endurance training leads to cortisol secretion, which can reduce the number and function of white blood cells [13]. Stressful situations such as intense training, long training sessions, attending athletic competitions, low carbohydrate food intake, and carbohydrate deprivation during training, or lack of adequate sleep are all factors that can increase cortisol levels [14]. Cortisol affects the late leukocytosis (neutrophilia) induced by physical activity [15,16]. Neutrophilia is often caused by increased neutrophil release from bone marrow [17,18] also reduced neutrophil outflow from the blood, however, some believe that release of the attached leukocytes is considered the most important mechanism of neutrophilia induced by glucocorticoids [19]. During short-term exercise activity, if the intensity exceeds 60 to 70% of maximal oxygen uptake, concentrations of plasma cortisol increase [15,20], while intensities lower than 50% of maximal oxygen uptake decrease cortisol concentrations [20]. Long-term activity, also, increases cortisol concentrations, as it increases gluconeogenesis and maintains blood glucose concentrations.

Intense athletic activities reduce the innate immune cell function and increases secretion of cortisol. Physiological concentration of cortisol improves the immune system function, while high physiological concentrations suppress the immune system. Intravenous administration of a small amount of cortisol decreases lymphocytes by inhibiting the entry of lymphocytes to the blood and facilitates the movement of lymphocytes into the tissue [21]. Long-term exercise increases plasma cortisol levels and depletes neutrophil storage of the bone marrow. The individual uses bone marrow neutrophil storage during endurance training faster than a normal person, thus neutropenia is common in endurance athletes.

Due to the influence of music on reducing levels of the blood's cortisol and also increase of this hormone during long-term and intense exercises and its harmful effects on reducing the number of bone marrow's neutrophils and immune system suppression, it is theoretically expressed whether music can reduce the stress on the immune system during long-term and intense activity by reducing plasma levels of cortisol.

Stressful situations, physically and mentally, lead to high plasma concentrations of cortisol with suppressive effect of this hormone on immune system. On the other hand it has been shown that music could balance the incremental elevation of plasma cortisol level, theoretically counteracting its' detrimental effect on the immune system in athletes. In this study we tried to prove this theory while trying to understand whether different kinds of music had the same effect or not.

## 2. Materials and Methods

The current study is a developmental quasi-experimental cross design study. Researchers have compared changes of independent variables on the dependent variables in post-test stage of four groups of physical activity (control), physical activity with relaxing music (relaxing), physical activity with exciting music (exciting), physical activity with music stimulating brain waves (brain wave exciting).

After preliminary studies, sampling, determining the intervention group, determining and providing research data collection tool, a sample of eight students of Khwarizmi Sports University of Karaj entered the study. Subjects characteristics are presented in Table 1.

Table 1. characteristics of subject's (N=8)

Statistics	mean	SD	maximum	Minimum
age	23/25	1/83	26	21
height	179/5	7/03	190	170
weight	75/25	6/36	92	71

Participants were advised to sleep six to eight hours the night before the test exercise. In addition, they were asked to drink plenty of liquids 24 hours before the test exercise and avoid eating, smoking, and taking caffeine three hours before the exercise. Required trainings for the test exercise were explained to them. Then, before the exercise protocol (exercise protocol is described below), blood samples were taken from volunteers to determine their pre-test cortisol levels and all participants underwent four intense endurance training protocols in non-consecutive days as following: control group, physical activity with relaxing music, physical activity with exciting music, and physical activity with music stimulating brain waves and their blood samples were taken after each exercise protocol. The interval of each exercise was one week. All participants were meanwhile released from daily pressures and stress by 15 minutes listening to Brain Refresher music before the exercise protocol. Subjects listened to music for 15 minutes before the test also during exercise the music was played continuously.

The Repeated High-Intensity Endurance Test (RHiet) test was used as the training protocol; the executive model includes eight cones placed in two rows of fours with two meters distance between each two four-rows and five meters distance between each cone in rows of four. Each participant started test with the "start" command, ran and returned the first five meters from cone A to B and then again from cone A to C, which is ten meters, and finally, from cone A to D, which is 15 meters. They ran a total distance of 60 meters (two five meters, two ten meters, plus two fifteen meters) in 30 seconds. Each participant must complete the test six times without break in a period of 30 seconds that ultimately makes the total test time 180 seconds (three minutes). If any participant ran sooner than 30 seconds during the test, he should wait and begin the next stage after 30 seconds. The test is repeated with the total time of three minutes several times. The time in each repetition of the test: 30 seconds, the distance in each repetition of the test: 60 meters, the time period of each test: 180 seconds (6 repetitions of 30 seconds), the rest time between each period of the test (rest time between

each three minutes of physical activity): 30 seconds, the total number of test periods at one training session (work-rest): 43 repetitions of each test period with rest intervals of 30 seconds, and the total time of one training session: 2.5 hours.

## 2.1. Blood Sampling

Before the training protocol and after 12 hours of fasting, 5 mL blood was taken from the right antecubital vein of each subject in the sitting position and at rest to determine the baseline cortisol level. After activity, another blood sample was taken to evaluate cortisol level. Blood was centrifuged for 10 minutes at 3000 rpm and the serum was separated. The isolated blood serum samples were kept in the freezer at  $-80^{\circ}\text{C}$ . ELISA kits (Biospes Company, China) were used to measure cortisol level.

## 2.2. Statistical Methods

To analyze the data, descriptive and inferential statistical methods were used. Descriptive statistics was used for mean, standard deviation, distribution, graphs, and tables and for testing research hypotheses, analysis of variance with repeated measure (ANOVA R.M) was used. As each of the four groups underwent all four training types in non-consecutive days, according to the crossover type of study, there was no need to synchronize the groups. But normal distribution of data was evaluated through

Kolmogorov-Smirnov test and as data distribution was normal, parametric tests were used. Decision measurement about all of the variables was within the alpha level of five hundredths ( $P < 0.05$ ). To draw charts, Excel 2013 Software and to calculate mean, standard deviation, and repeated measurements of variance SPSS 21 was used.

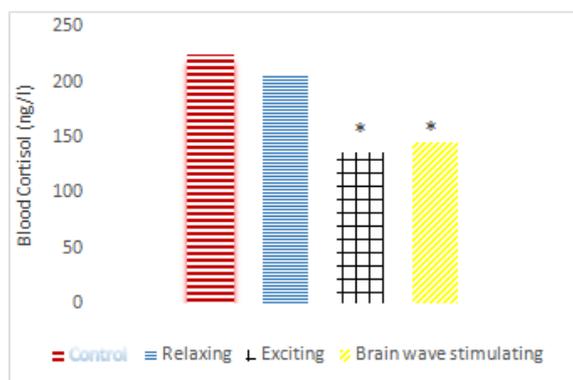
## 3. Results

The inter-group results showed that the exciting music group (during physical activity) and brain waves stimulating music group (during physical activity) revealed no statistically significant change in cortisol compared to pre-activity ( $P < 0.05$ ), but relaxing music group (during physical activity) and control group (only physical activity) had increased cortisol level (Figure 1). The between-groups results are shown in Table 2, demonstrating significant difference in cortisol levels between exciting music group (during physical activity) and brain waves stimulating music (during physical activity), compared to relaxing music group (during physical activity) and control group (only physical activity) ( $P < 0.05$ ) and these two groups had no increased cortisol levels than pre-activity, compared with relaxing music (during physical activity) and control group (during physical activity). For the coupled comparison of mean variables, LSD test was used. Table 2 presents the results of the statistical analysis.

**Table 2. Coupled comparison of mean differences of blood cortisol levels in different groups**

Between-group comparison	Inferential statistics	Differences in means	Standard deviation	P value
relaxing music group (during physical activity)		18/708	19/275	0/364
Control group (only physical activity)	exciting music group (during physical activity)	88/528	14/474	0/016★
	brain waves stimulating music (during physical activity)	80/474	15/279	0/027★
relaxing music group (during physical activity)	exciting music group (during physical activity)	69/820	23/160	0/02★
	brain waves stimulating music (during physical activity)	61/766	13/146	0/036★
exciting music group (during physical activity)	brain waves stimulating music (during physical activity)	8/054	15/251	0/614

★: Significant difference between groups by coupled comparison ( $p < 0.05$ ).



**Figure 1.** Between-group comparison of blood cortisol levels' variation

\*: No change in cortisol amount, compared to pre-activity in the exciting music group and brain waves stimulating music, compared to control and relaxing music groups ( $p < 0.05$ ).

## 4. Discussion and Conclusion

The results of the current study represent a huge increase in blood cortisol levels after exercise in the control group (those who did not listen to any music) and

relaxing music group (the group listening to relaxing music during intense endurance exercise), while less increase was observed in the groups listening to exciting music and brain waves stimulating music, compared to control and relaxing groups. Also, the increase in blood cortisol concentrations after intense endurance training was insignificant in exciting music and brain waves stimulating music groups, which indicates minor increase in cortisol levels than pre-test values. While, significant difference was observed between cortisol levels of control and relaxing music groups than pre-test values. Although the participants had listened to music during intense endurance training in three groups, exciting music and brain waves stimulating music were more effective in preventing severe increase in blood cortisol after intense endurance training. Unfortunately, there is no similar research on the effects of music on blood cortisol levels during intense endurance training available, but in other areas of research (medicine, psychology, and neurology) some researches have been conducted with different training protocol, research methods, and statistical analysis. Despite the differences mentioned, we outline some studies conducted.

Gra and colleagues (1998) found that listening to relaxing music reduces blood levels of cortisol, while

exciting music increases it [22], also, the study of Yamamoto et al. (2007) showed that listening to relaxing music after being placed in stressful conditions decreases blood cortisol concentrations [23]. The results of the current study, against Graand Yamamoto, showed significant decrease in cortisol levels immediately after intense endurance training in the group who had listened to exciting music during exercise, compared to those who had listened to relaxing music. Also Koolesh et al (2011) and Field et al (1998) reported that listening to music, regardless of the selected music tempo (fast or slow), reduces blood levels of cortisol [24,25]. Also Hajizadeh et al (2012) concluded in their study on three groups of patients: a) headset with music, b) headset without music, and c) without intervention that listening to music reduces the levels of cortisol and blood sugar after surgery [11]. Oddo et al (2003) also concluded in their study that listening to music causes less increase in cortisol levels, compared to the state of without music [26]. In the present study, also, listening to exciting and stimulating music during intense endurance training led to less increase in cortisol concentrations than the control and relaxing music groups immediately after exercise; this difference might be due to the different effectiveness of music types on the nervous system and hypothalamic-pituitary-adrenal axis adjustment that reduces cortisol secretion during intense endurance training.

Secretion of cortisol can be adjusted through rest, nutrition, music, and training supplements. 32 studies have examined the effect of music on hormones. Among these, 29 studies measured the amount of cortisol. Among these studies, 18 studied the effects of music on the reduction in cortisol, either actively or by recorded music. Only two studies had opposite trends, but in both studies cortisol increased less in the music group than in the control group. Ascher and colleagues (1993) found that this pattern of cortisol reflect ACTH secretion levels, reduced in the music group than the control group. When the researchers chose music for the participants, studies including cortisol have focused on the effects of relaxing music (n=11). But four studies that have assessed the effects of stimulating music have obtained different results. Movakkel and colleagues (1995) found similar decline by relaxing and stimulating music. While Yamamoto et al (2007) observed a decrease in cortisol only by relaxing music [23]. Also, Gra and colleagues (1998) observed increased cortisol only with stimulating music [22]. These results reveal the noticeable sensitivity of this hormone to stimulating music. Another variable is only assessed in .Leardi et al's study (2007), in which patients' cortisol level was investigated against the music selected by participants, which showed the maximum cortisol response to music selected by participants [6]. However, since this study only examined this variable with cortisol, more studies are needed to confirm these findings [6]. Of other hormones tested, Nilsson (2009) showed increased oxytocin, when participants were listening to relaxing music recordings [27]. Bateman (2001) showed increase in the proportion of dehydroepiandrosterone ratio to cortisol when participants had participated in the drama group [28], while Conrad et al (2007) have shown reducing cortisol levels with increasing growth hormone when the participants had listened to the recorded relaxing music. [29]. When participants listened to their

own recorded music, Migneault (2004) showed increase in testosterone levels in men and decrease in women and insignificant changes in four other biological markers evaluated in this study, including cortisol, ACTH, epinephrine, and norepinephrine [30]. Generally, no research has studied the effect of music during intense endurance training on blood cortisol levels.

In conclusion, the current study showed that listening to exciting music and music with stimulating effect on brain waves during intense endurance training, in comparison to relaxing music or no music exposure during the same activity, can prevent blood cortisol level elevation in relation to the pretest situation. Due to the negative effects of high cortisol concentration on immune system, bone marrow storage, and other negative effects of cortisol in intense endurance training, listening to music with stimulating effect during exercise can reduce the negative effects of cortisol on the body. This effect has not been shown to appear with relaxing music.

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