PHYSICAL EDUCATION OF STUDENTS

The effect of an exhaustive aerobic, anaerobic and resistance exercise on serotonin, beta-endorphin and BDNF in students

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

Abstract

Purpose: Sport exercises play a major role in many hormonal factors which related to happiness in human. Therefore, the short-term effects of three anaerobic, aerobic and resistance exercises on (BDNF) and hormones related to happiness such as serotonin and beta-endorphin has been studied in young men in this research.

Material: Thirty-two students (19 to 25 years old) who did not have regular physical activity were randomly divided into four groups, after the subjects were eaten the same breakfast, the blood of them were taken before and after the various short aerobic exercises (Exhaustive exercise with 70% of maximum heart rate) and anaerobic (Exhaustive exercise with maximum intensity) and exhaustive resistance exercise (with 8 stations). Control group did not practice any activity. Specific kits and ELISA method have been used to determine their values. Data were analyzed using ANOVAand ANCOVA method at a significant level of 5%.

Results: Beta-endorphins showed a significant increase in resistance and aerobic training sessions compared to control group. However, serotonin and BDNF had a significant intra-group change in the aerobic group.

Conclusions: It seems that aerobic exercises are the best practice for increasing some of the hormones associated with happiness.

Keywords: BDNF, Beta-endorphin, Serotonin, Aerobic Exercise, Anaerobic Exercise, Resistance Exercise.

Introduction

Sport is one of the most prevalent conditions for challenging the human physiological systems. A more contemporary label which has been often applied to these exercises induced changes, is the "runner's high." The runner's high has been described subjectively as pure happiness, elation, a feeling of unity with one's self and/or nature, endless peacefulness, inner harmony, boundless energy, and a reduction in pain sensation [1]. Up to date, Brain-Derived Neurotrophic Factor (BDNF), a member of the neurotrophin family which is promoting neuronal survival and proliferation, has been described as one of the best potential candidate molecules that plays a role in exercise-induced antidepressant effects [2]. In general, this neurotrophic factor has been found in the brain and peripheral nerves and it plays an important role in protection and production of neurons [3]. Sport activity has been shown to increase the secretion of BDNF in protein and mRNA levels of a Mice hippocampus and it provides evidence to claim that sport activity has a potential to increase neurotrophins in humans [4]. There is contradictory information about the impact of endurance and strength of training on BDNF values. Probably, these three training methods can affect the synthesis and BDNF release. However, it is not clear that this system will respond to the anaerobic and circuit strength exercises. Besides, no research has yet investigated the effects of various training methods on this system during a training period.

Serotonin or 5-hydroxytryptamine is a monoamine neurotransmitter that plays a significant role in regulating the neuro-hormonal system, modifying the mood, appetite, joy, sleep, physiological activities, and effective cognitive activities in learning and memory [5]. Serotonin has been synthesized in an enzyme pathway from the tryptophan amino acid. This mediator has been also known as the hormone of happiness. The density of tryptophan in the brain and hence the synthesis rate of 5-hydroxytryptophan depends on the density of free tryptophan in plasma and the density of large non-polar amino acids that pass through the blood to the brain via transfer mechanisms that are similar to tryptophan [6]. The results of various studies have showed that aerobic exercises such as jogging, running, cycling and swimming seemed to affect serotonin secretion in humans significantly [7]. The exact mechanism of this function is still unclear, but it is clear that aerobic exercise has been improved individuals' mood as a result of increase in serotonin level [7]. Information on acute changes at serotonin levels is still unclear because of exercising. [8]. Researches on strength training suggest that there is no change in serotonin levels in most cases [9, 10]. The level of serotonin depends on the intensity and duration of the exercise, the exercise protocol and the elapsed time after the last training session that samples were taken [11]. Endorphins or hormones of happiness have been released in every physical activity; endorphin is secreted by the anterior pituitary gland in response to exercise; physical and psychological stress [12]. The most important of all hormones related to happiness that is beta-endorphin and it is released in the blood. Beta-endorphin has been released from hypothalamic neurons in the spinal cord and brain, and from the pituitary gland. The behavioral effect of beta-endorphin has been determined by brain growth function and possibly by hypothalamic neurons, which are the largest source of beta-endorphin [12]. Various research results show that different aerobic, anaerobic, and strength training will result in serum beta-endorphins increase [13, 14]. Various studies have shown that beta-endorphin responds differently to the intensity of exercises and it depends on the various features of both aspects, i.e. individuals (e.g., health status, preparation level), and type of exercise [15]. Researches on exercise training and its effect on endorphin density

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have contradictory results. Therefore a research that has been conducted on various types of training programs and their effects on endorphin density in plasma can provide valuable information to the researchers.

The results of most short-term studies of beta-endorphins show that higher-intensity exercises have been increased the amount of β-endorphin in proportion to pre-exercise state, the results of this type of research on serotonin levels appear to be influenced by the training program and the results are different according to training method, and regarding BDNF the results are contradictory that is mostly related to training method and the specimens. Therefore, further research is needed to investigate the features of hormone responses which are related to happiness, such as serotonin, beta-endorphin, and BDNF, in relation to the physical activity, and especially in relation to relevant and important factors such as duration and intensity of the physical activity, type of the activity, gender, and weight of the participated specimens in the study that can have a significant effect on research results. Therefore, the purpose of this study is to evaluate the short-term effects of three anaerobic, aerobic and strength training methods on serotonin, beta-endogenous and BDNF hormones in young men.

Material and Methods

Participants.

The study population included boy students aged 19-25 in Babol who did not regularly participate in sports activities. 32 of the participants were volunteers. The inclusion criteria were age range of 19-25, the willingness to participate in the study, no smoking, no use of notorious or mood enhancing supplements, physical and mental health and no diseases in specimens' medical history. Exclusion criteria were non-compliance with the training protocol and inability to collect the information sought by the researchers.

Research Design.

The present research is semi-experimental. The research and methodology and possible dangers during the training were described to the specimens in one session, and then the informed consent was taken from all the specimens. All ethical principles were followed during the training process; code of ethics for this study was obtained from Sabzevar University of Medical Sciences under the following number (IR.MEDSAB.REC.1395.127); specimens randomly divided into four groups of aerobic, anaerobic, strength training and control groups. The height, weight and the fat percentage of the specimens were collected in the first session. One hour after having breakfast, that was identical for all (included juice and breakfast cake with 250 cal), all specimens according to the classified groups performed in a training session (anaerobic, aerobic, or strength training). 5Cc of blood were taken in two phases of before and after short-term activity from the cephalic vein of the right arm in the resting position, then immediately poured into the test tubes that contained EDTA (anti-coagulation agent) and centrifuged for 3 minutes at 10,000rpmand the isolated plasma was stored at -20° C till the variables were measured.

Each set consists of 30, 60 and 90 meters running, respectively.

Statistical Analysis.

Analyzes of serotonin, β-endorphin and BDNF hormone densities were measured by ELISA method. To measure β-endorphin, serotonin and BDNF, plasma density ELISA was used; it is produced by EASTBIOPHARM Company in China, with a sensitivity of 2.59ng/l, 1.22ng/ml, and 0.01ng/ml. Finally, all data were analyzed using SPSS software version 20. Shapiro-Wilk test was used to determine the normality of the data. After assuring the data were normal, ANCOVA, ANOVA and dependent t-test were used to compare the data. Alpha is assumed 0.05.

Results

According to the Shapiro-Wilk test, it was found that all variables data in the research groups are of normal distribution. Table 4 shows the anthropometric characteristics of the subjects. One session of anaerobic exercise, aerobic exercise and strength training had no significant effect on serotonin and plasma BDNF levels in proportion to the control group and there was no

Table 1. Aerobic exercise program for one session

Type of exercise	Intensity(Maximum heart rate)	Time sets	Rest between sets	Number of sets
Running	70% HR max	3 minutes	1 minutes	Until exhaustion

Table 2. Anaerobic exercise program for one session

Type of exercise	Intensity	Practical Distances(m)	Rest between sets	Number of sets
Running	Maximum	30,60,90	30 s to 1 min	Until exhaustion

Table 3. A strength circuit training program for one session

Type of exercise	Number of stations	Number of repetitions	Rest between stations	Number of sets
Resistance	8	8-12	1 to 2 min	Until exhaustion

significant difference between the groups in this regard. However, one aerobic exercise session has significantly increased plasma beta-endorphin in proportion to control group. One anaerobic exercise session had no significant effect on the same index. Nevertheless, intra-group changes were significant in this group. In the aerobic group, a significant change was observed in serotonin and BDNF level in pre-exercise group (Table5).

Discussion

One session of anaerobic, aerobic and strength training had no significant effect on serotonin and plasma BDNF and there was no significant difference between the groups in this regard. However, one session of aerobic exercise has significantly increased plasma beta-endorphin in proportion to the control group, while one session of anaerobic exercise did not apply the same effect in proportion to the control group. Nevertheless aerobic exercises led to a significant increase in intra-group serotonin and BDNF compared to the pre-exercise state.

In the present study, one session of aerobic and strength training has significantly increased plasma beta-endorphin in proportion to control group; while one anaerobic exercise session had no significant effect on the same index. In various studies that have investigated the effect of short-term strength training on beta-endorphin, it was observed that these exercises led to an increase in the serum beta-endorphin levels [13, 14] that is consistent with the same study results. Variation in beta-endorphin levels during strength training may be related to the exercise protocol (intensity, repetition, and breaks between the sets) [13].

Multiple research results have showed that various short-term aerobic exercises by professional and amateur individuals with an intensity of 90-60% of maximum oxygen would result in a significant increase in the plasma beta-endorphins levels [16] that are consistent with aerobic exercise results that are in the present study. The beta-endorphin secretion depends on the intensity and volume of both aerobic and anaerobic exercise [17]. In the present study, the intensity of exercise was at maximum but since the duration of the exercise was optional and depended on the physical capacity of the individuals until exhaustion, therefore, they did not finish the exercise at the same time. On the other hand, Bandar et al. (2007) have stated that duration of the exercise has been more effective in beta-endorphin secretion than intensity of the exercise [18], consistent with Bandar et al., since in the present study, anaerobic exercises were performed at maximum intensity, they were done in shorter time frame than aerobic exercises; and on the contrary, since aerobic exercises were done with less intensity, they were performed in longer time frame than anaerobic exercises. Therefore, these anaerobic exercises did not increase β-endorphins. De Luigi et al. (2003) have showed that

Table 4. Anthropometric characteristics of subjects

Group/Parameter	Height (cm)	Age (year)	Fat Body percentage	Weight(Kg)
Control group	181.12±2.79	21±1.19	20.51±6.81	78.87±11.88
Anaerobic group	182.12±7.92	21.12±1.72	17.62±7.14	72.88±20.27
Aerobic group	179±7.17	20.27±1.4	15.64±6.04	68.25±12.89
Resistance group	180±11.2	20.12±1.55	22.67±6.15	85.11±22.29
P	0.88	0.48	0.1	0.2

Table 5. Statistics related to the happiness mediators

Parameter	Group	Before Exercises	After Exercises	P of Intergroup	P of Out of group
Serotonin (ng/ml)	Control group	82.48±7.21	86.84±15.81	0.46	0.26
	Anaerobic group	83.14±21.67	95.74±28.53	0.28	
	Aerobic group	64.43±14.24	78.09±24.07	0.03	
	Resistance group	61.06±23.92	70.22±23.47	0.16	
Beta-Endorphin (ng/L)	Control group	141.08±67.86	142.08±77.86	0.29	0.03
	Anaerobic group	157.47±91.50	175.47±91.50	0.27	
	Aerobic group	195.66±104.5	237.81±105.54	0.007	
	Resistance group	245.26±99.31	276.39±103.21	0.008	
BDNF (ng/ml)	Control group	1.25±0.39	1.24±0.35	0.88	0.63
	Anaerobic group	1.08±0.31	1.53±0.95	0.26	
	Aerobic group	1.23±0.15	1.38±0.31	0.001	
	Resistance group	0.97±0.52	1.17±0.44	0.21	

an anaerobic exercise session on 18 male athletes did not increase serum beta-endorphin level [19], and it is consistent with the same study results. Octdalen et al. (2001) have stated that physical activity causes acidosis and as a result reduces blood PH in the body. This will activate the hypothalamus-pituitary axis and will result in the secretion of corticoliberin. Corticoliberin has been directly poured from the hypothalamus into the pituitary gland and corticotrophin and ACTH have been released by the pituitary. The beta-endorphin secretion from the anterior pituitary is associated with ACTH secretion, thereby increasing the production and secretion of β-endorphins from the pituitary [20]. Moreover, by binding to receptors, beta-endorphin keeps potassium channels open and calcium channels close, that leading to hypoglycemia, and this phenomenon provides the conditions for beta-endorphin production [21].On the other hand, the physical activity in hypoxic condition increases beta-endorphin secretion [22].

The present study has showed that three training groups during one sedation session could not result in a significant increase in serotonin level compared to the control group; although aerobic exercises will led to significant intra-group changes. Zhao et al. (2015) have showed that aerobic exercise with an intensity of 65-70% of maximum heart rate did not significantly increase serotonin [23] that is consistent with the results of the same study. Shaykh al-Islam and Salavati (2011) in a study on young men have showed that accession of acute strength training with a small-to-large muscle training protocol led to a significant increase in serotonin, that is not consistent with the present study results; however, the large-to-small training protocol did not result in a significant increase in serotonin that is consistent with the present study results [24]. In the present study, one movement has been considered for the upper trunk and one movement for the lower trunk, respectively. Sharifi et al. (2012) have showed that a training session with Bruce instructions up to fatigue limit resulted in a significant increase in serotonin levels immediately after exercise that is not consistent with the results of the present study [7]. To justify the differences, we can assert that serotonin levels depend on the exercise intensity, duration, protocol, and the elapsed time after the last training session that samples have been taken [11]. As stated, in this study, the plasma levels of BDNF has been increased after three training methods but that was not significant in any of the groups compared to the control group, although there was a significant intra-group difference which has been observed in aerobic exercises. Curie et al. (2010) in a study on 16 young men have showed that strength training session did not significantly change plasma BDNF density; he suggested that the type of exercise program could be a determinant factor of BDNF change in blood circulation [25]. Of course, the results are consistent with the same study results. Several studies that examined short-term moderate-intensity training have showed that this type of exercise will led to an increase in instability in serum BDNF levels that does not have significant implications [26], and it is consistent with the results of the present study. Different results of studies that examine the effect of training can be attributed to the type, duration, and intensity of the training [25]. Peko et al. (2014) have observed that epinephrine has been increased in endurance exercises and intense periodic training; however, epinephrine increase is retained for one hour after endurance, while the same was not observed in the periodic training group. Regarding the maintenance of epinephrine increase for an hour after endurance exercise and cortisol increase in response to severe periodic training, it can be argued that endurance exercises is more proper to increase BDNF than intense periodic training. [27]. BDNF levels are expected to increase regarding the use of muscles in strength training to produce maximum force. [25]. This viewpoint has been supported by reports that BDNF expression is increased in response to skeletal muscle contraction. [28]. It has been suggested that the sources of BDNF are the neurons between the skeletal muscles [25].On the other hand, Matthias et al. (2009) have showed that although BDNF is produced by muscle, it cannot be transmitted to the bloodstream [29]. It seems in strength training, this is one of the main reasons for the absence of significant increase. On the other hand, Hinen et al. (2015) have argued that BDNF levels were adjusted during aerobic exercise by age, gender, and genetics [30] that could justify these differences in aerobic exercise.

Conclusions

The results of this study have been shown that the increase of internal factors leads to euphoria and feeling of happiness in human beings that seems to be different according to the type of exercise. Factors such as beta-endorphin have been significantly increased after acute strength training and aerobic exercise sessions, while serotonin and BDNF did not significantly increase. Aerobic exercises seem to be the best type of exercise in increasing some hormones which are relevant to joy. With aerobic, anaerobic, and strength training, you can increase joy with respect to the duration and intensity of the exercise but this behavior is not influenced by some hormones alone and many factors affect this behavior.

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Ethical Approval

All ethical principles were observed during the training process. Code of ethics for this study was obtained from Sabzevar University of Medical Sciences under the following number of IR.MEDSAB.REC.1395.127.

Conflict of Interests

No conflicts of interest have been stated by the authors.

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