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β-endorphin response to aerobic and anaerobic exercises in Wistar male rats

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ABSTRACT

BACKGROUND Physical exercise is strongly associated with the release of β-endorphin. It is assumed that the type and intensity of physical exercise contributes to the release of β-endorphin. This study aimed to compare levels of β-endorphin in brain tissue in response to aerobic and anaerobic physical exercise.

METHODS This study was an experimental laboratory study using 35 male Wistar rats divided into one control group and two physical exercise treatment groups: aerobic and anaerobic. Physical exercise was conducted on an animal treadmill running at a speed of 20 m/min for 30 min of aerobic exercise and 35 m/min with 1-min intervals every 5 min for 20 min for anaerobic exercises. Each aerobic and anaerobic exercise group was furtherly classified into three subgroups (1×/week, 3×/week, and 7×/week). β-endorphin levels were determined using enzyme-linked immunosorbent assay. The data were analyzed using independent *t*-test and one-way analysis of variance.

RESULTS The highest mean of β-endorphin level was found in the weekly exercise (54.45 [1.41] pg/ml) of aerobic exercise group and daily exercise (70.50 [11.67] pg/ml) of anaerobic exercise group. Mean of β-endorphin level in control group was 33.34 (3.54) pg/ml. A significant increased of β-endorphin mean level ($p<0.001$) was found in all aerobic and anaerobic exercise groups except the aerobic exercise 7×/week group (37.37 [6.30] pg/ml) compared to control.

CONCLUSIONS Both aerobic and anaerobic physical exercise conducted for 6 weeks could increase the level of β-endorphin in brain tissue.

KEYWORDS aerobic exercise, anaerobic exercise, β-endorphin

Apart from improving heart and lung health, physical exercise can also increase a cognitive function[1] and influence the reward system in the brain.[2] In addition, mediated by various signals, physical exercise can increase immune system functions[3] and improve mood.[4] This is highly correlated with the release of β-endorphin during physical exercise. The increased plasma β-endorphin levels after physical exercise can strengthen the immune system.[5]

β-endorphin is released from the anterior pituitary gland in response to psychological conditions and somatic stress.[6] Athletes' psychological stress prior to competition triggers β-endorphin release. During physical exercise, psychological and physical stress synergistically increase β-endorphin that plays a primary role as an analgesic.[6,7] β-endorphin also inhibits the transmission of pain signals and induces euphoria. The high affinity between β-endorphin and µ-opioid receptors causes analgesic effects in brain reward pathways.[8] It is thought that β-endorphin also plays a role in "runner's high," a feeling of euphoria during or after heavy physical exercise.[9] Different type of exercise, e.g. a session of aerobic and strength training has significantly increased plasma β-endorphin.[10]

Rats have been used to answer many hypotheses in exercise physiology including physical performance because they adequately mimic human responses to exercise in term of blood biochemical examinations. The physiological responses resemblance in rat and human blood after exercise indicates that the research involving rats for exercise physiology is justified.[11] Many studies have been conducted to investigate the correlation between physical exercise and endorphin release and their correlation to analgesic effect and euphoria.[8] Clinical studies have also been done to determine the levels of endorphin before, during, and after physical exercise, though the results are still debatable. In those studies, some researchers found significant increases in endorphin levels, while others did not. This inconsistency occurs due to different references for defining the types of physical exercise.[7,9] This study aimed to compare the levels of β-endorphin in brain tissues stemming from aerobic and anaerobic physical exercise.

METHODS

The current study was conducted in the Bioscience Research Laboratory, Palembang, in April 2017, and received its ethics approval from the Health Research Review Committee, Faculty of Medicine, Universitas Sriwijaya (No. 56/kepkrsmhfkunsri/2017).

Subjects

The sample in this study was 35 Wistar male rats, 6–8 weeks old, weighing 80–100 g, divided randomly into seven groups, i.e., control group (no physical exercise), three groups with aerobic physical exercise (1×/week, 3×/week, and 7×/week), and three groups with anaerobic physical exercise (1×/week, 3×/week, and 7×/week). The subjects were treated with physical exercises on a treadmill for 6 weeks. Since the research was conducted for 6 weeks, to avoid drop-out samples (leg injury, electric shock, and rats getting too lazy to run on the treadmill), we added two more rats to each aerobic and anaerobic group. Thus, the total sample was 49 male rats. However, during experiment there were 9 rats that experienced leg injury and 5 rats that experienced electric shock, thus for the data analysis we still analyzed 35 samples (5 samples for each seven groups) that did not experience leg injury and electric shock. Based on the habits of rats to be more active at night, physical exercise activities were carried out at night. Before the treatment, the animals were acclimated for 2 weeks to adapt them to the research environment and treadmill.

Procedures

Physical exercise was conducted by placing the rats on an animal treadmill running at a speed of 20 m/min for 30 min for aerobic physical exercise, and 35 m/min for 20 min, with 1-min intervals every five min for anaerobic physical exercise. Before and after running on a treadmill, the body weights of the animals were taken. The physical exercise treatments were adapted from a study by Flora et al.[12] In the 6th week, immediately after physical exercises, the rats were decapitated and the brain tissues were collected from all groups.

Preparation of homogenate and determination of endorphin levels

After brain tissues were collected, the homogenate was prepared using a homogenizer. The procedure was adapted from a study by Flora et al.[13] The level of endorphin in brain tissue was determined using Rat β-EP (Beta-Endorphin) ELISA Kit (Elabscience Ltd, China).

Data analysis

The data were presented in mean and standard deviation. Differences of mean endorphin levels between control and treatment groups were analyzed with independent *t*-tests. Meanwhile, differences of mean endorphin levels between the control group, aerobic group, and anaerobic group were analyzed with one-way analysis of variance. $p<0.05$ was considered significant.

RESULTS

After the 6-week treatment, it was found that the mean body weights increased in all groups. However, the increased weights of the control group were found to be higher than those given aerobic and anaerobic physical exercises (Table 1).

The brain tissue β-endorphin levels in rats treated with physical exercise revealed that both β-endorphin level in aerobic and anaerobic groups (Figure 1) were

Table 1. Rats' body weight before and after 6 weeks (N = 35)

Group		BW before, mean (SD) (g)	BW after, mean (SD) (g)	Δ BW (g)
Control		77.3 (10.29)	175.5 (22.06)	98.1
Aerobic exercise	1×/week	103 (20.64)	175.3 (11.98)	72.2
	3×/week	97.2 (8.81)	179.5 (24.48)	82.3
	7×/week	80.2 (11.51)	171.0 (19.39)	90.8
Anaerobic exercise	1×/week	86.5 (22.85)	167.7 (10.76)	81.1
	3×/week	93.3 (12.30)	183.9 (27.87)	90.4
	7×/week	82.1 (12.84)	168.5 (25.59)	86.4

BW=body weight; SD=standard deviation

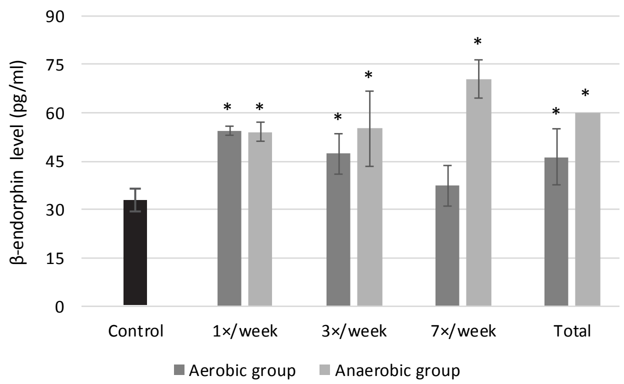

Figure 1. Mean level of β-endorphin in brain tissue in aerobic and anaerobic group. *$p<0.001$ compared to control

higher compared to the control group. In subjects having aerobic exercise, the greatest increase was found in the 1×/week exercise. Meanwhile, in anaerobic physical exercise, the highest increase was found in subjects which had exercise 7×/week. There were increases of β-endorphin level in brain tissues in all types of physical exercises compared with control ($p<0.001$), except in aerobic physical exercise 7×/week ($p = 0.25$).

DISCUSSION

This study shows the brain tissue endorphin levels in Wistar rats given either aerobic or anaerobic physical exercise were higher than control. This supports that physical exercise, both aerobic and anaerobic, caused physical stress leading to increase of endorphin level in brain tissue. Several previous studies have also proved that physical exercise can increase β-endorphin levels.[14] β-endorphin was involved in response to pain relief and stress suppression in animal testing.[15] Furthermore, it is known that endorphins can also produce addictive behavior to physical exercise.[16] Endorphin is a substance in human and certain animal bodies that is involved in regulating stress, relieving pain, improving immunity, inhibiting the aging process, controlling appetite, lowering blood pressure, and inducing a reward system in brain and mood.[17]

According to Fuss et al,[15] during physical exercise our bodies will release β-endorphin that affects both brain and body. After physical exercise, the body will experience fitness and comfort, which is indicated by the increase of alpha and theta waves contributing to positive psychological impacts such as calm, comfort, relaxation, and decreased stress. These positive responses pass through the hypothalamic–pituitary–adrenal axis pathway that stimulates hypothalamus and locus coeruleus. The hypothalamus decreases the secretion of corticotropin-releasing hormone causing decreased levels of adrenocorticotropic hormone (ACTH) and stimulation of endorphin and proopiomelanocortin production, which also decreases the level of ACTH.[17]

The results of this study showed that the mean increase level of β-endorphin in daily anaerobic physical exercise conducted was higher than that in the aerobic and control groups. This significant increase occurred because the physical exercises were both, high-intensity and done daily. β-endorphin production is needed to overcome the pain caused by exercise. Some studies have shown that β-endorphin will not increase if the exercise intensity is 60% of maximal oxygen consumption (VO_2 max) or lower.[16,17] The results of this study were similar to Sharifi et al,[10] which showed a significant increase of β-endorphin not only while performing activities resistance (exhaustive resistance exercise) but also aerobic training sessions (exhaustive exercise with 70% of maximum heart rate). The duration of exercise also has a big impact on the release of β-endorphin. Short-intensity workouts (sprinting or weightlifting) and prolonged, continuous exercise (running, long-range swimming, aerobics, cycling, or cross-country skiing) appears to contribute to endorphins production and release. β-endorphin levels have been significantly increased after acute strength training and aerobic exercise.[18]

High-intensity physical exercise for 30–60 min is sufficient to raise the level of plasma β-endorphin. The elevated β-endorphin level raises subjects' feelings of euphoria and insensitivity to pain.[10] Increased secretion of endorphin in heavy physical exercise will not only provide analgesic effects but also improve mood. β-endorphin compounds formed of proopiocortin play a role in controlling pain perception endogenously so that it functions as a strong analgesic for several hours. The analgesic potential of this compound is 18–30 times stronger than morphine.[19]

This study's result also reveal that physical exercise can increase β-endorphin levels. Sinaei et al[20] was also found that the β-endorphin level was positively correlated with the intensity and duration of exercises. Serum β-endorphin level was higher in swimmers than runners, moreover an acute exercise session was significantly increased serum β-endorphin levels in sprint swimmers and runners.

A study by Amin et al[21] which aimed to evaluate the effects of physical exercise on plasma β-endorphin levels in patients with migraine showed that physical exercise served beneficial effects on all migraine parameters (frequency, duration, and intensity of attacks; $p<0.001$). Hence, regular exercise may have a prophylactic effect on migraine frequency. β-endorphin level was inversely correlated with frequency, duration, and the intensity of migraine attacks in subjects who performed regular exercise. The levels of β-endorphin in migraine patients were also found to be lower than those in patients without migraines. Furthermore, β-endorphin levels in patients with chronic migraines were found to be very low. However, physical exercise results in an increased β-endorphin levels.

Aerobic physical exercise can release β-endorphin, a neuron chemical substance causing relaxed effect, support total alertness, and decreased symptoms of depression. Saanijoki et al[22] stated that opioid functions during physical exercise can be reached by observing the changes of β-endorphin level. The levels of β-endorphin are influenced by intensity and duration of physical exercise.

From this present study, both aerobic and anaerobic physical exercise can increase the level of β-endorphin in brain tissues of Wistar male rats. The high-intensity physical exercise affects the amount of increase in endorphin levels. The intensity of physical activities affects its release. The highest increase of β-endorphin was found in the group performing daily anaerobic physical exercise because the anaerobic physical exercise was high-intensity. High-intensity exercise is related to mechanisms of antinociception and stress relief. An acute bout of high-intensity interval training induces greater physiological,[23] emotional stress, and pain than aerobic exercise.[2] Higher levels of β-endorphin are required to inhibit pain during physical exercise and to produce euphoria. A study on opioid receptors and pharmacological interventions for killing pain in animals demonstrated that β-endorphin is involved in analgesic responses and mood changes.[15]

There are some limitations to this study, such as not all rats are capable of finishing 6 weeks programs of physical activity, especially when performed 7×/week. Injuries to legs and tail, age, and body weight influenced their abilities to run on the treadmill. Also, some rats tend to be lazier or reluctant to perform physical activities as they age. Thus, a large number of rats were needed to replace drop-out subjects and to repeat the study protocols. Consequently, the finishing times of each group were different.

In conclusion, physical exercise, both aerobic and anaerobic, can increase the level of β-endorphin in brain tissues of male Wistar rats. The intensity of physical activity affects the release of β-endorphin.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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