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Effect of 8 weeks moderate intensity aerobic exercise on brain derived neurotrophic factor (BDNF) in female athletes

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Abstract

Introduction: The effects of exercise training on serum BDNF is still unclear, thus the purpose of this study was to examine the effects of 8 weeks moderate intensity aerobic exercise on serum BDNF levels in female athletes.

Material & Methods: Twenty female karate athletics were randomly assigned to one of the exercise group (n=10) or control group (n=10). The training group performed endurance training 3 days a week for 8 weeks at an intensity corresponding to 50-60% individual maximum oxygen consumption for 45 min.

Results: Body mass and BMI increased ($P<0.05$) after 8 weeks aerobic exercise compared to the control group. For WHR, body fat percentage and maximal oxygen consumption there were no significant differences between the exercise group and the control group. There were

virtually no changes in body fat percentage, fasting glucose, insulin, insulin resistance and BDNF levels after 8 weeks training.

Conclusions: Serum BDNF level was not affected by 8-week moderate intensity aerobic exercise in female athletes.

Key words: BDNF, Aerobic exercise, Female athletes, Insulin resistance

1. Introduction

Metabolic syndrome, a clustering of cardiovascular risks, is associated with cardiovascular events and increased mortality (1,2). Because of the high prevalence, metabolic syndrome has become a heavy burden on global health (3,4). Obesity in turn is considered to represent the core pathogenesis of metabolic syndrome (5). Several meta-analysis studies have reported that obesity was associated with a higher risk of cardiovascular death than normal weight in the metabolically healthy population. Furthermore, metabolic syndrome was shown to contribute an additional risk of cardiovascular events in subjects with obesity categorized based on body mass index (BMI) (6). Therefore, both BMI and metabolic syndrome should be considered for the assessment of cardiovascular risks (7). Weight reduction was found to result in an improvement of cardiovascular risks among subjects with obesity following short-term intervention of less than 1 year (8). However, the effect of weight reduction on the central nervous system remains controversial.

Brain-derived neurotrophic factor (BDNF) is a neuronal growth factor that plays a regulatory role in neuronal differentiation, synaptic plasticity, and apoptosis (9). BDNF is also associated with energy homeostasis (10). It has been reported that high fasting serum BDNF concentrations were observed in women with obesity (11). Furthermore, circulating BDNF also positively correlated with the risk factors of metabolic syndrome (12). On the other hand, BDNF affects glucose metabolism and possibly insulin sensitivity. BDNF reduces serum glucose, insulin, and HbA1c levels when injected into diabetic rats,

possibly improving insulin sensitivity (13). However, there are inconsistent findings on BDNF and glucose metabolism interactions in humans: individuals with type 2 diabetes had decreased plasma BDNF, independent of obesity (14), while others reported increased serum BDNF in type 2 diabetes patients, associated with obesity (15).

Exercise has been shown to have beneficial effects on obesity, type 2 diabetes, and the metabolic syndrome. Several studies exploring the effects of exercise on circulating BDNF levels have resulted inconsistent findings. Circulating BDNF not affected (16), or increased (17) in response to exercise. Study results showed that BDNF level associated with obesity profiles (11) and insulin resistance (15), thus we hypothesized that exercise training would reduce the adipose tissue, insulin resistance and regulates BDNF concentrations; therefore, we investigated the effects of 8 weeks of moderate aerobic exercise on body composition, insulin resistance and BDNF concentrations in female athletes.

2. Materials and methods

Subjects

Twenty female karate athletics (24.3 ± 4.8 years; mean ± SD) participated in this study. All the subjects were asked to complete a personal health and medical history questionnaire, which served as a screening tool. The subjects were given both verbal and written instructions outlining the experimental procedure, and written informed consent was obtained. Our participants were nonsmokers and none of them had any disease. All the subjects completed the 3-day diet recall forms and were instructed to maintain their normal physical activity and dietary habits throughout the study. The subjects were randomly assigned to one of the exercise group (n=10) or control group (n=10). The study was approved by the Islamic Azad University, Fars Science & Research branch Ethics Committee.

Exercise training

The 8 weeks exercise training program included 3 running sessions per week. The intensity of exercise was customized for each subject based on the relationship between heart rate and oxygen uptake measured at baseline. During the 8 weeks intervention, the subjects were trained for 45 min per session at a heart rate corresponding to 50-60% of the maximal oxygen uptake measured at baseline. Each participant wore a heart rate monitor (Beurer, PM70, Germany) to ensure accuracy of the exercise level. Subjects performed the exercise training besides their karate training of team.

Measurements

Anthropometric and body composition measurements

Height and body mass were measured, and body mass index (BMI) was calculated by dividing body mass (kg) by height (m^2). Waist circumference was determined by obtaining the minimum circumference (narrowest part of the torso, above the umbilicus) and the maximum hip circumference while standing with their heels together. The waist to hip ratio (WHR) was calculated by dividing waist (cm) by hip circumference (cm). Body fat percentage was assessed by skinfold thickness protocol. Skinfold thickness was measured sequentially, in triceps, suprailiac, and thigh by the same investigator using a skinfold caliper (Harpenden, HSK-BI, British Indicators, West Sussex, UK) and a standard technique (18).

Measurement of VO_{2max}

VO_{2max} was determined by Rockport One-Mile Fitness Walking Test. In this test, an individual walked 1 mile as fast as possible on a track surface. Total time was recorded and HR was obtained in the final minute. VO_{2max} was calculated using formula (18).

Biochemical analyses

Fasted, resting morning blood samples (10 ml) were taken at the same time before and after 8 weeks intervention. For menstrual status, all the participants were menstruating regularly and defined as eumenorrheic

(28- to 32-day menstrual cycles during the previous year); all testing was performed during the follicular phase of the menstrual cycle. All the subjects fasted at least for 12 hours and a fasting blood sample was obtained by venipuncture. Serum obtained was frozen at -22 ^{oC} for subsequent analysis. The serum BDNF level was measured in duplicate using an enzyme-linked immunosorbent assay (ELISA) kits (Casabio Biotech Co. LTD.; China). The sensitivity of kit was 0.08 ng/ml. Serum glucose was determined by the enzymatic (GOD-PAP, Giucose Oxidase-Amino Antipyrine) colorimetric method (Pars Azmoun, Tehran, Iran). The intra and inter-assay coefficients of variation for glucose were $<$1.3% and a sensitivity of 5 mg/dl. The serum insulin level was measured by a electrochemiluminescence immunoassay (ECLIA) and the insulin resistance index was calculated according to the homeostasis model assessment (HOMA-IR) which correlates well with the euglycemic hyperinsulinemic clamp in people with diabetes (19).

Statistical analysis

Results were expressed as the mean ± SD and distributions of all variables were assessed for normality. Independent sample t-test, Paired t-test and Mann-whitney U test were used to compute mean (±SD) changes in the variables in control and training group pre- and after the intervention and between the groups. The level of significance in all statistical analyses was set at $P \leq 0.05$. Data analyses were performed using SPSS software for windows (version 17, SPSS, Inc., Chicago, IL).

3. Results

Physical and physiological characteristics of the subjects at baseline and after training are presented in Table 1. Before the intervention, there were no significant differences in any of variables among the two groups. Body mass and BMI increased ($P<0.05$) after 8 weeks aerobic exercise compared to the control group. For WHR, body fat percentage and maximal oxygen consumption there were no significant difference between the exercise group and the control group.

Table 1. Anthropometric and metabolic characteristics (mean ± SD) of the subjects before and after training

	Control (mean±SD)		Training (mean±SD)	
	Pretraining	Posttraining	Pretraining	Posttraining
Body mass (Kg)	57.8 ± 8.4	57.9 ± 8.4.0	55.1 ± 9.1	57.4 ± 9.1*†
BMI (Kg/m)	21.4 ± 3.0	21.4 ± 3.0	21.3 ± 2.8	22.2 ± 2.6*†
Body fat (%)	17.3 ± 5	17.8 ± 5.2	18.6 ± 3.3	19.0 ± 3.0
WHR	0.74 ± 0.05	0.75 ± 0.05	0.73 ± 0.04	0.7 ± 0.03
VO_{2max} $(ml.Kg^{-1}.min^{-1}$ $))$	47.7 ± 3.5	47.9 ± 3.4	47.5 ± 3.8	48.2 ± 2.8

*:P<0.05 for between-group differences.
†:P<0.05, pretraining *vs.* posttraining values.

The results on BDNF, fasting glucose, fasting insulin and HOMA-IR before and after the intervention are presented in Table 2. Mann-whitney U test and Independent sample t-test indicated that BDNF, fasting glucose, fasting insulin and HOMA-IR did not change in the exercise training compared with the control group.

Table 2. Biochemical characteristics (mean ± SD) of the subjects before and after training

	Control (mean±SD)		Training (mean±SD)	
	Pretraining	Posttraining	Pretraining	Posttraining
FBS (mg/dL)	90.3 ± 8.8	85.8 ± 8.5	89.1 ± 2.7	84.6 ± 7.9
Insulin (μU/mL)	8 ± 2.9	9.6 ± 4	10.2 ± 4.1	10.1 ± 2.3
HOMA-IR	1.7 ± 0.5	1.9 ± 0.7	2.2 ± 0.9	2 ± 0.5
BDNF (ng/mL)	5.3 ± 4.5	4.5 ± 4.0	2.9 ± 1.4	3.2 ± 1.5

4. Discussion

BDNF is a member of the neurotrophin family expressed in many areas of the adult mammalian brain. The effects of exercise training on serum BDNF is still unclear. The purpose of this study was to examine the effects of 8 weeks moderate aerobic exercise on serum BDNF levels in female athletes. Our results showed that BDNF levels at baseline were lower in female athletes (median 4.1 ng/mL) than in type 2 diabetic, obese and healthy subjects. Fujinami et al. (2008) demonstrated median levels of plasma BDNF concentrations in the type 2 diabetic patients (median 15.5 ng/mL), and healthy subjects (median 20.0 ng/mL) (20).

Lee et al. (2016) reported serum BDNF levels were significantly lower in obese people compared to control subjects (40.4 ± 7.8 ng/mL *vs.* 43.0 ± 6.1 ng/mL) (21).

The present results demonstrate that moderate intensity aerobic exercise does not induce significant alterations in serum BDNF concentrations in female athletes, however, previous reports that showed elevated blood BDNF after moderate (aerobic) and intense exercise (22,23). These discrepant results may be attributed to some mechanisms. At the first, Lee et al. (2016) showed that the BDNF decreased following body-weight reduction in subjects with obesity and metabolic syndrome. The BDNF level was associated with the reduced percentage of body weight, independent from the baseline BDNF level (21). Our results showed that body weight and body fat percentage did not significant change after 8 weeks exercise, thus it seems that the lack of effect of exercise training on BDNF in the present study might be due to the absence of reductions in body weight and body fat percentage.

Secondary, a previous study found that serum BDNF was associated with fasting insulin and HOMAIR in type 2 diabetes (12). Krabbe et al. reported that plasma BDNF was inversely associated with HOMA-IR but not insulin (13). Boyuk et al. (2014) also reported that serum BDNF levels showed a positive correlation with HOMA-IR in type 2 diabetes (24). In our study, there was virtually no change in fasting glucose and insulin and HOMA-IR after 8 weeks training.

On the other hand, the degree of physical effort during the exercise protocol may be important for altering blood BDNF levels. In humans, the BDNF response to exercise differs depending on the type and intensity of exercise. At the end, the differences in subject populations may be attributed in these discrepant results.

5. Conclusion

BDNF level associated with obesity profiles and insulin resistance, thus we examined if exercise training would reduce the body fat and insulin resistance and regulates BDNF concentrations. Our results showed that serum BDNF levels were not affected by 8 weeks moderate intensity

aerobic exercise in female athletes. Additional research is needed to examine our hypothesized.

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