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Original Article

The impact of exercise training on basal BDNF in athletic adolescents

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Abstract. [Purpose] The purpose of this study was to investigate the impact of exercise training on basal brain-derived neurotrophic factor in athletic adolescents. [Subjects and Methods] Twenty-two male adolescents participated in this study. The subjects were divided into a control group (n=9) and trained group (n=13). The trained group comprised table tennis athletes with more than 3 years of training who regularly exercised 18 hours per week. [Results] The results of this study show the trained group had significantly lower basal brain-derived neurotrophic factor levels than the control group. Further, platelet levels were significantly higher in the trained group than in the control group. However, no significant differences were observed between the groups in serum nerve growth factor level or physical characteristics (body weight, body mass index, fasting blood glucose). [Conclusion] This study showed that the basal brain-derived neurotrophic factor level of well-trained athletic adolescents was lower than that of the control group. Further research with a larger sample size is required to confirm the finding that lower basal brain-derived neurotrophic factor levels are associated with long-term habitual exercise in athletic adolescents.

Key words: BDNF, NGF, Adolescent

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INTRODUCTION

Multiple studies investigating the effects of acute or regular exercise on changes in neurotrophins brain-derived neurotrophic factor (BDNF), nerve growth factor (NGF), insulin-like growth factor-1 (IGF-1), vascular endothelial growth factor (VEGF), etc. have been recently conducted. Central BDNF exerts a positive influence on neurogenesis, neurodegeneration, and hippocampal neural plasticity, all of which help promote memory and learning[1)]. In addition, BDNF is the primary neurotrophic factor in the brain, and is involved in the neural activities of the central and peripheral nervous systems; therefore, the BDNF level can exert a significant effect on human neural physiology. During learning and memory, higher-order thinking requires hippocampal activation; the cortex, cerebellum, and basal forebrain are also activated. These regions play an important role in long-term memory formation[2)]. Lower resting levels of BDNF are observed in patients with obesity, Alzheimer's disease[3)], Parkinson's disease, Huntington's disease[4)], and depression[5)], and a study of elderly women suggested that plasma BDNF is a biological marker of general cognitive function and memory impairment[6)].

In addition to the association of low resting BDNF levels with these diseases, some studies have suggested that lower resting BDNF levels are found in well-trained athletes[7, 8)], or in people who have habitually trained for a long time[9)]. These studies attracted our interest. Our research differs considerably from previous research because our target group was adolescents, and adolescence is an important period of growth and development. The subjects of previous studies who showed lower BDNF levels were well-trained adults between 20 and 50 years of age, and our present findings appear to confirm these previous adult findings in an adolescent population.

Although recent research has suggested there is an effect of exercise on neurotrophic factors, the claim that regular training

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and long-term exercising alters the basal BDNF level remains controversial. It is important to study basal BDNF levels during the critical development period of adolescence. Thus, the purpose of this study was to investigate the impact of exercise training on basal BDNF in athletic adolescents.

SUBJECTS AND METHODS

Twenty-two adolescents participated in this study. They were assigned to either the control group (CG, n=9) or the trained group (TG, n=13). All the participants were male and between the ages of 14 and 18 years. The TG was comprised of elite table tennis athletes who had participated in a regular exercise program for an average of 18 hours per week for more than 3 years. Subjects in the CG had not participated in any regular exercise program for more than 1 year. The CG was age-matched to the TG.

All subjects underwent a medical examination performed by a medical specialist before inclusion in the study. The study conformed to the principles of the latest revision of the Declaration of Helsinki, and all subjects read and signed a written informed consent statement consistent with the guidelines of the Department of Taekwondo at Youngsan University. In addition, signed consent forms were obtained from the guardians of all the participants before their participation in the study.

Physical characteristics [height, weight, and body mass index (BMI)] were measured using a height/weight analyzer (Venus 5.5, Jawon Medical, Gyeongsan, Korea). Blood samples were drawn from a forearm vein after a 12-hour fast. The samples were centrifuged at 3,000 rpm for 10 minutes and stored at −80 °C until analysis. To avoid changes in parameters induced by continuous training, the TG did not train or compete for at least 24 hours before blood sampling.

Serum NGF was measured biochemically with an enzyme-linked immunosorbent assay for the quantitative detection of human NGF (Abcam, Cambridge, MA, USA). Serum NGF was quantified using polyclonal antibodies recognizing native human NGF in wells coated with predetermined amounts of recombinant human NGF.

Serum BDNF levels were analyzed with an R&D system (Minneapolis, MN, USA) kit using a Sino Biological kit (Sino Biological Inc., Beijing, China). First, the antibody was incubated overnight and washed 3 times. Next, the samples and standard were reacted with the detection antibody. Then, substrate solution and streptavidin-HRP were added. The reaction was terminated with a stop solution, and the results were obtained by measuring the optical density at 450 nm.

Fasting blood glucose (FBG), white blood cells (WBC), red blood cells (RBC), hemoglobin (Hb), hematocrit (Hct), platelets, total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG) were determined using enzymatic methods.

For all data, means and standard deviations were calculated using SPSS for Windows version 14.0 (SPSS, Chicago, IL, USA). Data are shown as means ± standard deviations. Comparisons between CG and TG were performed using the unpaired Student's t-test. Statistical significance was accepted for values of $\alpha \leq 0.05$.

RESULTS

Subject characteristics are presented in Table 1. There were no significant differences in age, height, weight, BMI, FBG, TC, TG, HDL-C, LDL-C, WBC, RBC, Hb, or Hct between the two groups. However, platelets were significantly different between the CG and TG ($254.4 \pm 36.8\ 10^3/\mu l$ vs. $301.5 \pm 58.9\ 10^3/\mu l$, $p<0.05$).

Table 2 shows that TG had a significantly lower serum BDNF level than CG (17.7 ± 3.2 ng/ml vs. 20.9 ± 4.0 ng/ml, $p<0.05$). However, the serum NGF level was not significantly different between the CG and the TG (5.0 ± 2.2 ng/ml vs. 6.7 ± 2.8 ng/ml).

DISCUSSION

This study examined the influence of long-term, regular training on basal BDNF levels in adolescents. The basal BDNF level increases during acute exercise[10–12], suggesting it would increase with long-term aerobic training[13–15]. However, basal BDNF in athletes appears to be reduced by habitual exercising and training[7, 8, 13]. Contrary to this finding, some trained subjects in another study had particularly high basal levels of BDNF, but this was not discussed by the researchers[16]. In the present study, the well-trained group was initially expected to have high levels of basal BDNF, but, in contrast, the well-trained group had lower levels of basal BDNF. Nofuji et al.[7] suggested two potential explanations for lower BDNF levels in well-trained athletes: that an increase in BDNF release from platelets is responsible for the repair of damaged tissue; and that BDNF production is not necessary in a well-trained group.

The first hypothesizes is based on the fact that more than 90% of blood BDNF proteins is stored in platelets and then released through platelet activation or during the clotting process[17, 18]. Exercise causes functional stress and muscle damage[19]. Since most athletes do a lot of high-intensity training, damaged tissue must be continuously repaired, and BDNF would play a role in this process of recovery from injury and trauma[20]. Our present results support this hypothesis as the TG had significantly higher platelet levels than the CG. Referring to the literature, it was found that previous general exercise research had sufficiently predictable results. Our research was limited in that the level of BDNF in platelets was not measured, and future research measuring platelet BDNF levels is required to support this hypothesis.

Table 1. Characteristics of the subjects

Variable	Control (n=9)	Trained (n=13)
Age (years)	16.3 ± 1.1	15.3 ± 1.4
Height (cm)	172.4 ± 4.1	169.2 ± 5.2
Weight (kg)	67.2 ± 14.4	58.9 ± 6.0
BMI (kg/m^2)	22.5 ± 4.1	20.5 ± 1.8
Glucose (mg/dl)	89.6 ± 13.0	81.1 ± 6.3
TC (mg/dl)	152.4 ± 20.3	146.2 ± 21.9
HDL-C (mg/dl)	53.5 ± 9.5	56.1 ± 8.7
LDL-C (mg/dl)	92.8 ± 18.3	86.3 ± 17.7
TG (mg/dl)	55.2 ± 30.4	72.5 ± 45.8
WBC (10^3/μl)	6.0 ± 0.9	6.1 ± 1.8
RBC (10^3/μl)	5.1 ± 0.2	5.2 ± 0.2
HB (10^3/μl)	15.3 ± 0.9	15.2 ± 1.0
Hct (%)	44.2 ± 2.4	45.0 ± 2.6
Platelet (10^3/μl)	254.4 ± 36.8	301.5 ± 58.9*

Means ± SD.
*Significant difference ($p<0.05$) between the control and trained groups

Table 2. Comparison of basal serum BDNF and NGF

Variable	Control (n=9)	Trained (n=13)
BDNF (ng/ml)	20.9 ± 4.0	17.7 ± 3.2*
NGF (ng/ml)	5.0 ± 2.2	6.7 ± 2.8

Means ± SD.
*Significant difference ($p<0.05$) between the control and trained groups

The second hypothesizes involves the role of BDNF in food intake, weight control, appetite suppression[21, 22], and increased glucose and lipid metabolism[23]. Well-trained groups require little BDNF for the regulation of food intake and energy balance[7]. The reduction in serum BDNF may reflect an exercise training adaptation of decreased BDNF synthesis and/or increased consumption by the central nervous system, and this also requires further investigation[8] and should be a point of focus. According to Babadi et al.[8], one bout of aerobic and anaerobic exercise increased BDNF immediately after exercise in both control and well-trained groups. However, in the well-trained group, the increase in BDNF was relatively small, because the generation of BDNF would not be necessary in the well-trained group. It is our opinion that this second hypothesis is also correct. Currie et al.[9] observed reduced basal BDNF levels in a physically active group along with greater BDNF uptake and efficiency in the central nervous system. Altogether, the evidence from the literature indicates lower levels of basal BDNF in well-trained groups[7–9], and inverse correlations between BDNF and energy consumption/VO_{2max}[8, 9], and between BDNF and better intermediate-term memory[8], it is evident that regular physical activity is associated with lower basal BDNF levels. Similar to previous research[7–9], a difference was observed in basal BDNF levels in the present study: TG had significantly reduced levels of BDNF compared to CG. However, the present study provided limited evidence to clarify the responsible mechanisms for lower BDNF in well-trained athletes. In order to study these mechanisms, future studies involving measurement of BDNF in athletes and long-term exercisers, as well as measurement of BDNF levels in platelets will be necessary. These future studies should include larger numbers of participants to enhance their statistical power.

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