Increased basal plasma brain-derived neurotrophic factor levels in sprint runners

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Abstract: Objective Exercise is known to enhance circulating brain-derived neurotrophic factor (BDNF) levels in healthy humans. BDNF changes have been measured in endurance but not in strength exercise. The present study aimed to investigate whether anaerobic activity such as sprinting differentially alters basal plasma BDNF concentration. **Methods** Brazilian sprinters (100 m) at either the international (Olympics and Outdoor World Championships) ($n = 14$) or the domestic level ($n = 8$), and sedentary subjects ($n = 15$), were recruited. Plasma BDNF concentrations were analyzed by enzyme-linked immunosorbent assay. **Results** The basal plasma BDNF concentrations were significantly higher in the international and the domestic sprinters than in the sedentary subjects. In addition, sprinters at the international level had higher plasma BDNF concentrations than those at the domestic level. **Conclusion** Our findings suggest that increased basal plasma BDNF level is related to enhanced exercise performance.

Keywords: brain-derived neurotrophic factor; physical exercise; sprint; plasma; brain; human

1 Introduction

Brain-derived neurotrophic factor (BDNF) plays important roles in neurons by promoting and improving plasticity, retarding cell death, inducing regeneration, and stimulating survival^[1]. BDNF is produced and secreted within the central nervous system and peripherally^[2] by vascular endothelial cells^[3], skeletal muscle cells^[4], smooth muscle cells^[4] and immune cells^[5]. Since BDNF crosses the blood-brain barrier in both directions, it is thought

that circulating BDNF is transported into the brain and contributes to homeostasis^[6]. BDNF synthesis is centrally mediated and activity-dependent, and it has been suggested that physical exercise activates various systems by which BDNF influences energy metabolism and neural plasticity^[7].

Although it is well-known that exercise increases BDNF transcription in the brain^[8], recent findings have reported that physical exercise, mostly aerobic endurance exercise, enhances circulating BDNF levels in healthy humans^[9–16]. Interestingly, neither high-intensity strength exercise^[17] nor general strength training^[25] induces any significant changes in BDNF levels. An elegant review has compared the effects of high-intensity exercise and/

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or training on BDNF in healthy subjects with the effects in subjects with chronic diseases^[7]. Since the release of BDNF is influenced by aerobic training, which increases the release at rest^[16,18], increased circulating BDNF may depend on the level of physical exertion as well as fitness. In a study by Zoladz and collaborators^[18] employing a group of athletes competing in various athletic events (sprinters, jumpers, and distance runners), the basal BDNF levels were compared between trained and untrained subjects. The basal plasma BDNF level in athletes was significantly higher than that in untrained subjects, suggesting that the elevation in plasma BDNF level can be attributed to the training status. However, anaerobic activities, which consist of repeated brief efforts, impose different physiological demands compared with prolonged aerobic activities. Sprint sports (short-distance running events) are characterized by coordination, speed, strength/power, flexibility and reaction time, and reflect physiological capabilities that differ from those required for longer-distance events. In this regard, there is no information on whether specific sporting disciplines differentially alter circulating BDNF levels. Investigation of this issue can reveal whether the exercise-induced increase in BDNF is limited to aerobic and strength activities (low to high intensity), and thus provide additional information to characterize training status or athletes' performance levels. Therefore, we set out to analyze the basal plasma BDNF concentrations in sprinters competing at the domestic and the international levels.

2 Materials and methods

2.1 Subjects Twenty-two young Brazilian sprinters competing at the domestic ($n = 8$; 4 males and 4 females) or the international level (Olympics and Outdoor World Championships) ($n = 14$; 8 males and 6 females) and 15 sedentary control subjects ($n = 15$; 9 males and 6 females) were recruited. None of the control participants had previously been involved in regular physical activities. From among the sprint events currently held at the Olympics and Outdoor World Championships, 100-m sprinters were selected for this study. The sprinters in the international category had participated in the Olympics and Outdoor World

Championships over the last 4 years, while the sprinters at the domestic level were those restricted to regional events but with a similar period of training (approximately 4–8 years). All participants were informed about the aim of the study and received a detailed written description of the experiment and the potential discomforts, risks and procedures used in the investigation. All the recruited volunteers were in good health and free of any physical condition that might place them at risk while participating in this study. The study was approved by the Ethics Committee of the Universidade Federal de São Paulo and all subjects signed an informed consent document.

2.2 Measurement of BDNF Blood samples (5 mL) from fasting subjects at rest were taken from an antecubital vein into plasma venipuncture tubes at 07:30–08:00. Samples were centrifuged at 3 000 rpm for 10 min at 4 °C and stored in Eppendorf tubes at –70 °C until analysis. Plasma BDNF concentrations were analyzed by enzyme immunoassay using enzyme-linked immunosorbent assay (ELISA) kits (Millipore; Temecula, CA, USA) according to the manufacturer's instructions. Samples were analyzed in duplicate and the mean concentration was calculated.

2.3 Statistical analysis Statistical analysis was performed using SPSS (SPSS Inc.; Chicago, IL, USA). Normality of data was checked using Shapiro Wilk and heterogeneity of variance. One-way analysis of variance (ANOVA) followed by Tukey *post hoc* tests was used for comparison of the 3 groups. $P < 0.05$ indicated statistical significance. Data of BDNF levels were presented as mean $\pm$ SEM.

3 Results

There were no statistical differences in age, height or weight among the groups (Table 1). The basal plasma BDNF

Table 1. Age, height, and weight of the 3 groups (mean $\pm$ SD)

	International	Domestic	Sedentary
Age (years)	25.6 $\pm$ 5.8	24.2 $\pm$ 4.1	26.2 $\pm$ 3.8
Height (cm)	176.5 $\pm$ 7.6	177.2 $\pm$ 6.1	173.5 $\pm$ 6.6
Weight (kg)	79.9 $\pm$ 13.9	78.6 $\pm$ 11.8	80.9 $\pm$ 6.6

concentrations in the international and the domestic sprinters were both higher than those in sedentary subjects ($P < 0.05$). In addition, the mean basal BDNF value in sprinters at the international level was higher than that in the domestic-level sprinters [$F(2.32) = 24,694$; $P < 0.05$] (Fig. 1).

Fig. 1 Basal plasma brain-derived neurotrophic factor (BDNF) concentrations in the 3 groups. Differences were found between the sprinters and the sedentary subjects and between the international and the domestic sprinters. Data were expressed as mean $\pm$ SEM. * $P < 0.05$.

4 Discussion

A growing body of evidence shows that physical exercise increases the circulating BDNF concentrations in healthy humans^[9–11]. Changes in circulating BDNF level after endurance exercise have been reported^[16]. The novel finding of the present study was that short-distance running events such as sprinting particularly enhanced basal plasma BDNF concentrations in humans. To our knowledge, few studies have explored the effect of sprint activities alone on blood BDNF level. Recently, Winter *et al.*^[19] reported that short-duration and high-intensity running (2 runs to exhaustion, lasting 3 min each, with a 2-min break) leads to a significant increase in plasma BDNF concentration in healthy men. In a subsequent study, Zoladz and collaborators^[18] reported higher basal plasma BDNF concentrations in athletes than in untrained subjects. Nevertheless, the comparison was made based on athletes from different events, i.e. sprinters, jumpers and distance runners. Other studies on this topic (which did not include experimental intervention protocols) have reported lower concentrations of blood BDNF at rest in trained than in untrained

subjects. For example, using a questionnaire, Chan *et al.* found lower serum BDNF levels in subjects with more than 30 times of 30-min exercise per month, who were not elite athletes, than in subjects with no exercise or with 1–30 times of 30-min exercise per month^[20]. In another investigation revealing decreased serum BDNF levels in trained men, the ‘trained’ group which included 7 distance runners, one sprinter, 3 tennis players and one badminton player^[21], was not matched for mode or volume of training, and it is essential to determine the exercise parameters (i.e. intensity, duration and mode) that are necessary to induce an increase in blood BDNF concentration.

The effects of other short-duration intensive exercise, e.g. strength training, on circulating BDNF concentration have been investigated. In a study by Goekint *et al.*^[15], a period of strength training in sedentary subjects did not significantly change the concentration of growth factor compared to the control group. Another study reported that the resting concentration of BDNF was not influenced by strength training in young subjects^[14]. Maximal speed and strength are known to be important determinants of sprint performance^[22,23]. Concentric and eccentric muscle strength are correlated with sprint performance because they reflect sprinting in both the duration and the application of force. However, although strength is one feature of sprint athletes, other factors may contribute to BDNF changes. For instance, our findings may be attributed to the specific physiological characteristics found in sprint activities. We have to take into account that sprinters may also engage in some aerobic training. In fact, aerobic metabolism may play a more active role in sprint-based events than previously thought. This is true especially in the 200- and 400-m sprint events. For instance, a study of elite sprinters has suggested that aerobic energy sources account for 29% of energy in 200-m and 43% in 400-m races^[24]. Nevertheless, here we evaluated only 100-m sprinters, so this component had less impact. Therefore, the differences in BDNF values between strength- and sprint-trained subjects may be partly due to the specific form of training. Heavy resistance exercise used in previous studies^[14,15] was not combined with explosive types of weight training or speed

and reaction time exercise. Besides these specific characteristics, we also have to consider the nature of the highly competitive athletes employed in our study in comparison with the sedentary healthy subjects participating in exercise training programs.

The limitations of this study should be considered when interpreting the results. Although the sample size was relatively small, significant differences were found among groups. However, with a larger sample size, a correlation between duration of participation in specific athletic events and BDNF level could have been established. Although Brazilian subjects participating in athletic events have a similar socioeconomic status, cognitive tests may be included to find whether there is an association between BDNF values and cognitive performance. This can be of particular relevance in the light of the role of BDNF in learning and memory.

In sum, we suggest that increased basal plasma BDNF concentration may be related to enhanced exercise performance^[25]. This may also apply to other sports modalities. However, the results must be interpreted with care as we consider the alactic component of anaerobic exercise. It remains to be determined whether basal BDNF concentrations differ among highly competitive athletes from different disciplines.

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短跑运动员血浆中脑源性神经营养因子水平较普通人群显著升高

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摘要: 目的 目前研究发现锻炼能增强健康人血液中脑源性神经营养因子(BDNF)的水平。BDNF水平的改变常发现于耐力运动而非力量锻炼。本研究旨在探讨厌氧型活动(如短跑)是否能改变人血浆中BDNF的浓度。**方法** 对22名巴西100米短跑运动员, 包括14名过去4年间参加过国际级奥林匹克及户外世锦赛的运动员(国际级)和8名只参加过本国比赛的运动员(国内级), 以及15名此前从未参加过任何运动比赛的健康对照人群, 用ELISA法检测其血浆中BDNF的水平。**结果** 与对照组相比, 国际级和国内级短跑运动员血浆中BDNF的水平均显著升高。此外, 国际级短跑运动员血浆中BDNF的水平显著高于国内级运动员。**结论** 血浆中BDNF水平的升高可能与运动加强有关。

关键词: 脑源性神经营养因子; 体育运动; 短跑; 血浆; 大脑; 人类