Response of circulating adrenocorticotropic, beta-endorphin, beta-lipotropin and cortisol to athletic competition

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Abstract. Acute physical exercise stimulates the activity of the hypothalamus-pituitary-adrenal axis in man. In the present study we measured plasma adrenocorticotropic, beta-endorphin, beta-lipotropin and cortisol levels in 27 male trained athletes in basal conditions, 60 min before and immediately after an official competition. The endocrine responses were evaluated in different groups of athletes participating in races (100 m, 1500 m, 10 000 m) or in the disc throw. The athletes competing for the runs showed a statistically significant increase in plasma adrenocorticotropic, beta-endorphin, beta-lipotropin and cortisol levels after the race (P < 0.01), whereas the disc throwers showed no significant change in the hypothalamus-pituitary-adrenal axis hormones after the competition. The percent increase in plasma adrenocorticotropic, beta-endorphin, beta-lipotropin and cortisol was higher in the athletes who run 1500 m and 10 000 m than in those participating in the short distance race (100 m). The present results showed that plasma proopiomelanocortin-related peptides and cortisol levels increase in trained athletes following running competition and that this increase is related to the duration of the physical exercise.

Among the physiological responses to the stress of physical exercise, the increase in the pituitary-adrenal axis hormones is one of the most common findings (Axelrod & Reisine 1984).

Previous studies have shown that a submaximal or a maximal run induces a significant increase in plasma ACTH, beta-endorphin (B-EP) and beta-lipotropin (B-LPH) levels in untrained subjects (Carr et al. 1981; Gambert et al. 1981). This response was even greater after a short period of training (Carr et al. 1981). Similarly, in well-trained athletes, a standard exercise, such as cycloergometer or programmed running, also increases plasma proopiomelanocortin (POMC)-related peptide levels (Bortz et al. 1981; Farrell et al. 1982; Fraioli et al. 1980; Janel et al. 1984; Wildmann et al. 1986). However, there are no reports on the acute changes of the POMC-related peptides in athletes before and after a competitive exercise. It is known that plasma ACTH, B-EP, B-LPH and cortisol levels increase also following metabolic (Makao et al. 1979; Petraglia et al. 1986a,b) and psychological stress (Bohus 1984; Henry & Stephens 1977), thus suggesting their possible role both in metabolic and behavioural adaptive responses to stress.

The aim of the present study was to evaluate in trained athletes the effect of the competition on plasma ACTH, B-EP, B-LPH and cortisol levels. Four different competition exercises were selected, two endurance runs (10 000 m and 1500 m), one sprint run (100 m) and one non-running speciality (disc throw).
This selection was done to obtain different conditions of physical stress, with different duration of muscular activity and of metabolic consumption. Moreover, because the excitement and the tension of the precompetition may be a psychic stress, the hormone levels were also measured in all subjects 1 h before the athletic competition.

Subjects and Methods

Subjects

After informed consent 27 male volunteers were recruited for the study (mean age 30.1 ± 7.2 years). They had undergone a regular training programme for at least 5 years. They were studied during a national athletic meeting. The competitions took place between 15.00 and 18.00 h. The subjects were divided into 4 groups: 10 000 m (8 athletes), 1500 m (7 athletes), 100 m (7 athletes) and disc throw (5 athletes). A group of 20 male non-athlete subjects (age-matched) served as controls.

In the athletes blood samples were drawn 2 days and 60 min before and immediately after the competition, between 14.00 and 17.00 h. In the controls a single blood sample was collected in ETDA and Trasylol® (1000 K-units/ml), was maintained at 4°C until centrifugation. Plasma was separated by centrifugation for 10 min at 2000 × g and stored at −20°C until assayed.

Assays

B-EP and B-LPH. Prior to specific radioimmunoassays for B-EP and B-LPH, each plasma sample was submitted to peptide extraction and column gel filtration in order to concentrate the hormones and to avoid non-specific binding of the antiserum to the two hormones. Plasma samples (3.5–4) were placed in plastic tubes containing 200 mg of silicic acid (Mallinkrodt, Heidelberg, FRG) and after 1 h in a rotary mixer, the peptides were extracted with a 0.5 N HCl-acetone mixture (2/8 vol/vol) as previously described (Genazzani et al. 1982). The extracts were dried in a speed vac concentrator (Savant, Hicksville, NY), were redissolved in 500 µl of 0.1% bovine serum albumin and placed on Sephadex G-75 columns (45 × 1.5 cm), and eluted with the same solution.

On the basis of different experimental validations (Genazzani et al. 1982) two fractions of 16 ml were collected, corresponding to the elution volume of B-LPH and B-EP, respectively. The fractions were lyophilized, redissolved in 0.12 mol phosphate buffer and submitted to specific RIAs. After gel filtration, the final recoveries were 75 ± 4.5% and 70 ± 5% for B-EP and B-LPH, respectively.

Synthetic B-EP (B-LPH 61–91) (Organon, Oss, The Netherlands) and human B-LPH (B-LPH 1–91) (kindly supplied by Dr C. H. Li, San Francisco, CA) were used as standards and for iodination (125I labelled by the chloramine T method). Anti-human B-EP (raised against the C-terminal portion) and anti-human B-LPH (raised against the N-terminal portion) antiserum were used in the two RIAs. The characteristics of the antiserum and of the RIAs have been reported previously (Genazzani et al. 1982). The assay sensitivity was 1.5 fmol/tube for B-EP and 1 fmol/tube for B-LPH. The inter-assay and intra-assay coefficients of variations were (50% binding) 7.9 ± 1.5% and 5.0 ± 0.5% for B-EP and 8.0 ± 2.0% and 4.3 ± 1.0% for B-LPH, respectively.

Plasma B-EP and B-LPH levels were presented as pmol/l and corrected for recoveries.

Cortisol and ACTH. Plasma cortisol and ACTH levels were measured using commercially available kits provided by Techno Genetics (S. Mauro Torinese, Italy). For cortisol RIA, the assay sensitivity was 20 pmol/tube and the inter- and intra-assay coefficients of variation were 6.0 ± 0.8% and 3.8 ± 0.5%, respectively. The ACTH RIA sensitivity was 2 fmol/tube and the inter- and intra-assay coefficients of variation were 6.5 ± 0.8% and 3.0 ± 3%, respectively. Plasma cortisol and ACTH levels were presented as nmol/l and pmol/l, respectively.

Statistical analysis

The statistical analysis of the results was performed by analysis of variance followed by Duncan’s test for multiple comparison.

All values are given as mean ± SEM.

Results

Mean ± SEM plasma ACTH (8.8 ± 1.1 pmol/l), B-EP (6.7 ± 1.2 pmol/l), B-LPH (7.0 ± 1.5 pmol/l) and cortisol (105 ± 21.5 nmol/ml) levels in the whole group of athletes in resting conditions were not significantly different from that found in the group of control subjects (ACTH: 8.5 ± 1.5 pmol/l; B-EP: 7.2 ± 0.8 pmol/l; B-LPH: 8.1 ± 1.7 pmol/l; cortisol: 97 ± 26.5 nmol/l).

In the different groups of athletes mean plasma levels of ACTH (Fig. 1), B-EP (Fig. 2), B-LPH (Fig. 3) and cortisol (Fig. 4) 1 h before the competition were significantly higher than 2 days earlier (P < 0.01). A further significant increase in plasma levels of POMC-related peptides (Figs. 1, 2 and 3) and cortisol (Fig. 4) was found in the athletes immediately after the 10 000 m, 1500 m and 100 m runs (P < 0.01). The athletes competing for the disc throw showed no significant increase.
**Fig. 1.**
Mean ± SEM of plasma ACTH levels in athletes (100 m, N = 7; 1500 m, N = 7; 10000 m, N = 8; disc throw, N = 5) before (1 h) and immediately after an official competition. The triangle shows the statistically significant difference ($P < 0.01$) between the two groups. □ before competition, ■ after competition.

**Fig. 2.**
Mean ± SEM of plasma B-EP levels in athletes (100 m, N = 7; 1500 m, N = 7; 10000 m, N = 8; disc throw, N = 5) before (1 h) and immediately after an official competition. The triangle shows the statistically significant difference ($P < 0.01$) between the two groups. □ before competition, ■ after competition.

**Fig. 3.**
Mean ± SEM of plasma B-LPH levels in athletes (100 m, N = 7; 1500 m, N = 7; 10000 m, N = 8; disc throw, N = 5) before (1 h) and immediately after an official competition. The triangle shows the statistically significant difference ($P < 0.01$) between the two groups. □ before competition, ■ after competition.

**Fig. 4.**
Mean ± SEM of plasma cortisol levels in athletes (100 m, N = 7; 1500 m, N = 7; 10000 m, N = 8; disc throw, N = 5) before (1 h) and immediately after an official competition. The triangle shows the statistically significant difference ($P < 0.01$) between the two groups. □ before competition, ■ after competition.
changes in the plasma levels of the various hormones (P < 0.08).

The post competition-related increase in plasma ACTH, B-EP, B-LPH and cortisol, evaluated as the percent change on basal values, was higher in athletes following the endurance runs (10000 and 1500 m) than in the sprinters (P < 0.05), and was not related to the athletic performance of the individual subject.

Discussion

The present study showed that agonistic activity increases the plasma HPA axis hormone levels in trained athletes, in relation to the type and to the duration of the physical exercise. Indeed, the endurance runners (10000 m and 1500 m) showed an increase in plasma ACTH, B-EP, B-LPH and cortisol levels higher than in sprint runners (100 m). Athletes competing for disc throw showed no significant variation of the HPA axis hormones. Our results, showing a relationship between the duration of the exercise and the increase of hypothalamus-pituitary-adrenal axis (HPA) hormones following a competition, agree with the finding that the increase of stress-related hormones is related to the intensity of the standard physical exercise (Grossman et al. 1984). The evidence that 1 h before the competition stress-related hormonal levels were already increased, suggests that the forthcoming competition causes a psychological tension in trained athletes, independent of the competition exercise.

The high plasma HPA axis hormones levels found in the athletes before the competition, suggest that the psychological condition prior to an official sport contest represents a psychic stress in the athletes. These results agree with those of Sutton & Casey (1975) who reported an increase in plasma cortisol levels both before and after 1500 m and 5000 m race in comparison to basal concentrations.

Therefore, the present results, showing that both physical and psychological stresses increase plasma ACTH, B-EP, B-LPH and cortisol levels, may indirectly support the role of these hormones in metabolic and behavioural adaptive responses to stress stimuli. The increase in peptide, lipid and glucose metabolism (Wahren 1979) and the decrease of pain sensitivity (Black et al. 1979; Markoff et al. 1982) and recognized to follow physical exercise. The anabolic effects of ACTH and cortisol (Lebovitz et al. 1965), the lipolytic action of B-LPH (Lohmar et al. 1968; Yamashiro & Li 1979), the mood and analgesic effects of B-EP (Koob & Bloom 1983), support the possible involvement of these hormones in the physiological response to stress. Moreover, other studies have revealed an important role of the central endogenous opioid system in regulating the secretion of prolactin and growth hormone in response to physical stress (Farrell et al. 1986; Grossman et al. 1984; Moretti et al. 1983).

In conclusion, from the present data we may assume that an official competition may represent a psychic stressful condition in the athletes, and run races further stimulate the HPA axis hormones in relation to the duration of the competition.

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