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Serum IGF-I, IGFBP-3 and ALS concentrations and physical performance in young swimmers during a training season

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ABSTRACT

Introduction: The GH/IGF-I axis is a system of growth mediators, receptors, and binding proteins that regulate somatic and tissue growth; and it has been shown that exercise programs are related to the anabolic function of this axis.
Objective: The aim of this study was to analyse the changes of serum IGF-I concentration and that of its binding proteins IGFBP-3 and ALS in adolescent swimmers at different stages of a training season, and compare them with physical performance parameters and body composition of the athletes.
Material and methods: Nine male athletes, aged 16 to 19 years and who trained regularly throughout the season, were included in this study. Serum IGF-I, IGFBP-3, and ALS concentrations were recorded before and after (pre × post) standardized training sessions during the different stages of a training season (extensive × intensive × tapering). Endurance in freestyle, anaerobic fitness in tied swimming (Peak Force and Average Force), body mass, fat percentage, and lean body mass were also analysed at the different stages of training in order to compare the changes of the IGF-I/IGFBP/ALS system with the physical performance and body composition of the athletes. Variations in the IGF-I/IGFBP-3-ALS system before and after a standardized training session, and at the different stages of training were analysed by the Wilcoxon and Friedman non-parametric tests, respectively. Significance was considered at 5%.
Results: The results from this study demonstrate that IGF-I is sensitive to the acute and chronic effects of training, exhibiting biphasic behaviour throughout the season. The catabolic phase was characterized by a reduction in serum IGF-I concentrations during the intensive stage ($\Delta_{IGF\text{-}I}$: - 43.33 ± 47.32 ng/ml; $P < 0.05$) while the anabolic phase was marked by similar basal concentrations at the different stages of training and an increase in post-training serum IGF-I concentrations during the tapering stage (320 ± 40; 298 ± 36 and 359 ± 94 ng/ml; $P < 0.05$). IGFBP-3 was only sensitive to the chronic effects of training, with a reduction in post-training serum concentrations during the intensive stage and an increase during the tapering stage (4.7 ± 0.7, 4.6 ± 0.4 and 5.0 ± 0.7 mg/l; $P < 0.05$). No significant difference ($P > 0.05$) was observed in pre- or post-training IGFBP-3 concentrations ($\Delta_{IGFBP\text{-}3}$) at the different stages. ALS concentrations remained unchanged throughout the season, demonstrating that in adolescent athletes they are unaffected by the acute or chronic effects of swimming. Peak Force (25.0 ± 6.3, 24.2 ± 5.7 and 28.5 ± 6.5 N; $P < 0.05$) and Average Force (10.3 ± 3.6, 8.8 ± 1.8 and 14.7 ± 1.8 N; $P < 0.05$) followed IGF-I and IGFBP-3 variations, with a decrease during the intensive stage and a significant ($P < 0.05$) increase during the tapering stage. The body composition and cardiorespiratory condition of the swimmers did not vary significantly throughout the season, exhibiting behaviour independent of IGF-I or IGFBP-3.
Conclusion: Serum IGF-I and IGFPB-3 concentrations have proven to be sensitive markers of training status and, thus, may be used as guides for coaches and athletes in the challenging task of modulating training intensity in young athletes.

1. Introduction

Physical activity is closely related to the anabolic function of the GH/IGF-I axis; a system of growth mediators, receptors, and binding proteins that regulate somatic and tissue growth in several species. Basal IGF-I concentrations are positively correlated to muscle mass and physical aptitude in children, adolescents, and adults [1,2,3].

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Possible adverse effects of physical training during childhood and adolescence, such as stress and decreased growth velocity, seem to be unrelated to the type of activity performed but result instead from the intensity of training [4]. Even though there are many studies on the IGF system and exercise, few have analysed the behaviour of anabolic and catabolic mediators throughout a training season [5,6,7,8]. IGF-I response to chronic training is not yet fully understood [9]. It is believed that the alterations in circulating IGF-I concentrations could indicate that no close correlation exists between IGF-I changes induced by a single training session and those observed after a long period of training [10].

It has been suggested that the GH/IGF-I axis exhibits biphasic behaviour during the training season; with a catabolic phase characterized by a reduction in hormone concentrations lasting 3 to 5 weeks followed by an anabolic phase that takes place after 5 to 6 weeks of training, characterized by an increase in hormone concentrations [8,11]. The increase in IGF-I concentrations observed following a long training program (4 to 9 weeks) has been supported by studies using animal models, which reported increases in IGF-I gene expression in the muscular-skeletal tissue [12] and in circulating IGF-I concentrations [13]. However, it remains unclear whether the biphasic behaviour of the GH/IGF-I axis also applies to humans during a prolonged training program [14]. Furthermore, this bi-phasic IGF-I response is largely speculative and has yet to be experimentally demonstrated.

Training sessions are part of the daily training program of pre-pubertal children and adolescent and the need for further field studies to better understand the effects of these sessions on the behaviour of the GH/IGF-I axis and their role on the resulting adaptations that occur throughout the training season [6] has prompted the present investigation. Thus, the aim of this study was to analyse the changes of serum IGF-I concentrations, its binding proteins IGFBP-3 and ALS (ternary complex), and the physical performance of adolescent swimmers at the different phases of a training season.

2. Material and methods

2.1. Sample

The sample was composed of nine volunteer athletes aged between 16 and 19 years (18.22 ± 1.09) who had been classified according to the Tanner scale [15] into stages 4–5 for pubic hair development, and had been training regularly.

This study was approved by the Ethics Committee in Research of the School of Physical Education and Sports of Ribeirao Preto, University of São Paulo, Ribeirao Preto-SP, Brazil (CAAE: 38761314.5.0000.5659; protocol n. - 968.146). A written consent was obtained for all participating subjects.

2.2. Data collection

Evaluation of the athletes took place thrice throughout the season: at the initial phase (extensive), intermediate phase (intensive) and at the end of the season (tapering). At each phase the athletes were evaluated at three different times: Day 1 – anthropometric evaluation to determine body composition (% fat and lean body mass) and blood sampling before and after (pre × pro) a standardized training session; Day 2- anaerobic fitness in tied swimming; Day 3- aerobic endurance in freestyle swimming. Blood samples were collected before the start of the training session, following 30 min of rest, and 60 min after the end of the session (Fig. 1). Samples were kept at 0–4 °C until centrifugation and the serum stored at −80 °C until analysis.

2.3. Immunoassays

2.3.1. Serum IGF-I, IGFBP-3 and ALS concentrations

Serum concentrations of IGF-I and IGFBP-3 (Immulite 2000, Siemens, Los Angeles, CA, USA), and ALS (DSL, Diagnostic Systems Laboratories, USA) were determined by specific immunoassays using commercial kits. All samples were analysed in duplicate within the same assay. The intra-assay variations were 2.4% for IGF-I, 2.3% for IGFBP-3, and 10% for ALS. Assay sensitivity was 5 ng/ml for IGF-I, 0.1 mg/l for IGFBP-3, and 2 mg/l for ALS.

2.3.2. Anthropometric measures and body composition

Body mass was determined using an electronic scale (Lucastec - Ple 180) and triceps, subscapular, suprailiac, and abdominal skinfold measurements obtained with a Cescorf adipometer skinfold calliper, according to the standards set by Behnke and Wilmore [16]. Body composition was determined according to the equation proposed by Boileau, Lohman and Slaughter [17].

2.3.3. Endurance in freestyle - anaerobic threshold

Endurance in freestyle swimming was determined using the minimum lactate protocol by Tegtbur, Busse and Braumann [18] adapted for swimming by Campos et al. [19].

The test consisted of a lactacidemia induction phase and an incremental exercise phase. During the hyper-lactacidemia induction phase the swimmers exerted maximum effort for 100 m in their preferred style (butterfly stroke, backstroke, breaststroke or front crawl stroke). On the 3rd, 5th and 7th minutes after the induction phase, blood samples (25 μl) were collected from the earlobe to determine lactate peak concentration ($[La\text{-}]_{P100}$) using a blood lactate analyser (YSI – 1500). After the 8th minute of passive interval, the swimmers were subjected to an incremental test, which consisted of five progressive efforts of 200 m with intervals only to collect blood samples and determine lactacidemia.

The values obtained from the relationship between $[La^{-}]$ and swim velocity ($m.s^{-1}$) were adjusted by a second order polynomial model so that the zero derivative of this adjustment corresponded to the minimum lactate intensity that enabled endurance (anaerobic threshold) to be determined [20].

2.3.4. Anaerobic fitness in tied swimming - Peak and Average Force

To determine anaerobic fitness, the swimmers were tied to a measuring apparatus standardized by Papoti et al. [21]. The equipment consisted of a data collection system with load cells as the primary

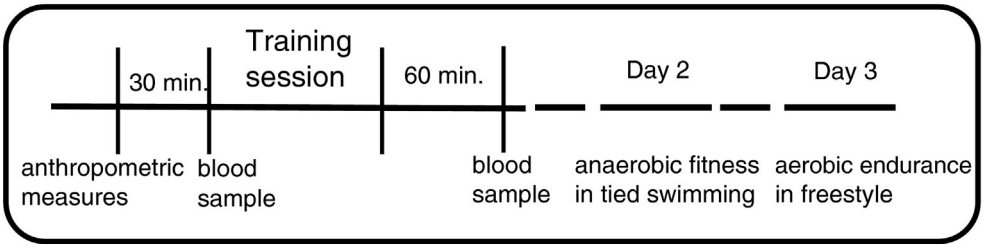

Fig. 1. Study Design Diagram. Day1: Recording of anthropometric measures and blood sampling; Day 2: evaluation of anaerobic fitness in tied swimming; Day 3: aerobic endurance in freestyle at the end of the extensive phase (week 7), intensive phase (week 14), and tapering phase (week 19).

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