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Original article

Preparatory training attenuates drastic response of the insulin-like growth factor binding protein 1 at the point of maximal oxygen consumption in handball players

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Abstract

Background: Intensive exercise changes physiological need for glucose and several biochemical pathways responsible for its metabolism response. Among them are those which involve insulin, insulin-like growth factor (IGF-1), and IGF-binding proteins (IGFBPs). Different types and degrees of exercise, as well as an athlete's fitness, may induce a range of responses regarding concentrations and time needed for the alteration. The idea of the work was to find out whether and how insulin/IGF axis responds to additional physical activity in the already trained subjects and if so, is the adaptation potentially beneficial from the aspect of metabolic control.

Methods: The effect of 4-week intensive training on campus (preparatory training) on the levels of insulin, IGF-1, and IGFBPs during maximal progressive exercise test (MPET) on a treadmill was compared to the results obtained during MPET conducted after a regular training season of a female elite handball team ($n = 17$, age: 17 ± 1 years, height: 171 ± 8 cm, weight: 65 ± 8 kg, body mass index: 22 ± 1 kg/m^2 at the beginning of the study; there were no significant changes at the end). Serum samples were obtained from players immediately before the test (basal), at the end of the test after reaching the point of maximal oxygen consumption (VO_{2max}), and after recovery.

Results: The concentration of insulin decreased at VO_{2max}, but remained higher in players after preparatory training (12.2 ± 2.5 mU/L *vs.* 8.9 ± 4.4 mU/L, $p = 0.049$). The level of IGFBP-1 decreased in players at VO_{2max} in either case of training, but it remained much higher in tests performed after the preparatory regime than before ($p = 0.029$). Concentrations of IGF-1, IGFBP-2, -3, and -4 did not change significantly.

Conclusion: The inverse relation between insulin and IGFBP-1 was lost during MPET, as these 2 molecules changed in the same direction. The results obtained suggest less severe stress-induced depression of insulin and IGFBP-1 after preparatory training. But another metabolic mechanism cannot be excluded, and that is potentially impaired insulin sensitivity resulting in higher level of IGFBP-1.

Keywords: Female; IGF-binding proteins (IGFBPs); Insulin; Insulin-like growth factor I (IGF-1); Progressive exercise test; VO_{2max}

1. Introduction

Active training induces alterations of hormones and cytokines involved in the regulation of glucose concentration. In general, long-term training leads to reduced insulin concentration[1] and increased secretion of growth hormone (GH).[2] Results on the concentration of insulin-like growth factor 1 (IGF-1), a mediator of GH activity,[2] and IGF-binding proteins (IGFBPs) are, however, contradictory. These molecules are involved in the regulation of glucose concentration, its utilization, and muscle growth and tissue repair.[3]

The close relationship between insulin and GH has been reviewed previously.[4] The physiological role of insulin is seen in lowering the concentration of glucose in blood, which is performed by 2 principal mechanisms—inhibition of glucose

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production in the liver and stimulation of intracellular transport of glucose via specific membrane transporters.[4] Glucose transport is mainly driven by the concentration gradient, but insulin is responsible for controlling translocation of transporters on the cell surface.[4] Intracellular glucose is metabolized and the metabolites further enter the Krebs citric acid cycle, enabling energy release.[5] During exercise, this mechanism, together with the one stimulating glycogen breakdown to insure additional glucose, is activated. After exercise, with reduced need for energy release, insulin stimulates processes favoring conversion of glucose into "energy storage molecules" such as glycogen and fat. Insulin is responsible for the intracellular transport of amino acids as well, essential for protein synthesis and muscle recovery. Contrary to insulin, glucagon, epinephrine, cortisol, and GH are known as glucose-raising hormones.[6] IGF molecules can be seen as specifically positioned in this network, as they are mediators of the anabolic function of GH and yet, they exert insulin-like activity.[4]

Increased concentration of IGF-1 was measured by several researchers after resistance training, alternating resistance exercise and running, long-term training in competitive swimmers, endurance exercise and in women involved in army physical training.[7–14] Decreased concentration of IGF-1 was reported in handball players and in healthy women after strength training.[15,16] Finally, Eliakim and colleagues[17] found no effect of volleyball practice in women on IGF-1; Meckel and co-workers[18] reported no effect of treadmill running on IGF-1 in handball players, and Nindl and his group[19] denied an effect of exercise on total, free, and bioactive IGF-1 in women.[19]

Similar inconsistency may be seen in the published results on IGFBPs. Intensive physical activity was found to increase,[9,10,18] decrease,[8] or not to affect IGFBP-3 concentration.[7,16,17,19] The concentration of IGFBP-1 was detected to increase,[20] decrease,[11,18] or remain unchanged.[8,10,16,19] Less data are available on other IGFBPs, but they are opposing as well. IGFBP-2 was measured to increase,[9] decrease,[11] or stay unaltered due to exercise,[19] while IGFBP-4 and IGFBP-6 were reported to increase in army women.[11] Such enormous variation in the results on the IGF/IGFBP axis in athletes indicates exercise-specific adaptation. Therefore, results obtained for 1 type of athlete cannot be extrapolated to others.

Handball is a globally popular team sport played by more than 30 million athletes all over the world.[21] It is a strenuous, intermittent physical activity that requires both aerobic and anaerobic power and endurance.[22] In spite of these facts, hormonal changes in handball players have been poorly studied, especially in female players. Thus, the aim of this study was to investigate changes in the insulin/IGF/IGFBP axis during maximal progressive exercise test (MPET) on treadmill performed by female elite handball team players after intensive training on campus (preparatory training) and to compare them with the response recorded after regular training. In accordance, it seemed relevant to find out whether and how insulin/IGF axis responds to additional physical activity in the already trained subjects and, if so, is the adaptation potentially beneficial from the aspect of metabolic control. The first test was carried out immediately after the competition season, at the beginning of preparatory training and the second one after preparatory training, which lasted 4 weeks. We determined additional influence of preparatory training on the insulin/IGF/IGFBP axis, especially at the point of maximal oxygen consumption (VO_{2max}), which is assumed to be the best single measure of aerobic fitness.[23]

2. Materials and methods

2.1. Participants

The study included 17 young female handball players, aged 16–18. The players were members of the Serbian national team, playing at national and international competitions. All of them were healthy, non-smokers and reported regular menstrual cycles (26–32 days). None of them received any medications or supplements for at least 1 month before the study. All participants (or their parents if they were under 18) were fully informed about the protocol before the start of the study and gave a written informed consent. The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Ethical Committee of the Faculty of Medical Sciences, University of Kragujevac.

2.2. Protocol

The study started immediately after regular competition season with the first MPET and lasted 4 weeks terminating with the second MPET. During this period, players were subjected to preparatory training in a closed campus in Serbia and they all had the same diet. The regular regime before the study included training once a day for 1.5 h, as a combination of aerobic, conditioning, and strength exercise. The campus regime included 2 training sessions per day, lasting a total of 3 h, with the same combination of exercises, but of higher intensity.

The research protocol started in the morning, between 8:00 a.m. and 9:00 a.m., after overnight rest and fast. A blood sample was taken from each subject's antecubital vein and a small catheter was inserted for further blood sampling. A routine medical examination was performed to confirm that all participants were healthy and without any acute or chronic diseases. A study protocol was carefully explained to each of them. Handball players were subjected to the same dietary protocol 3 days before the study. During those 3 days, they were asked to keep a diary of daily food intake. According to their data and the food composition database of the Italian National Institute of Nutrition, the average dietary intake was calculated. Athletes were instructed to avoid any heavy physical activity 24 h before the research and the consumption of alcohol and caffeine 48 h before the test, as well as not to have breakfast before the examination.

The exercise was performed in continuation on a treadmill (Pulsar 4.0 HP Cosmos Sports & Medical, Nussdorf-Traunstein, Germany). The starting velocity for the maximal test was the one at which subjects reached the heart rate of 150 beat/min during the 15 min warm-up period. The workload was increased by 2 km/h every 3 min with constant elevation of 3%.[24] This type of protocol was chosen to reach VO_{2max} accord-