Growth hormone and blood sugar changes following maximal and submaximal exercises in the young athletes

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Abstract

Introduction:
Growth hormone is a strong metabolic factor that facilitates growth and hypertrophy and increase transfer of amino acids into the cells. Exercise is a potent stimulant of growth hormone secretion. If it is regularly done, the rate of hormone secretion increases in 24 hours. In previous studies, the role of championship training has been little considered. So, given the importance of the above-mentioned hormone in puberty period and the necessity of participation in the championship, this study aimed to investigate the relationship between physical activity in championship level and changes of this hormone.

Material and Methods:
12 male adolescent athletes Estahban were chosen as the subjects. Finally, eight of them (mean age= 14.44, height= 1.56 m and weight= 46.3 kg) participated in the study. Blood samples were collected before exercise, after 10 weeks of submaximal exercise, and at the end of 3 weeks of maximal exercise. ,. The samples were collected 12 hours after the last training.

Results:
The results indicated that submaximal exercise had no significant effect on baseline growth hormone and blood sugar ($p=0.446$, $p=0.289$). But maximal training caused a significant increase in the baseline growth hormone and blood sugar ($p=0.048$, $p=0.045$).

Conclusion:
According to the results, exercise intensity below the maximum for male adolescents has a significant impact on the amount of baseline growth hormone whereas maximal exercise increases the amount of baseline growth hormone significantly. Increased growth hormone leads to increased protein synthesis, increased bone, increased muscle size and improved athletic performance.

Keywords: Growth Hormone, Blood Sugar, Exercise

Introduction:
Severe physical exercise leads to oxidative stress as well as lipid peroxidation. Oxygen consumption in human body systematically increases 10 to 20 times in response to endurance exercise (1). Homeostasis in the muscles must remain stable during exercise because body is in high demand in this condition which causes many physiologic changes. Researches indicate that growth hormone (GH), a non-tropic hormone secreted from anterior pituitary gland, is a strong metabolic factor which along with other complex hormonal changes during puberty facilitates muscle growth and hypertrophy and increases amino-acid transport into the cells (2).

It is believed that this hormone induces its effects either directly or indirectly by stimulating production of Insulin-like

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Growth Factor (IGF1) or somatomedin-C in liver and other tissues.

Previous investigations show that GH blood level increases significantly in particular situation such as during deep sleep along with raised plasma estradiol concentration, exercise and physical activity. It is also known that GH plays two main roles in body: first it induces growth process and second, as a hormonal regulator, it adjusts lipid and glucose consumption during body activities and exercise (4). The exact relation between GH production with duration and intensity of exercise as well as the necessary stimulation for an exercise- induced increase in GH production haven't been quiet understood. Literature review showed that exercises can directly double the frequency and amplitude of GH pulses. Simultaneous measurement of blood levels of lactate, alanine, pyruvate, glucose and body temperature have shown that none of these factors are responsible for regulating GH secretion pattern. There is a high probability that neural factors have the main role in GH secretion (3).

During puberty, a fast increase occurs in body size and mass and frequency of GH pulses reaches to a maximum level. In this period, plasma concentration of testosterone and estrogen increase in boys and girls respectively. These two hormones change into estradiol and amplify the effect of growth hormone releasing hormone (GHRH) on anterior pituitary somatotrope cells leading to increase in GH secretion (4). There is a hypothesis that exercise can directly stimulate GH production and pulsatile secretion which eventually leads to histogenesis. Moreover, exercise stimulates endogenous opiates production which facilitates GH release through preventing somatostatin production by liver cells (the hormone that attenuates GH release). GH has an active role in maintaining rather high blood glucose levels due to stimulating fat lysis and release from fat tissue as well as preventing glucose consumption by cells (3). Given the development of research fields in our century, the role of physical activities and their effect on normal growth in children and adolescents has attracted lots of interest.

Many studies have been carried out on the effects of exercise and physical activity on body organs and systems as well as their therapeutic role in management of physical and physiological abnormalities. Scientific researches during the twentieth century shed a light on the roles of neural and endocrine systems on the growth process which was followed by further investigations to find effective factors that can increase the efficiency of these tow systems to provide the physiologic demands during growth. It is known that GH as the endocrine hormone responsible for a normal growth process is secreted in a close relationship with neural system and its plasma level changes with physical activity. Therefore by stimulating GH secretion, physical activity and exercise not only lead to higher final height, muscular mass and lower body fat but also plays a therapeutic role in patients with GH deficiency by enhancing protein synthesis and insulin sensitivity (1). Two main matters must be mentioned about the selection of study population in the present study: first, study subjects were all chosen from athletes with previous championship history who were performing heavy exercises on a championship level regarding the common concern among families about positive and negative effects of heavy professional level exercises on their adolescents and second, all study subjects were adolescents in their puberty period regarding the importance of determining effective factors on growth process in this age.

Further studies demonstrated that exercise, similar to deep sleep, is a significant physiologic stimulant of GH secretion.

Therefore, exercise seems to be a more efficient replace for medical agents in management of GH deficiency (1).

GH secretion increases in response to hypoglycemia and stops to increase as the blood glucose level rises. This GH response to absolute hypoglycemia and rapid increase in blood glucose level occurs even if the GH level in serum is normal. In a research studying pituitary function, insulin-induced hypoglycemia caused 85 to 100% increase in GH level in normal healthy subjects (5). Hartley *et al* (1989) in their study asked seven men to exercise on stationary bicycle at 75% maximal O2 consumption (VO2max) until exhaustion and found that GH secretion increases at the beginning but drops off before exhaustion. They repeated the study with the same subjects at 42 and 98% VO2max. Comparing the results showed that GH level increase during exercise at 75% VO2max was significantly higher than others (6). Several studies confirm the effect of exercise on GH level and report that this effect is more obvious in women than men and in lean people than fat people (7-9).

Gaieni, et al studied 91 subjects with 15-17 years of age in two groups of athletes and non-athletes and concluded that GH level increases in both groups following maximal and submaximal exercise; however the increasing effect of maximal exercise was more evident (10). Sadeqi *et al* in 2009 carried out an investigation that compared the effect of two endurance exercise plans with equal contents but different resting time between the sets (one vs. three minutes) on 15 fitness athletes and reported that both exercise plans caused statistically significant increase in blood GH and lactate level; however GH level in endurance exercise plan with one minute rest was significantly higher in comparison with endurance exercise plan with three minutes rest (11). Studies show that severe anaerobic physical activity lead to increase in basal level of GH, but the effect of aerobic activity on GH level is not significant (12-13).

Material and Methods:
This study was carried out on adolescence male champion athletes as an applied study with semi-experimental design including pre-test and post-test measurements. The goal of the study was to determine the effect of submaximal and maximal (until exhaustion) physical activity on GH secretion in boy adolescent athletes. Considering the low number of adolescents with athletic championship and necessity of performing championship level exercises under the supervision of one trainer, all twelve adolescent boy athletes of the martial art team of Stahban province with the age of 12-18 years who at least had one championship history at national or provincial level were considered as the study population. Four of them were excluded from the study due to injuries or too many absences from the training sessions. Finally a total of eight athletes (mean age: 14.44; mean height: 1.56 m and mean weight: 46.3 kg) completed the study.

Fasting blood samples were collected from all subjects at the day of the beginning of the exercise plan (pre-test samples). After ten weeks of submaximal exercise (before the camp) and 12 hours after the last set of exercise another fasting blood sample was obtained from each athlete. Given that maximal exercises (during the camp) were started immediately after submaximal exercises, the second blood sampling was considered as both post-test for submaximal exercise and pre-test from maximal exercise. Maximal exercises during the camp continued for three weeks and again 12 hours after the last set of exercise, a third time blood sample was taken. Blood samples were centrifuged at the lab and GH level was measured in serum using ELIZA (human enzymatic kit, Germany).

Exercise plan: Subjects were asked to complete a medical questionnaire and were all examined by a physician before participating in the exercise plan. Subjects' pulses were checked by pulse meter (Finland) during exercise.

Exercise period duration: Submaximal and maximal exercises lasted for ten and three continues weeks, respectively.

Exercise intensity: Submaximal and maximal exercises were performed at 65-75% and 85-90% maximum heart rate reserve, respectively which was calculated using Karvonen method (14).

Duration and frequency: Submaximal exercise plan included three sessions of two hours each week (a total of 30 sessions) and maximal exercise plan included six sessions of two hour a week (a total of 18 sessions).

Exercise plans: Submaximal plan during a week was performed in three parts of fitness, kata practices and combat. The first session was dedicated to fitness including 20 minutes warm up, 30 minutes review of techniques, 20 minutes aerobic exercises at 75% maximum heart rate reserve, 10 minutes rest followed by eight stations of 1.5 minute strength and speed trainings followed by 3 minute rest and a 10 minute break between the 4th and 5th stations. Exercise intensity at the end of the 8th station was nearly 75% maximum heart rate reserve. The second session of each week was about kata and included 20 minutes warm up, 30 minutes review of techniques, 60 minutes kata group practice at 60% maximum heart rate reserve followed by 30 minutes cooling down. The third session of the week was assigned to combat practices and included 20 minutes warm up, 30 minutes review of techniques and training of key combat skills, six combat rounds two minute long with 70% intensity and two minutes rest between

them followed by 10 minutes break and then two more two minute combat rounds. During the maximal exercise period, the athletes were in camp and participated three sessions of training each week. On even days, training was focused on fitness exercises with maximal intensity and odd days were assigned to combat and professional skills training with intensity of 90% maximum heart rate reserve. Fitness trainings included 20 minutes running at 80% heart rate reserve, 15 minutes tension exercises, 10 minutes speed running with 90% intensity, 12 stations of strength and speed trainings each 2 minutes long at 90% maximum heart rate reserve and finally 10 minutes cooling down. Professional trainings included 20 minutes warm up, 20 minutes skills review, 30 minutes shadowboxing training at 85% maximum heart rate reserve, 10 minute break followed by 30 minutes of combat at 90% maximum heart rate reserve and a final 10 minutes of cooling down.

Statistical analysis: Study variables were presented as mean± standard deviations. Given the small sample size, Kolmogorov-Smirnov statistical test was used in order to evaluate the distribution of numerical variables and its consistency with theoretical normal distribution. Data was analyzed using SPSS software version 16 at significancy level of $\alpha=0.05$. Dependent t-test was used to compare GH levels before and after the exercises.

Results:
According to Kolmogorov-Smirnov test, the study variables had a normal distribution and hence parametric tests could be used to analyze these variables. Basal GH level was 1.04±1.22 mg/ml. The results of independent t-test on GH and blood sugar levels before and after the test for both submaximal and maximal exercise are demonstrated in table 1.

Table 1: Changes in GH and blood sugar levels following submaximal and maximal exercise in adolescent athletes

Variables	Exercise Intensity	Mean±SD	Significancy Level	df	T	Standard Deviation	Standard Error	Mean Difference
Growth	submaximal	1.43±0.49	0.446	7	0.808	0.479	1.356	0.387
Hormone	maximal	2.81±1.5	0.048*	7	2.39	0.578	1.635	1.383
Blood	submaximal	76.87±11.9	0.289	7	1.148	6.2	17.55	7.12
Sugar	maximal	79.75±7.77	0.045*	7	2.43	2.72	7.7	6.62

*significancy at α=0.05

Basal GH level didn't show a significant change after submaximal exercise (P=0.0446) but the increase in GH basic level after maximal exercise was significant in comparison with the pre-test level (P=0.048). Blood glucose level wasn't significantly different after submaximal exercise (P=0.289) but a significant increase was found in blood sugar level following maximal exercise (P=0.045).

Discussion:
Literature review showed that most researchers have reported a rise in GH level during the first two hours of recovery period (15,16). In addition, it has been shown that regular exercise leads to an increase in GH secretion rate during 24 hours (9,17). Regarding the effect of physical activity on basic GH level, some researchers have found that moderate and submaximal aerobic and anaerobic exercises don't have any significant effect on the basic level of GH, but maximal anaerobic exercises cause a significant increase in GH secretion (10-13, 18-19).

The present study is considerable for two reasons; first, the study subjects were all well-trained athletes with championship history who performed heavy professional trainings; and second, they were all adolescents and at their puberty period. Adolescence period in boys is from 12 to 20 years and their maximum height growth rate occurs at the ages of 13.5 to 14 years. GH is more effective during childhood and adolescence (20). The findings of this study showed that 30 sessions of submaximal exercise (10 weeks) doesn't affect GH basic level significantly. Given the fact that blood sugar level is effective on GH secretion, we measured blood glucose level concurrently and the mentioned result about submaximal exercise was found while blood glucose level didn't have a significant difference before and after the test. This issue is less addressed in previous studies. The results show that submaximal exercise isn't effective on GH level of adolescent boys even in kata as one of the heaviest martial arts. This finding is consistent with previously mentioned studies; however there are some contradictory reports (6,19,21). These conflicts might be due to differences in type and intensity of exercise, subjects' age, genetic factors, nutrition and most importantly the time of blood sampling after the training. The small sample size might also affect the results of submaximal exercise which can be studied more precisely in further studies by increasing the study population. Maximal exercise was found to cause a significant increase in GH basic secretion which is in consistent with previous studies (10-13,19). Blood glucose level of the subjects was also significantly increased after maximal exercise.

These findings are obtained while there was a high pressure on the studied athletes during Kyokushin Kata exercises, nevertheless GH level showed a significant increase. Detailed analysis of data demonstrated that GH basic level of all subjects increased symmetrically following maximal exercise.

Increase in GH secretion leads to higher efficiency of the athletes particularly in long-term sports directly by raising oxygen transmission, fat oxidation and muscular

potency and indirectly by changing body composition or increasing body temperature set (17).

Conclusion: Given the significant rise in GH basic level after maximal exercise, it seems that Kyokushin Kata as a heavy martial sport is beneficial for skeletal and soft tissue growth in adolescent boys. However, regular examination by specialists is recommended. Further studies are suggested on athletes from other sports in different age ranges investigating other stress hormones such as cortisol, epinephrine and oxytocin as well as GH.

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