The Effect of 12 Weeks Moderate Intensity Aerobic training on Serum Leptin, GH / IGF-1 in Mature and immature Inactive Girl Students

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Abstract

Background & Aims: puberty is a process in which physical and physiological changes lead to changes in the child's body as an adult with reproductive capacity. The purpose of the present study was to investigate the effect of 12 weeks of moderate intensity aerobic training on serum leptin, growth hormone / Insulin-Like Growth Factor-1, in Mature and immature Inactive Girl Students.

Materials & Methods: 40 non-athlete girl students aged 10 to 15 years were matched according to Tanner scale at stages 1, 2 and 3, 4 of puberty and each group was divided into two experimental and control groups. Experimental groups (n = 20) performed 3 sessions per week for 12 weeks, each session performed aerobic training with 45-65% of maximal heart rate for 45 minutes, control groups (20 subjects) in no intervention they did not attend. Blood samples were measured before and after the exercise training. For data analysis, Kolmogorov-Smirnov test (k-s), Leven test, ANCOVA, and P-value <0.05 were used for data analysis.

Results: In experimental groups compared with control groups, after 12 weeks of aerobic training, a significant decrease in leptin and Insulin-Like Growth Factor-1 (P <0.001) and a significant increase in growth hormone (P <0.001) was observed.

Conclusion: See also, moderate-intensity aerobic training appears to have resulted in significant changes in the hormonal indices that are effective in puberty, which indicates the desired effect of type, intensity, duration of activity in girl students inactive.

Keywords: Leptin, Growth Hormone, Insulin-Like Growth Factor-1, Aerobic training

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Introduction

According to the definition of World Health Organization (WHO), people aged 10 to 19 are called teenagers. This age group forms nearly half of the world's population (1). Based on the numbers given by Iran's Statistics Center, more than 20 percent of the country's population are teenagers and more than half of the population is formed by those below 25 years old

(2). This period is a valuable part of one's life because it is the beginning of physical, psychological, and socials changes. It is a critical period when adolescence occurs and that's why it is considered a turning point in one's life. Puberty is the transitional period from childhood to adulthood and it is the time to gain reproductive capacity (3, 4).

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Physical changes related to puberty are: changes in the fat gland and muscle and mass of bone based on hypothalamic-pituitary-gonadal. This axis is active in three phases of one's life (fetus, infant, adult) (5). After a rather long silence period in childhood, this axis is reactivated during the puberty. The Gonadotropin-releasing hormone (GnRH) is secreted faster from hypolathamus and as a result sexual hormones are released faster from sexual glands and this leads to quick changes in a teenager and appearance of sexual secondary characteristics. It is obvious that girls' health is crucially important at this level (6).

Puberty in girls occurs when they are 8 to 18 years ole and includes thelarche, pubarche, gonadarche, adrenarche, and menarche (7). Marshal and Tanner, who proposed a five-stage scale for puberty bases on secondary sexual features, showed that thelarche is the first puberty sign in girls starting from 8 to 13 years old usually appearing when the girl is 11 years old. Menarche or the first menstruation is among the last signs which occurs after peak high velocity and 2 or 3 years after thelarche (8).

Studying the lifestyle of teenagers around the world indicates that in the industrial countries during the 19th century, the age of puberty decreased which was accompanied by wrong diets, psychological pressures, low physical activity, increasing inaction and staying at home. All these lead to obesity and immature puberty in girls (9, 10). Troiano et al. reported that only 8 percent of teenagers aged 12 to 19 take part in physical activity for 60 minutes per day (11). Also researchers have suggested that teenagers do moderate to intense, various and enjoyable physical activity for 60 minutes or more per day (12).

Although the most important determining factor for puberty timing is genetic, it has been observed that metabolic status and the amount of stored energy in body plays a key role in puberty timing. With the progress of puberty in girls, body fat mass increases

because of the effect of sexual hormones. Fat tissue is not merely a storing place for fat, though. It can also produce biologic active proteins called adipocytokines, one of which is leptin. Once the child approaches its puberty, fat percentage of the body increases as does the level of serum leptin (13). Leptin is a hormone derived from fat tissue which has a direct relation with fat mass amounts in the body and is observed in white adipose and brown adipose tissues, as well as in embryonic tissue (heart, bone, cartilage). mRNA related to ob gene is called leptin which is derived from the Greek work leptos meaning thin. It is a signal for the beginning of the sexual puberty. It is a hormone made by adipose cells that consists of 167 amino acids and helps to regulate energy balance by inhibiting hunger (14).

Leptin sends signals about the sufficiency of fat stores, reduction in energy absorption and rise in energy consumption to the brain. In the thin, normal leptin levels are related to the rise in the energy use. In the obese, high amounts of leptin (resistance to leptin) leads to disturbance in energy balance. Given leptin's central role, it is probable that its amounts are related to low physical activity during the teenage years and early adulthood (15, 16). Kulik et al. (2008) didn't observe a significant difference between mature and immature girls in terms of leptin gene expression (17). However, the results of a study by Schoof et al. (2004) showed the amount of leptin gene expression went up in the early years of puberty and its plasma density was related to the total fat mass of the body (18).

In a study, Rudroff et al. stated that decreasing physical activity is one of the important factors in being exposed to different diseases and developing more far during the childhood. Regular physical activity in children and teenagers helps them be in a better shape. The physiological pressure caused by the physical activity is one the potential adjusters for leptin secretion from fat tissue (19). Researches about leptin and physical activity has ended in different results since

some report the reduction of leptin and some others report no significant change. Jimenez-Pavon et al. studied 509 girls and 393 boys aged 12.5-17.5 and showed there is a reverse relation between physical activity and leptin serum density after body fat control (20). Also, Labayen et al. measured physical activity in boys and girls aged 12.5-17.5 and concluded that moderate to intensive activity (60 minutes per day) can reduce leptin levels (21). However, Barbeau et al. investigated the effect of 8 weeks of exercise with different intensities on overweight teenagers' leptin plasma levels and didn't observe any change in leptin plasma levels (22). It seems type, intensity, and duration of exercise as well as exercise routine, nutrition, gender, and other characteristics of participants result in different outcomes.

Also, growth hormone (GH) and insulin-like growth factor (IGF-1) are basic to physical growth during childhood. The main component of growth factor is a single chain axis with 191 amino acids and is known as HGH. Its secretion is controlled by a complicated mechanism including GHRH and Somatostatin. Since birth until teenage years, GH-IGF-1 is necessary for developing balanced muscles and bones. During puberty, IGF-1 increases gradually and based on the pattern of size increase and bone mass. IGF-1 has a positive effect on both length and width of the muscle and is responsible for building bone tissues (23, 24).

IGF-1 is a tropic factor which is secreted to the blood after it is produced in the liver. It helps to the development and revival of the tissues. Although it is produced during one's life, the peak of its secretion is during the puberty and it controls growth up to the age of 12 solely. These anabolic effects, then, are completed by sexual hormones (testosterone in men, estrogen in women). Sexual steroids play a key role in determining one's physical fitness during puberty (25). The rise in GH increases the density of IGF-1 which lasts after puberty. Half of the characteristics of puberty rapid

growth is related to the direct effect of sexual steroids on epiphysis growth and the other half is related to stimulating the relevant growth factor. Growth factor is necessary for desirable effects of Gonadotropin on the growth of gonads and the effect of sexual steroids on sexual secondary features (26). In terms of structure, leptin is similar to growth factor and both belong to cytokines family. Thus, one cannot reject the theory of leptin's connection to connective proteins with growth factor. The effect of leptin on growth factor is a popular subject among researchers. Leptin increases during obesity and functions as a signal for decreasing the secretion of growth hormone. The adjustment of GH secretion is done through leptin receptors in hypothalamus. Leptin prevents somatostatine genes expression in hypothalamic neurons. There is a reverse correlation between leptin and GH secretion in human beings. Also, leptin receptors are expressed at pituitary gland where leptin releases GH (27).

Studies reveal that physical activity in healthy girls before puberty and in their teens is related to anabolic compatibilities of GH/IGF-1 system. Stimulating GH/IGF-1 axis through exercise in both girls and boys before puberty and in their teens along with genetic, nutritional, and other environmental factors, leads to increasing muscular mass and finally improving cardiovascular response to the exercise. In the adults, GH increases during the exercise. The physiologic mechanism of this hormone is yet unknown. However, it may have a key role in adjusting and using energy from fat stores. Thus, it seems it affects the fat accretion. Pulse-based secretion of GH and its peak amounts during the exercise is hard to interpret (28).

Marin et al. reported that GH levels during 15 minutes of exercising on treadmill with 170-190 heart rate increased during puberty (29). Also, a short period of aerobic training (5 weeks) decreased basic levels and rest levels of IGF-1 in children and adults although muscular mass had increased (30). Therefore, it seems

exercising creates resistance in children in the early stages. This resistance leads to more catabolic effects rather than anabolic activity of hormones. This contradictory findings show the fundamental role of energy balance in adjusting IGF-1. It seems that negative energy balance due to energy use in exercises leads to decrease in IGF-1 but inappropriate nutrition and lack of change in physical activity increases IGF-1. These studies propose a simple theory that IGF-1 levels decrease after exercise due to negative energy balance and increases due to positive balance of energy (29, 31).

Thus, given the importance of puberty and its effects on children's health as well as the effect of interventions like aerobic training with moderate intensity in healthy individuals, this research investigates the effect of 12 weeks of moderate intensity aerobic training on serum leptin, growth hormone/ insulin-like growth factor-1, in mature and immature inactive girl students.

Materials and Methods

This semi-experimental research consists of 2 experimental and 2 control groups. Participants took part in pre-test and post-test. Once the Education Administration issued its permission, healthy girl students in different stages of puberty from Districts 1 and 2 in Urmia were invited. The evaluation of puberty stage was done by using Marshal-Tanner 5-stage pattern. Stages 1 and 2 include pre-puberty and its early stages and stages 3 and 4 include the time of puberty and after puberty (8). Sampling was done based on entering criteria (not having medical records including cardiovascular, high blood pressure, diabetes, not taking medicine, health and regular sleep, not doing regular exercise) and exit criteria (harmonic and menstruation disturbances, being athletes, BMI more than 25 kg/m^2). To determine desirable weight of the participants the table offered by International Obesity Task Force (IOTF) was used. Given the age of the participants, 15-85 percent point was selected as the desirable weight

(32). Once the health questionnaire was filled in and participants' parents declared their satisfaction, a briefing session was held and the final 40 girls aged 10-15 were chosen.

Physical and Anthropometric Measurement:

Participants' height was measured by meter (1 cm accuracy) and their weight was measured by scale (0.1 kg accuracy). BMI was measured by the formula n which body weight is divided by square height. Body composition was measured by body logic/body fat analyzer model OMRON made in Finland. It can measure percentage of fat and BMI, it is portable and works with battery. Sphygmomanometer (model M6, OMRON, made in Japan) blood pressure was measured during rest and while training.

Biochemical Measurement:

Before the test and after 12 hours of fasting, blood sample was taken from the participants. Also, in the post-test stage and after 48 hours of the last exercise session, 5 ml leptin, GH, and IGF-1 was taken from the participants right arm vein while they were seated. Samples were kept in -80 centigrade after their plasma was separated by centrifuge. The plasma amount of lepin was done by leptin kit made in Germany with 0.1 ng/ml sensitivity through ELISA method. GH was measured by radium kit and IGF-1 by DRG IGF-1 1600 enzyme immunoassay kit made in Germany with 0.1 ng/ml sensitivity through ELISA method.

Exercise training:

Participants were randomly categorized in 4 ten-member groups including experimental and control groups (10-12 years old) and experimental and control groups (13-15 year old). Aerobic exercise program with moderate intensity for 12 weeks, 3 sessions each week, with 45-65 percent of maximum heart rate for 45 minutes was done in a sports club in Urmia. The training started with 45 percent in the first week and ended with 65 percent in the 12th week. The main part of the aerobic training included 10 minutes warming up, 30 minutes

running, jump roping, jumping from step platform, a mixture of running and jump roping, different ball games, 5 minutes cooling down. Polar was used to measure the heart rate of participants during the training. Three rate were recorded in the memory of Polar and then participants started running (33). During the training, those girls in the control groups didn't take part in any kind of physical activity (34).

Nutrition Control:

In the first and last weeks of the protocol, participants submitted the information about their nutritional habits and diets. Participants' breakfast included one egg, 50 g cheese, one glass of juice, one and half pieces of bread, and tea (35). After 12 weeks,

post-test and blood sampling were taken in the same situation as the pre-test.

Statistical Methods:

Kolmogorov-Smirnov was used to study the normal distribution of data. Leven test was used to investigate the consensus of variances and ANCOVA was used to compare groups. SPSS 16 was used to analyze data. The significance level in all stages was $P \leq 0.05$.

Results

Table 1 shows descriptive features of control and aerobic training groups as separated for two stages of puberty (T1, T2 and T3, T4).

Table 1. General and physiologic features of student girls aged 10-15 in research groups (average ± standard deviation)

Variable	Control group T1. T2	Intervention group T1, T2	Control group T3, T4	Intervention group T3, T4	Total
Age (yrs.)	11.5±0.52	11.6±0.51	13.9±0.87	14±0.81	12.75±1.39
Height (cm)	150.2±2.82	149±3.81	163.6±1.71	162±1.63	156.3±7.22
Weight (kg)	44.9±2.76	44.1±2.13	52.9±2.02	55.1±3.51	49.25±5.51
Fat (%)	13.13±0.58	14.17±0.64	14.24±0.46	14.48±0.65	14±0.77
BMI (kg/m2)	19.80±0.54	19.80±0.53	19.76±0.45	20.9±1.11	20.07±0.83

Table 2 shows results of ANCOVA analysis based on serum leptin, GH, and IGF-1 in mature and immature inactive girl students.

The results of ANCOVA analysis show that the effect of pre-test is significant in serum leptin in T1 and T2 (F= 45.24, P≤0.05) and in T3 and T4 (F= 64.77, P≤0.05). Once the effect of pre-test was removed, the main effects of exercise on serum leptin in T1 and T2 is less in experimental group (M=4.65) than the control group (M=6.81) (F= 136.48, P≤0.05). In T3 and T4, the main effects of exercise on serum leptin is less in experimental group (M=10.20) than the control group (M=12.78) (F= 219.99, P≤0.05).

In case of GH, the effect of pre-test is significant in T1 and T2 (F= 30.45, P≤0.05) and in T3 and T4 (F= 2.36, P≤0.05). Once the effect of pre-test was removed, the main effects of exercise on GH in T1 and T2 is more in experimental group (M=3.86) than the control group (M=2.05) (F= 192.07, P≤0.05). In T3 and T4, the main effects of exercise on GH is more in experimental group (M=4.96) than the control group (M=2.98) (F= 22.02, P≤0.05).

In case of IGF-1, the effect of pre-test is significant in T1 and T2 (F= 50.15, P≤0.05) and in T3 and T4 (F= 50.15, P≤0.05). Once the effect of pre-test was removed, the main effects of exercise on IGF-1 in T1 and T2 is less in experimental group (M=210.80) than the control

group (M=225. 50) (F= 38.07, P≤0.05). In T3 and T4, the main effects of exercise on IGF-1 is less in

experimental group (M=258.30) than the control group (M=334.20) (F= 32229.81, P≤0.05).

Table 2. The results of ANCOVA to study the effect of exercise on GH/IGH-1, serum leptin in inactive girl students in different stages of puberty

Dependent variable	Source	Square averages	Df	F	Sig.	Partial n2
Leptin group	Pre-test	8.04	1	45.24	0.001	0.727
T1, T2	Post-test	24.24	1	136.48	0.001	0.889
GH group	Pre-test	2.68	1	30.45	0.001	0.642
T1, T2	Post-test	16.89	1	192.07	0.001	0.919
IGF-1 group	Pre-test	10682.90	1	50.15	0.001	0.747
T1, T2	Post-test	8109.22	1	38.07	0.001	0.691
Leptin group	Pre-test	11.86	1	64.77	0.001	0.792
T3, T4	Post-test	40.27	1	219.99	0.001	0.928
GH group	Pre-test	2.36	1	55.57	0.001	0.766
T3, T4	Post-test	22.02	1	518.06	0.001	0.968
IGF-1 group	Pre-test	18704.28	1	144.57	0.001	0.895
T3, T4	Post-test	32229.81	1	249.65	0.001	0.936

Table 3 shows the results of ANCOVA 2*2. The results indicate that once the effect of pre-test is removed, significant effects between exercise training and puberty type and serum leptin are observed (F= 6.82, P≤0.05). Serum leptin is less in experimental groups (M=7.42) than control groups (M=9.79). Also, the groups in T3 and T4 (M=11.49) have more leptin serum than the groups in T1 and T2 (M=5.73). Moreover, leptin serum is more in experimental T3 and T4 groups (M=10.20) than experimental T1 and T2 groups (M=4.65). Also, leptin serum is more in control T3 and T4 groups (M=12.78) than experimental T1 and T2 groups (M=6.81).

The results indicate that once the effect of pre-test is removed, significant effects between exercise training and puberty type and GH are observed (F= 4.81, P≤0.05). GH is less in experimental groups (M=4.41) than control groups (M=2.52). Also, the groups in T3 and T4 (M=3.97) have more GH than the groups in T1

and T2 (M=2.95). Moreover, GH is more in experimental T3 and T4 groups (M=4.96) than experimental T1 and T2 groups (M=3.85). Also, GH is more in control T3 and T4 groups (M=2.98) than experimental T1 and T2 groups (M=2.05).

The results indicate that significant effects between exercise training and puberty type and IGF-1 are observed (F= 6.49, P≤0.05). IGF-1 is more in experimental groups (M=234.55) than control groups (M=279.85). Also, the groups in T3 and T4 (M=296.25) have more IGF-1 than the groups in T1 and T2 (M=218.15). Moreover, IGF-1 is more in experimental T3 and T4 groups (M=258.30) than experimental T1 and T2 groups (M=210.80). Also, IGF-1 is more in control T3 and T4 groups (M=334.20) than experimental T1 and T2 groups (M=225.50). Therefore, there is a difference between variables in different groups of inactive girls.

Table 3. The results of ANCOVA 2*2 based on source of effect on GH/ IGF-1, serum leptin in inactive girl students

source	Dependent variable	Square averages	Df	F	Sig.	Partial n2
	leptin	1.19	1	6.82	0.013	0.163
Training * puberty type	GH	0.313	1	4.81	0.035	0.121
	IGF-1	1172.20	1	6.49	0.015	0.157

Discussion

The present research is set to investigate the effect of 12 weeks of moderate aerobic training on serum leptin, GH, and IGF-1 on mature and immature inactive girl students. The first finding was that moderate aerobic training decreases leptin. Also, there was a difference between variables in different groups of girls. The amount of leptin hormone is effected by factors such as glucocorticoids, insulin, and some cytokines like TNFα, IL-1, Catecholamines, endrogenes and thyroid hormones. Also, because this hormone is secreted from adipose tissue, can activate NPY and lead to metabolism effects such as decreasing the secretion of NPY, food consumption, weight, far percentage, appetite, and increasing tone sympathetic and energy consumption. This hormone has effects on free fat acids' metabolism in skeletal muscles and leads to deceasing of triglyceride stores in muscular tissue (36). Martinez et al. (2012) reported that teenagers aged 13-17 doing moderate or intense regular physical activity, have less leptin plasma level than teenagers doing activity less than recommended (60 minutes per day) (37). Sport activities result in decreasing serum leptin but its response to a single-session exercise is dependent on its being done with more intensity or done more than an hour (38). In studies about adults, adaptation to exercises lasting at least for 4 weeks came with leptin reduction. Also, most studies on children before puberty and teenagers in their puberty show aerobic exercise decreases serum leptin significantly (39). Souza et al. (2004) showed that intense aerobic exercise leads to reduction of serum

leptin in children and teenagers (40). Also, in this research 12 weeks of aerobic training led to reduction of serum leptin in T1 to T4. The justification for this change is that physical training includes the most changeable part of energy use and long-term training can activate effective metabolic paths in leptin expression. They can also moderate leptin density. Therefore, change in energy cost by exercise is effective on leptin amount (41). Moreover, long-term training can change the density of hormones that play a role in development of puberty and adjustment of leptin and make changes in leptin incentives (GH, cortisol, insulin) and leptin controllers (testosterone, epinephrine and norepinephrine). This explains the effect of training on plasma level (20). Also, regular exercise training in children and teenagers increases insulin sensitivity and decreases resistance to insulin. There is a strong link between leptin and resistance to insulin in teenagers. Thus, increasing insulin sensitivity can be another mechanism for the effect of regular physical exercise in teenagers on decreasing leptin density (22). The effect on physical training on leptin is still unclear, though. The results of this research are in line with the studies of Roman et al. (2004), Jemenz-Pavon et al. (2012), and Ackel et al. (2014) (20, 42, 43) which report the reduction in leptin density. However, the results of this study didn't confirm Barbeau et al. (2003), and Casimiro et al. (2009) (23, 44) which report no significant effect on serum leptin. The difference can be due to different intensities of the activity for teenagers aged 10-15. The moderate exercise training was selected for this study

because it is one of the most common exercises. Doing exercise moderately or intensely can change the density of some effective hormones on puberty such as leptin (45).

This research showed that changes in GH in T1, T2 and T3, T4 groups who did 12 weeks of aerobic training with 45-65 percent of maximum heart rate, increased significantly. Also, there was a difference in variables amounts among different groups of inactive girls. Seo et al. (2010) reported thee increase of GH in elderly women after 12 weeks of aerobic and mix exercises (46). The increase in GH synthesis as the result of training depends on the individual's physical fitness. The more robust the person, the less the response of GH to the exercise. It is probable that when adrenergic alpha receptors are controlled during exercise training, no significant change occurs in GH response to stress. However, when adrenergic beta receptors are controlled, GH secretion accelerates. Increasing GH secretion can be also due to the reduction in catabolism amount. The total increase in GH shows significant increase in serum GH level by pituitary gland during the exercise training. GH response to exercise is more in women which can be due to Estrogen amount, low fitness or high metal stress during the exercise training. The temperature also influences GH secretion. The increase in environment temperature can intensify GH secretion or vice versa (47). Different mechanisms have been proposed for GH increase after doing exercise. One of the mechanisms is exercise training duration as one of the factors for GH response to exercise. If the duration of the training is less than 5 weeks, it leads to catabolic response and if it is more than 5 weeks, it leads to anabolic response (48). Thus, it seems in this study, anabolic effect is stimulated. Also the hormone which releases GH can be effective. One of the other mechanisms is the chronic effect of exercise training. GH increases in response to different exercises but the type of response is different. Researches show short-term exercise can increase

reactive-immune responses of GH while exercises which last for some weeks, stimulate biologic and anabolic GH responses (48). The other mechanism can be increase in blood lactate density, increase in hydrogen ion in blood, rate of needed oxygen to available oxygen, afferent signals resulting from muscle's metabolic receptors, activity of motion center and change in central temperature. All these factors are influenced by exercise training. Training stimuli dose can determine the change in these factors and finally the extent of GH response (49). The results of this study about GH increase are in line with those of Meckel et al. (2009), Zaldivar et al. (2006), Bosco et al. (2000) (50, 51, 52). Buukyazi et al. (2003) reported that 8 weeks of aerobic training has affected GH in boy teenagers and the rest levels of this hormone before and after training have also increased.

Aerobic training included frequent running and continuous running. The results of this study were in line with the present one as the types of both studies resemble to a great extent. Buyukyazi et al. pointed to the increase in sympathetic activity as one of the reasons behind this increase. They stated that the increase in sympathetic activity leads to epinephrine and norepinephrine release which in turns increases the release of GH (53). Craig et al. (1991) reported that 10 weeks of training didn't change GH response to one session activity in weight lifting and mixed groups (54). Also, Barari et al. (2012) showed that short-term resistance training didn't make a significant change in GH amounts (55). The results of this study don't match the present one. Since participants in this study were untrained, GH response to training was remarkable in them. Finally, it can be said that many factors influence on the effect of training on GH release. Type of study is one of these factors. Some studies report total density of GH and maximum density of GH while others evaluate GH release using cluster analysis. On the other hand, intense and long-term response of training creates

different results about the effect of training on GH release and can explain the controversies.

Despite the anabolic adaptation (increase in GH) in the trainees, the 12-week training program of this research didn't have a significant increase in IGF-1 and that was predictable from other studies (56). Trainings in mature and immature girl students decreased IGF-1 significantly. These results are in line with those of Eliakim et al. (2001) in girls before puberty (57), Eliakim (1996) in teenage girls after puberty (58), Timothy et al. (2002) in mature and immature boys (59), and Yuichiro Nishida et al. (2010) (60). Yuichiro Nishida et al. (2010) (60) reported 9% decrease in IGF-1 in 40 healthy men aged over 22 after aerobic training with low intensity on ergometer bicycle for 2 days (60). Smith et al. (1987) studied healthy mature men for 10 days and reported that increasing in the physical activity accelerates the decrease in IGF-1 which came with calorie limits. One potential variable for interpreting these results is the intensity of training program for decreasing IGF-1 (61). Exercises with high intensity leads to a slight increase in IGF-1 but if they are done with sufficient intensity, IGF-1 densities would decrease (59). There have been no studies yet investigating training duration with decrease in IGF-1 densities. However, Nindl et al. showed that after one intense training session, IGF-1 returns to basic levels at least after a night (62). Moreover, some studies like that of Koziris et al. (1999) (63), Gulmans et al. (2001) (64), Santos-Filho et al. (2011) in the elderly (65), reported increase in IGF-1 after training which didn't confirm this research findings. This difference can be due to participants' age and training type.

Decreasing IGF-1 amounts after training sessions in children can be explained with a mechanism like the one in adults. Stimulating TNFα, IL-1, and IL-6 controls anabolic activity of GH/IGF-1 directly and collective effect of individual trainings leads to decreasing of basic levels in IGF-1 (66, 67). In support of this recent study,

increase in TNFα, IL-1, and IL-6 was reported after football training in children (68) and also after 5 weeks of resistance training in mature and immature boys (59). Smith proposed that in adults, blood circulation levels like TNFα in those exposed to hyper-training syndrome had a significant increase (69). Timothy reported that each training program with considerable increase in energy costs due to physical activity first increases inflammatory cytokines in blood circulation. Moreover, as the training goes on, if adaptability to trainings is achieved, inflammatory cytokines decrease and thus, IGF-1 suppression decreases. Then, GH/IGF-1 revision occurs once more and IGF-1 goes more than pre-training level (59). As mentioned earlier, studies show that IGF-1 amounts in blood circulation is related to muscular mass and cardiovascular indexes. Changes in IGF axis includes decrease in IGF-1, and increase in IGFBP-1 which comes with lifestyle improvement with a decrease in the growth of cancer cells (70). Physiological effects of IGF-1 decrease after aerobic training are not clear now although studies show IGF-1 injection leads to hypoglycemia which usually comes with stimulation of environment glucose absorption (71). Thus, another theory for changes in IGF-1 levels is an adaptation response for preventing hypoglycemia as the result of insulin insensitivity to training (60). The main factor for increasing IGF-1 in liver is GH which stimulates IGF-1 synthesis and increases with insulin increase. Although there are few fasting insulin levels, they decrease significantly after exercise intervention. Therefore, it can potentially participate in decreasing IGF-l levels (72). Jahreis et al. proposed some suggestions for decreasing IGF-1 levels in their study of girl gymnasts: 1. direct effect of energy deficiency during long-term training, 2. decreasing T3 densities and T3 deficiency syndrome, 3. Anti-insulin effect of GH and its high secretion during exercise, 4. Multi-increase in the density of bound proteins to IGF-1 during exercise which decreases receptors linked to IGF-1 (73).

Since scientific data lack in determining desirable level of physical activity in children and teenagers, data of present research speculates that moderate physical activity can change factors such as GH and IGF-1 and create balance in both catabolic and anabolic processes in the growth of mature and immature girls.

In general, results of this research showed that 12 weeks of training with moderate intensity in healthy inactive girl students in their T1 to T4, makes significant changes in hormone and growth indexes in the puberty process which indicates the desirable effect of exercise type, intensity and duration in inactive mature and immature girl students. It is noteworthy that some of these changes are the results of growth natural process during puberty. Thus, regular aerobic training with moderate intensity can be a preventive treatment for fatness during puberty, amenorrhea, early puberty, and dysmenorrheal in teenage girls. Therefore, considering effective mechanisms with different intensities during puberty in inactive teenage girls and choosing larger population are crucial for the next studies. It is necessary to have a deeper understating of effective hormones on puberty and their relation with physical activity as well as physiological changes particularly in girls.

Acknowledgments

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