

Effect of Six Months of Aerobic Exercise on Serum Levels of Insulin, Growth Hormone and Insulin-Like Growth Hormone 1 in Sedentary Obese Women

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ABSTRACT

Background and Objectives: Inactivity, obesity and hormone disorders can lead to various diseases in obese and non-athletic individuals. The objective of this study was to investigate effects of six months of aerobic exercise on serum levels of insulin, growth hormone (GH) and insulin-like growth hormone 1 (IGF-1) in sedentary obese women.

Methods: In this quasi-experimental study, 15 inactive, obese (body mass index >30) women aged 37-47 years were selected from employees of the Ferdowsi University in Mashhad (Iran), via purposive and available sampling. The participants were randomly divided into an experimental group (n=10) and a control (n=5) group. The experimental group performed 60 minutes of aerobic exercise at 55-65% of heart rate reserve, three sessions a week, for six months. Serum GH, IGF-1 and insulin levels were measured in both groups before the first training session and after the last training session. The Shapiro–Wilk test and the Levene's test were used to assess normal distribution of data and homogeneity of variance, respectively. Independent and dependent t-tests were used to compare between-group and within-group differences at significance of 0.05. All statistical analyses were performed using the SPSS software (version 18).

Results: Serum concentrations of IGF-1 and insulin reduced significantly following the six-month aerobic exercise program. In addition, the exercise training caused an insignificant increase in GH levels.

Conclusion: Our proposed aerobic exercise protocol significantly reduces IGF-1 level, which is closely related to the incidence of atherosclerosis, breast cancer, and colon cancer. The significant decline in insulin secretion following the six-month aerobic exercise program may provide more amounts of nutrients for muscle glucose metabolism.

Keywords: Growth hormone, Insulin, Insulin-like growth factor 1, Exercise.

INTRODUCTION

Overweight and obesity are among the major issues of the 21st century. Obesity is one of the most important risk factors of cardiovascular disease, diabetes, skeletal abnormalities, respiratory and metabolic disorders, cancer, and psychosocial disorders (1). Atherosclerosis is the most important cause of coronary artery disease (2). Genetic, hormonal, metabolic and behavioral factors are involved in development of obesity (3).

Hormones are important factors that affect all body functions (4). Exercise induces considerable changes in the level of some hormones compared to rest period (5). Exercise training increases body demands and causes extensive physiological changes. Therefore, evaluating the physiological events during exercise and adaptation to physical demands is of great importance (6).

Growth hormone (GH) is a non-tropic hormone secreted from the anterior lobe of the pituitary gland that increases muscle growth and hypertrophy by facilitating the transfer of amino acids into the cells. This hormone can exert these effects through production of an intermediate protein in the liver and other cells, known as insulin-like growth factor-1 (IGF-1) or somatomedin C (7). Obese individuals have lower serum concentration of GH and significantly reduced GH secretion, which may present as abdominal fat and increased fat mass (8). The level of plasma GH can influence the amount of plasma free fatty acids. The secretion of GH declines with age, resulting in reduced β -oxidation of lipids and metabolism of free plasma fatty acids. This increases the amount of insoluble fats such as cholesterol and the deposition of these substances in the arterial wall, ultimately leading to the development of atherosclerosis (9).

IGF-1 is a polypeptide hormone with an amino acid sequence similar to that of proinsulin. The hormone exerts strong growth-promoting effects on muscles and bones and plays a crucial role in growth and metabolism (10). There is a regulatory feedback relationship between GH and IGF-1 where GH secretion increases the hepatic production of IGF-1. Moreover, insulin levels can affect IGF-binding protein 1 (IGFBP1) levels and contribute to the regulation of IGF-1 availability to tissues (11). There may be a correlation between serum IGF-1 levels and

increased carotid intima-media thickness and atherosclerosis (12). In this regard, a study demonstrated a reduction in vascular inflammatory responses, systemic vascular oxidative stress and progression of atherosclerotic plaques in experimental mice (13). Decrease in IGF-1 levels or increase in IGF-BP3 protein can reduce the risk of breast cancer and colon cancer in women (5). It has been shown that aerobic exercise can increase level of anabolic hormones such as GH and IGF-1 in women. Dysfunction of these hormones may result in an increase in fat mass and in a progressive decline in muscle mass (14,15).

As an anabolic hormone, insulin plays an important role in nutrients entry to the cells. In absence of insulin, the transfer of glucose and fatty acids into myocytes is not possible (16). Deficiency or reduction of insulin is associated with development of diabetes. Obese individuals have reduced sensitivity to insulin, thus the pancreas of these individuals should release more insulin to lower plasma glucose (17).

Reduced insulin level increases lipolysis and hepatic glycogenolysis, and inhibits glycogen synthesis. In addition, reduction in insulin secretion increases blood glucose levels (18). Although several studies have been conducted on hormonal responses to exercise activities, especially to resistance training, results of studies on physiological and hormonal responses to aerobic exercise in obese, middle-aged women are limited and contradictory. Therefore, the aim of this study was to investigate effects of a six-month aerobic exercise program on serum levels of GH, IGF1 and insulin in sedentary middle-aged women.

MATERIAL AND METHODS

In this quasi-experimental study, 15 inactive, obese [body mass index (BMI) >30] women aged 37-47 years were selected from employees of the Ferdowsi University in Mashhad (Iran), via purposive and available sampling. Exclusion criteria included drug use, menopause, smoking, and participation in a training program within the last six months. The participants were randomly divided into an experimental group (n=10) and a control (n=5) group. Before the start of training sessions, information and characteristics of the subjects including age, gender, medical

records, blood pressure, heart rate, and cardiovascular fitness were recorded. Written consent was taken from all participants. Anthropometric characteristics such as height, weight and BMI of each subject were measured and recorded. After completion of questionnaires and examinations, the subjects participated in a briefing before the start of the protocol. The variables were measured by collecting venous blood samples (7 ml) from the left hand of each subject in seating position, 48 hours before the first training session (pretest) and 48 hours after the last training session (after six months of training). The subjects performed 60 minutes of aerobic exercise, three sessions a week, for six months. The training protocol included slow walking and running, aerobic exercise at constant intensity and 55-65% of heart rate reserve. The exercise intensity was controlled with a heart rate monitor (Polar, Finland). The control group did not perform any exercise. Insulin level was measured with double-antibody radioimmunoassay using DRG ELISA kits. GH level were measured using DiaSorin kits and an ELISA reader (USA) with a sensitivity

of 0.2 ng/ml. IGF-1 level was measured by chemiluminescence immunoassay using an calculating the mean and standard deviation (SD) for each variable, the Shapiro–Wilk test and the Levene's test were used to assess normal distribution of data and homogeneity of variance, respectively. Independent and dependent t-tests were used to compare between-group and within-group differences at significance of 0.05. All statistical analyses were performed using the SPSS software (version 18).

RESULTS

Table 1 shows the characteristics of the subjects in both study groups. Results of the dependent t-test showed that IGF-1 and insulin levels reduced significantly after the six months of aerobic training ($P < 0.05$). Although GH increased in the training group, this increase was not statistically significant (Table 2). Results of the independent t-test revealed a significant difference in the insulin level between the two groups, but there was no significant difference in terms of GH and IGF-1 levels (Table 3).

Table 1- Characteristics of the participants in the training and control groups

Variable	Training group	Control group
Height (cm)	156.00±5/033	157.00±3.606
Weight (Kg)	80.53±9.224	77.780 ±7/074
Age (year)	41.70±3.198	43.40±1.51
BMI (Kg/m ²)	31.7±5.4	30.8±6.3

Data are shown as mean ± SD

Table 2- Mean ± SD of GH, IGF-1 and insulin levels in the training group

Index	Pretest	Posttest	P-value
GH (ng/ml)	8.18 ± 2.002	8.23 ± 2.29	0.927
IGF-1 (ng/ml)	192.8 ± 22.69	178.4 ± 25.35	*0.035
Insulin (mIU/ml)	9.17 ±2.71	7.63 ±1.78	*0.03

Table 3-Comparison of posttest values of GH, IGF-1 and insulin between the training and the control group

Index	Control group	Training group	P-value
GH (ng/ml)	8.8 ± 2.239	8.23 ± 2.293	0.655
IGF-1 (ng/ml)	196.4 ± 8.502	178.4 ± 25.35	0.152
Insulin (mIU/ml)	11.46 ±3.123	7.63 ±1.78	*0.009

DISCUSSION

The six-month aerobic training program resulted in an insignificant increase in the GH level. There was no significant difference between the two groups in terms of GH level. Evidence demonstrates that GH response to submaximal exercise depends on the exercise intensity. The threshold of growth hormone response is approximately 60-80% of the maximal oxygen uptake (VO_{2max}). Performing

exercise for sufficient time and at moderate intensity does not affect the GH level. Ultimately, the exercise-induced increase in GH synthesis relies on the physical fitness of the individual (19). On the other hand, GH release is regulated by growth hormone releasing hormone; a neuropeptide secreted by the hypothalamus (20). Since sedentary women have low physical fitness, this

intensity of exercise leads to fatigue, which is accompanied with lactic acid accumulation. This induces GH secretion and stimulates metabolic receptors and transmission of neural signals to the central nervous system and hypothalamus, subsequently resulting in GH secretion from the anterior pituitary gland (21, 22). Another factor involved in the GH release and partial increase in GH values could be the increase in sympathetic nervous system activity (23). Overall, the GH response to exercise is more notable in women, which may be attributed to the estrogen level or the low physical fitness of people with high stress during exercise (24). In this regard, studies have shown that 12 weeks of aerobic exercise (three sessions per week and at various intensities) have no significant effect on GH levels of 15 45-year-old men (25). It has also been reported that 16 weeks of 30-minute submaximal aerobic training at 70% VO_{2max} have no significant effect on the level of anabolic hormones, such as GH (26). In a study, 12 weeks of aerobic and combination exercise training consisted of walking and resistance training with 50-70% of one-repetition maximum significantly increased GH level in elderly women (50-65 years old) (14). It has also been shown that eight weeks of aerobic training at 35-60% of the target heart rate caused a significant increase in GH level of elderly women (27). Based on the results of previous studies, it can be concluded that GH response is more influenced by the intensity and duration of trainings, the type of exercise training, the physical fitness of individuals, and time of blood sampling (14, 25-27). The most effective exercise programs not only should meet the exercise goals, but also stimulate secretion of hormones involved in anabolism (28).

The results of this study showed that the six months of aerobic training significantly reduced the IGF-1 level. In line with this finding, a study reported that six months of aerobic exercise at 55-65% of heart rate reserve significantly reduced IGF-1 levels in 19 inactive middle-aged women (24, 29). Serum IGF-1 concentrations are influenced by various physiological factors, and GH is the most important determinant of IGF-1 synthesis in the liver (30). Since reduction in serum IGF-1 concentrations in response to exercise could also be due to a reduction in hepatic IGF-1 release in response to GH, the reduced

IGF-1 concentrations in our study can be attributed to the lack of a significant increase in the GH levels, as GH only increases in response to intense training (31, 32). The incidence of colon cancer is thought to be closely related to changes in the IGF-1 concentration, in a way that individuals with high IGF-1 concentrations are at 2.5-fold higher risk of developing colon cancer (33,34). In general, the mechanisms involved in the secretion and control of GH and IGF-1 include growth hormone releasing hormone secretion from the hypothalamic nuclei, secretion of GH from the anterior pituitary gland, and GH-induced IGF-1 secretion from the liver. Proteins bound to IGF-1 are considered as factors that indirectly affect musculoskeletal growth. These proteins reduce concentrations of free IGF-1 and subsequently reduce their anabolic effects, but they also increase IGF-1 longevity by preventing its breakdown (35). We also found that the six-month aerobic exercise program could significantly reduce insulin levels. Strong evidence supports the role of GH/IGF-1 axis in maintaining normal glucose homeostasis, and the association of insulin with increased IGF-1 synthesis and activity (36). Some myogenic effects of insulin may be generated through interaction with IGF-1 receptors (37). Thus, the decreased level of insulin in our study can be attributed to the reduction in IGF-1 levels. Reduced physical activity with age may partially lead to a decrease in anabolic hormones, indicating the effectiveness of increased physical activity for compensating the reduction of hormones (38). In addition, insufficient insulin secretion and the development of insulin resistance can lead to diabetes mellitus. Previous studies reported a significant decrease in serum insulin levels following several weeks of aerobic training (39, 40). Moreover, a study reported that eight weeks of aerobic training in obese women does not cause a significant decrease in insulin levels (41). Other studies demonstrated lack of a significant change in serum insulin levels of obese women following several months of low-intensity aerobic exercise, which might be associated with insufficient intensity of walking exercises (42).

CONCLUSION

We demonstrated that exercise at moderate (submaximal) intensity significantly affects insulin and IGF-1 levels, but has no

significant effect on GH levels. This hormonal response to physical activity could be influenced by the intensity and duration of exercise. It can be concluded that the six-week aerobic training program used in the study has positive impact on metabolism.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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