ORIGINAL ARTICLE

The Effect of Aerobic and Resistance Exercises on Hormonal Changes in Non-Athlete Students at Shiraz University, Southern Iran

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Abstract

Background: Considering the effect of leptin and different hormones on energy homeostasis, metabolism and weight changes, the relationship between these variables and sport activities have been taken into consideration by researchers. This study was conducted to determine the effect of aerobic and resistance exercises (weight training) on hormonal changes of leptin, insulin, cortisol, thridotironine and thyroxin levels in non-athlete students at Shiraz University, southern Iran.

Methods: Sixty non-athlete male students at Shiraz University were randomly divided into 3 groups of control, aerobic and resistance exercises. The exercise programs were continued for 8 weeks, 3 sessions each week. Participants were bled between 8 and 10 o'clock in the morning in a fasting state. Leptin, insulin, cortisol, thridotironin and Thyroxin levels of plasma were measured in 5 phases (before the beginning of exercise, at the end of the second, fourth, sixth, and eighth weeks of exercise).

Results: In the aerobic group, the mean leptin and insulin levels decreased significantly during the 5 measurement phases but the cortisol and thyroxin levels increased significantly. In the resistance exercise group, there was a significant decrease in leptin and insulin levels. When the mean levels of cortisol, thridotironine and thyroxin increased, these changes were not significant.

Conclusion: Exercise can change hormonal concentration of insulin, cortisol, growth hormone, catecholamine, testosterone, etc. and the metabolism of free fatty acids, lactic acid, triglyceride, etc and reduce the amount of adipose tissue and energy consumption.

Keywords: Leptin; Insulin; Cortisol; Thridotironine; Thyroxin**;** Aerobic exercises

Introduction

Leptin, a protein consisted of 146 amino acids was first introduced following the separation of obesity gene in 1994 and structurally belongs to the cytokine family.[1-3] Although there are evidences to show that this protein is produced by skeletal muscle, liver, fetal, ovary and gastric epithelium cells,[4] it is also secreted by the fat cells.[5] Leptin conveys the information related to energy sources to the hypothalamus receptors and prevents the overeating (anti-obesity hormone).[5] Leptin also affects the hormones involving the metabolism.[6] Furthermore, it is effective in establishing a balance between food consumption to maintain energy homeostasis too.[7]

Thyroid hormones increase the metabolism of carbohydrate and fat resulting into the loss of weight. Cortisole as a catabolic and insulin as an anabolic hormone (glycogens) are the effective hormones in metabolism.[8,9] Considering the effect of leptin and different hormones on energy homeostasis, metabolism and weight changes, the relationship between these variables and sport activities have been taken into consideration by researchers.[9,10]

This study was undertaken to determine the effect of aerobic and resistance exercises (weight training) on

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hormonal changes of leptin, insulin, cortisol, thridotironine and thyroxin levels in non-athlete students at Shiraz University, southern Iran**.**

Materials and Methods

Sixty non-athletic male students studying at Shiraz University, southern Iran entered this study. They were randomly divided into 3 equal groups, control, aerobic and resistant exercise groups. Before performing the research, all subjects were informed about the study protocol, and a written consent was provided from each participant. All participants had their food at university self-service. The physical and physiological characteristics of the subjects are presented in Table 1.

The experimental groups were one participating in aerobic exercise and the other in resistant (weight) exercise. The training program for aerobic exercise was performed during 8 weeks, 3 sessions each week. The intense of the training program proceeded form 50% to 55% (in the first 2 weeks), 55% to 60% (in the second 2 weeks), 60% to 65% (in the third 2 weeks) and 65% to 70% of maximum heart beat (in the last 2 weeks). The duration of training programs without the warm up and cool-down was 15 minutes (balk field test). The intense training program was controlled and regulated, using a polar. All subjects performed a warm up (20 minutes) and a cool-down (15 minutes) program in every training session. The resistance group performed the training program during 8 weeks, 3 sessions each week. The subjects carried out a 45 minute weight training program after 20 minutes warm up (Delworm and Watkins method).[8] Each training program consisted of 3 sessions with10 maximal repetitions at every set. At the end, they performed a 15 minute cool-down program. Before the beginning of research, the subjects became familiar with the procedure of light weight training for 2 sessions. The subjects' blood samples were taken between 8 and 10 o'clock in the morning in a fasting state. Plasma Leptin, insulin, cortisole, thridotironine and thyroxin levels were measured in 5 phases (before the beginning of exercise, at the end of the second, fourth, sixth, and eighth weeks). All blood samples were transferred to the laboratory and the serum was separated and frozen for further analysis at -70°C. The plasma leptin was measured by the RIA method, and insulin, cortisole, thridotironine and thyroxin by ELISA method, using special kits. Weight, height, body mass index and consumed oxygen were measured, using proper devices/methods: weight by scale, height by measuring-tape, body mass index (BMI) by the ratio of weight to square root of height and consumed oxygen by Quinn ladder. Also, descriptive statistics was used to determine the means and standard deviations and the ANOVA test used to determine the significance of the hypotheses (p<0.050) Pearson method was used to specify the correlation coefficient (p<0.050) and the Excel program to draw the graph.

Results

The changes in the control group was not significant (p>0.050). Table 2 demonstrates the mean changes in leptin, insulin, cortisol, thridotironine and thyroxin levels of plasma in 5 phases (before the beginning of exercise, at the end of the second, fourth, sixth, and eight weeks). All participants who carried out the aerobic exercise lost some weight. In this group, a significant relationship was observed between the decrease in plasma leptin levels and the decrease in weight and body mass index [(r=0.65, p=0.021); (r=0.69, p=0.020) respectively]. Mean Leptin (p=0.014) and insulin (p=0.031) levels decreased during the 5 measurement phases but cortisol (p=0.023) and thyroxin (p=0.012) levels increased significantly. There were significant relationships between the

Table 1: Physical and physiological characteristics of the subjects

Group	Frequency	Mean height (cm)	Mean weight (kg)	Mean age (Year) (	BMI (kg/m^2)	Vo2max (ml.Kg-1.min-1)
Control	20	175±1	81±3	21±1.1	26.5±.7	45.6±1.3
Aerobic exercise	20	177±1	83±2	21±1.6	26.5±.5	44.3±1.6
Resistance exercise	20	175±3	82±6	21±1.2	26.7±.5	45.8±1.2

Note .BMI - body mass index; VO2max – maximal oxygen consumption

Table 2: Mean changes in plasma leptin, insulin, cortisole, thridotironine and thyroxin levels in 5 phases

Group	Variables	First stage	Second stage	Third stage	Fourth stage	Fifth stage
Control	Leptin (ng.ml)	12.22	12.11	12.33	12.41	12.42
	Insulin (µu.ml)	13.14	13.14	13.22	13.18	13.17
	Cortisol (µg.dl)	12.74	12.81	12.82	13.9	12.86
	Thyroxin (ng.ml)	109	111	112	111	115
	Thridotironine (ng.ml)	1.39	1.42	1.4	1.45	1.41
Aerobic	Leptin (ng.ml)	13.47	13.32	11.80	11.41	*11.12
	Insulin (µu.ml)	13.27	13	11.90	11.50	*11.13
	Cortisol (µg.dl)	13.39	13.81	14.30	14.90	*15.38
	Thyroxin (ng.ml)	106	111	114	117	*120
	Thridotironine (ng.ml)	1.14	1.16	1.21	1.23	1.28
Resistance exercise	Leptin (ng.ml)	11.61	11.90	11.61	10.90	*10.3
	Insulin (µu.ml)	13.37	13.61	13.12	12.68	*12.09
	Cortisol (µg.dl)	12.52	12.70	13.11	13.70	14.20
	Thyroxin (ng.ml)	110	112	116	119	120
	Thridotironine (ng.ml)	1.41	1.41	1.42	1.78	1.91

*There is a significant different in comparison with the first stage (p<0.05).

decrease in leptin and decrease in insulin level (r =0.82, p=0.045) and also the decrease in leptin and increase in cortisol and thyroxin levels [(r=-0.67, p=0.032); (r =-0.62, p=0.041) respectively]. However, no significant relationship was observed between changes in leptin and thridotironine levels.

Moreover, the 8 week resistant exercise program resulted in a significant decrease in leptin (p=0.013) and insulin (p=0.024). However, the size of this decrease was less than the increase in the mean levels of cortisol (p=0.311), thridotironine (p=0.234) and thyroxin (p=0.097). This research showed that there was a positive significant relationship between the decrease in leptin and insulin levels (r=0.79, p=0.043). Moreover, the results showed that there was a negative and significant relationship between the decrease in leptin and the increase in weight and body mass index [r=-0.73, p=0.032); (r=- 0.77, p=0.034) respectively].

Discussion

Fatarus *et al.* showed that plasma leptin concentration decreased after resistance exercise (6 months, 3 days a week, 10 repetitions in 3 sets) in 50 non-athlete men. Furthermore, they observed a significant relationship between decrease in leptin and decrease in insulin and cortisole and increase in epinephrine and norepinephrine.[11] Ishii *et al.* proved that plasma leptin level decreased after 6 weeks of aerobic exercise in type II diabetics patients, but there was not any relationship between the decrease in leptin concentration and changes in adipose tissue, insulin and glycocorticoeids. Moreover, the researcher demonstrated that there were no changes in leptin levels after resistant exercises.[12] Hickey, *et al.* expressed that distance swimming exercises for 12 weeks could decrease leptin level accompanied by a decrease in insulin. They stated that an increase in plasma leptin level led to an increase in insulin level in response to food consumption but a decrease in the insulin concentration by decreasing the leptin concentration during a fasting state.[13] Some authors reported that the duration and intense of exercise have a vital role in changes of the leptin level. In 5 males and 12 females athletes, they showed that exercises for 45 minutes duration and a 100% intense strength of aerobic exercise, the plasma leptin concentration did not change but the cortisole level in males and females increased.[14] Researchers recently express that cardiovascular and respiratory systems, antioxidants and even environmental factors (height, temperature, and gravity force) affected the plasma leptin level.[2] Some studies evaluating the effect of short-term exercise on leptin level have shown that a decrease or absence of any change in the plasma leptin level.[11,15-18] The decrease in leptin may be due to the increase in the accessible energy.[14,19]

Some researchers suggest that the insulin hormone may regulate and control the involved leptin, although it is related to the plasma glucose level. It was shown that by an increase in the insulin level, plasma leptin level can increase and in case of a decrease in

the insulin level, the leptin production would decrease.[11,12] Some researchers noticed that following a resistant exercise (weight training), the leptin and insulin levels remain unchanged and or in case of any changes, they are not significant. Furthermore, there was not any significant relationship between these two hormones.[15]

Table 2 shows that leptin and insulin in the aerobic group decreased gradually while the decrease in both groups occurred in the second week. Cortisol, thyroxin and thridotironine increased in the five phases. Moreover, in the weight training group, both variables of leptin and insulin increased in the first week, but in other phases, they decreased gradually. Besides, Table 2 shows a gradual increase in the cortisol, thyroxin and thridotironine levels. In Figure 1, the changes after and before exercise is presented showing that the rate of leptin and insulin changes in the aerobic and resistant exercise is negative (although this decrease in the aerobic group is more significant) but in the control group is positive. In relation to cortisol, thyroxin and thridotironine, an increase is visible in all groups. Although these changes are not equal (the rate of increase in cortisol and thyroxin in the aerobic group and thridotironine in the resistant exercise group are more). The duration of exercise program in these studies was less than 6 weeks (one session a week).

In our study, following the resistant exercise program, plasma insulin level increased slightly in the first 2 weeks, but gradually decreased until the end of the program (Table 2). Furthermore, a significant relationship was observed between the decrease in leptin and the decrease in insulin levels ($r = 0.79$, $p=0.043$). The amount of plasma glucose decreased due to the increase in the insulin level and the rate of leptin increased because of the decrease in the accessible energy. So after continuing the exercises, a decrease was observed in the insulin level and resulted in to an increase in the plasma glucose level. As a result, the increase in leptin level can be explained by decreasing the accessible energy. Furthermore, in our research, aerobic exercise could lead to a decrease in the mean of leptin and insulin levels (13.47 to 11.12, 13.27 to 11.13, respectively).

The most important property of cortisol was to affect the energy metabolism[19] accelerating the rate of transition and use of fat as an energy source during exercise activities.[19-22] So the liver breaks down the transitional adipose tissues into ketoacids[21] leading to ketosis. Ketosis increases the cortisol secretion in people who use low caloric diet (ketosan) especially during heavy exercises for losing weight.[22,23]

Despite some controversies,[24] some studies demonstrated that cortisol production rises when the exercise distance is increased. So after long- term exercises such as marathon, the subjects' cortisol levels rise.[13,20] It is expected that increase in the accessible energy due to cortisol to decrease the leptin level. In our study, increase in the cortisol level could decrease the leptin level which wee in agreement with some studies[19,20] and not in concordance with some studies.[21,24,25] Cortisol response depends on many factors such as intense, duration, level, nutritional status and daytime rhythm.

Some researchers showed that after weight training (6 weeks) in non-athlete people, the amount of cortisol level increased significantly.[26] The leptin and cortisol changes may be due to their production levels.[18] It was shown that in weight training, the increase in glycocorticoids level increases the leptin production.[21,22,24] In our study, plasma cortisol level increased significantly due to weight training but did not have any relationship with the decrease in leptin level.

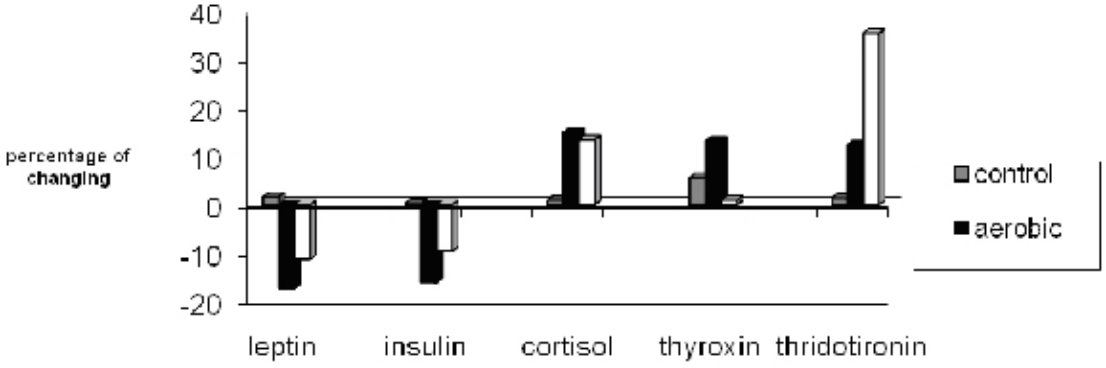

Fig. 1: The percentage of hormonal changes after and before exercise

Pocai *et al.* (2003) noticed that the rate of thridotironine and thyroxin levels increased by the increase in leptin level.[26] Magni (2005) found that when T3 and T4 levels rise, the leptin level declines.[22] In our study, after weight training, the thridotironine level remained almost unchanged during the 4 first weeks and increased in the 4 second weeks and the thyroxin level gradually increased during the program and the changes in these 2 hormones were not significant.

Many researchers suggested that intensity, duration, the number of sessions in a week, and the level of physical exercise were the effective factors in the level of T3 and T4.[9,17,18] Moreover, the mean thridotironine and thyroxin levels gradually increased during the 8 weeks of aerobic exercise, but only the changes in the thyroxin level was significant. Besides, a significant negative relationship was seen between the increase in thyroxin and the decrease in leptin levels. However, no significant correlation was observed between thridotironine and Leptin levels which may be due to the low intensity and short duration of exercises.

The rate of leptin changes affects the energy balance, adipose tissue, sensitivity to insulin, cardiovascular diseases, antioxidants and hormonal status.[18,22] Exercise would decrease the adipose tissue and would affect energy consumption and hormonal concentrations (insulin, cortisol, growth hormone, catecholamine, testosterone) and metabolism (free fatty acids, lactic acid, triglyceride).[25,23,9]

Therefore, the intensity and duration of the exercise program are important and an increase in accessible energy would result in a decrease in leptin level.

We can conclude that exercise can change hormonal concentration of insulin, cortisol, growth hormone, catecholamine, testosterone, etc. and the metabolism of free fatty acids, lactic acid, triglyceride, etc and reduce the amount of adipose tissue and energy consumption.

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References

1 Unal M, Unal DO, Baltaci AK, Mogulkoc R, Kayserilioglu A. Investigation of serum leptin levels in professional male football players and healthy sedentary males. *Neuro Endocrinol Lett* 2005;**26**:148-51. [15855887]

2 Baltaci AK, Ozyurek K, Mogulkoc R, Kurtoglu E, Ozkan Y, Celik I. Effects of zinc deficiency and supplementation on the glycogen contents of liver and plasma lactate and leptin levels of rats performing acute exercise. *Biol Trace Elem Res* 2003; **96**:227-36. [14716102] [doi:10.1385/BTER:96:1-3:227]

3 Baratta M. Leptin--from a signal of adiposity to a hormonal mediator in peripheral tissues. *Med Sci Monit* 2002;**8**:RA282-92. [12503048]

4 Chehab FF, Qiu J, Mounzih K, Ewart-Toland A, Ogus S. Leptin and reproduction. *Nutr Rev* 2002; **60**:S39-46. [12403083] [doi:10.1301/002966402320634823]

5 Dagogo-Jack S, Tykodi G, Umamaheswaran I. Inhibition of cortisol biosynthesis decreases circulating leptin levels in obese humans. *J Clin Endocrinol Metab* 2005;**90**:5333-5. [15985478] [doi:10.1210/jc.2005-0803]

6 Delorm T, Watkins A. Techniques of progressive resistance exercise. *Med Rehabil* 1948;**29**:263-273.

7 Dyck DJ. Leptin sensitivity in skeletal muscle is modulated by diet and exercise. *Exerc Sport Sci Rev* 2005;**33**:189-94. [16239836] [doi:10.1097/00003677-200510000-00007]

8 Gomez-Merino D, Chennaoui M, Drogou C, Bonneau D, Guezennec CY. Decrease in serum leptin after prolonged physical activity in men. *Med Sci Sports Exerc* 2002; **34**:1594-9. [12370560] [doi:10.1097/00005768-200210000-00010]

9 Zoladz JA, Konturek SJ, Duda K, Majerczak J, Sliwowski Z, Grandys M, Bielanski W. Effect of moderate incremental exercise, performed in fed and fasted state on cardiorespiratory variables and leptin and ghrelin concentrations in young healthy men. *J Physiol Pharmacol* 2005;**56**:63-85. [15795476]

10 Karamouzis I, Karamouzis M, Vrabas IS, Christoulas K, Kyriazis N, Giannoulis E, Mandroukas K. The effects of marathon swimming on serum leptin and plasma neuropeptide Y levels. *Clin Chem Lab Med* 2002;**40**:132-6. [11939485] [doi:10.1515/CCLM.2002.023]

11 Fatouros IG, Tournis S, Leontsini D, Jamurtas AZ, Sxina M, Thomakos P, Manousaki M, Douroudos I, Taxildaris K, Mitrakou A. Leptin and adiponectin responses in overweight inactive elderly following resistance training and detraining are intensity related. *J Clin Endocrinol Metab* 2005;**90**:5970-7. [16091494] [doi:10.1210/jc.2005-0261]

12 Ishii T, Yamakita T, Yamagami K, Yamamoto T, Miyamoto M, Kawasaki K, Hosoi M, Yoshioka K, Sato T, Tanaka S, Fujii S. Effect of exercise training on serum leptin levels in type 2 diabetic patients. *Metabolism* 2001;**50**:1136-40. [11586483] [doi:10.1053/meta.2001.26745]

13 Hickey MS, Houmard JA, Considine RV, Tyndall GL, Midgette JB, Gavigan KE, Weidner ML, McCammon MR, Israel RG, Caro JF. Gender-dependent effects of exercise training on serum leptin levels in humans. *Am J Physiol* 1997;**272**:E562-6. [9142875]

14 Buyse M, Aparicio T, Guilmeau S, Goïot H, Sobhani I, Bado A. Paracrine actions of the stomach-derived leptin. *Med Sci (Paris)*

2004;**20**:183-8. [14997438]
15 Koutkia P, Canavan B, Johnson ML, DePaoli A, Grinspoon S. Characterization of leptin pulse dynamics and relationship to fat mass, growth hormone, cortisol, and insulin. *Am J Physiol Endocrinol Metab* 2003; **285**:E372-9. [12721156]
16 Kraemer RR, Chu H, Castracane VD. Leptin and exercise. *Exp Biol Med (Maywood)* 2002;**227**:701-8. [12324651]
17 Popovic V, Duntas LH. Leptin TRH and ghrelin: influence on energy homeostasis at rest and during exercise. *Horm Metab Res* 2005; **37**:533-7. [16175489] [doi:10.1055/s-2005-870418]
18 Zafeiridis A, Smilios I, Considine RV, Tokmakidis SP. Serum leptin responses after acute resistance exercise protocols. *J Appl Physiol* 2003;**94**:591-7. [12391130]
19 Lavie CJ, Osman AF, Milani RV, Mehra MR. Body composition and prognosis in chronic systolic heart failure: the obesity paradox. *Am J Cardiol* 2003;**91**:891-4. [12667583] [doi:10.1016/S0002-9149(03)00031-6]
20 Lyngsø D, Simonsen L, Bülow J. Metabolic effects of interleukin-6 in human splanchnic and adipose tissue. *J Physiol* 2002;**543**:379-86. [12181308] [doi:10.1113/jphysiol.2002.021022]
21 Loos RJ, Rankinen T, Chagnon Y, Tremblay A, Pérusse L, Bouchard C. Polymorphisms in the leptin and leptin receptor genes in relation to resting metabolic rate and respiratory quotient in the Québec Family Study. *Int J Obes (Lond)* 2006; **30**:183-90. [16231024] [doi:10.1038/sj.ijo.0803127]
22 Magni P. Hormonal control of the neuropeptide Y system. *Curr Protein Pept Sci* 2003;**4**:45-57. [12570784] [doi:10.2174/1389203033380296]
23 Meier U, Gressner AM. Endocrine regulation of energy metabolism: review of pathobiochemical and clinical chemical aspects of leptin, ghrelin, adiponectin, and resistin. *Clin Chem* 2004;**50**:1511-25. [15265818] [doi:10.1373/clinchem.2004.032482]
24 Okazaki T, Himeno E, Nanri H, Ogata H, Ikeda M. Effects of mild aerobic exercise and a mild hypocaloric diet on plasma leptin in sedentary women. *Clin Exp Pharmacol Physiol* 1999;**26**:415-20. [10386231] [doi:10.1046/j.1440-1681.1999.03044.x]
25 Penkowa M, Keller C, Keller P, Jauffred S, Pedersen BK. Immunohistochemical detection of interleukin-6 in human skeletal muscle fibers following exercise. *FASEB J* 2003; **17**:2166-8. [12958150]
26 Pocai A, Morgan K, Buettner C, Gutierrez-Juarez R, Obici S, Rossetti L. Central leptin acutely reverses diet-induced hepatic insulin resistance. *Diabetes* 2005;**54**:3182-9. [16249443] [doi:10.2337/diabetes.54.11.3182]