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The effect of strength and resistance training on changes in total fat, body mass index and serum leptin as well as their correlation in obese sedentary employees

Amir Falahnezhad Mojarad[1] and Nematolah Nemati[2]

[1]*MA in Exercise Physiology*

[2]*Assistant Professor, Islamic Azad University of Damghan Department of Physical Education, Faculty of Human Sciences, Islamic Azad University of Damghan Damghan, Iran*

ABSTRACT

This study aims to investigate the effect of strength and resistance training on changes in total fat, body mass index (BMI), and serum leptin as well as correlation between serum leptin and BMI in obese sedentary employees. Research variables include total fat, serum leptin, body mass index, and strength training protocol for a month and in 3 sessions per week, each session lasts for 84 minutes as well as 60 to 70 percent of maximum heart rate. The strength training protocol lasts for one month and the weight training for 3 times per week, 60 to 75% for 1 repetition maximum (1RM) and the total exercise lasts for 70 minutes per session. In this study, the research method is experimental. 30 out of 110 obese employees are randomly selected as the statistical sample. The sample is categorized into three groups, including control (n = 10), resistance (n = 10), and strength (n = 10). In pre-test, demographic and physical characteristics of the sample are measured and recorded. In the post-test and after the course of the training protocol, the previous measurements are repeated. Statistical methods to compare training groups in the test process include repeated measures ANOVA, the Bonferroni post hoc test whenever a significant difference between three or more sample means has been revealed by an analysis of variance (ANOVA), and Pearson correlation coefficient to investigate the relationship between variables. Spss version 19 software is used to analyze the data and the error rate in all cases is (α = 0.5 %). The findings of the study include: 1) for both groups, the resistance training has no significant effect on serum leptin level, 2) endurance training has a significant effect on body mass index, but strength training has no significant effect on body mass index, 3) Strength and resistance training have a significant effect on total fat, 4) for the group with resistance training, there is a positive correlation between the variables of leptin and body mass index, 5) for the group with strength training, there is a positive correlation between the variables of leptin and body mass index. These changes are associated with an increase in the level of readiness for participants in both training protocol groups. Perhaps by increasing the statistical population, the intensity, and duration of exercise activities, there will be a different effect on changes of variables and their significance.

KEY WORDS: TOTAL FAT, BODY MASS INDEX, SERUM LEPTIN OBESE SEDENTARY EMPLOYEES

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**Corresponding Author: amirfalah.sport@gmail.com*
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INTRODUCTION

Obesity is considered as a major risk factor for diseases such as diabetic and coronary heart diseases. Levels of the hormone leptin are associated with body fat mass and can be regulated by hunger, eating a meal, insulin and many other factors. Exercise is one of the strategies to reduce the obesity (Jockehovel *et al.* 1997). The ratio of leptin to fat mass is relatively constant during the period of sexual maturity. However, the reason for obesity in youth is resistance against leptin through changing hypothalamic leptin receptor isoforms due to mutations of the coding region of leptin receptor long isoform. It can be said circulating leptin concentrations have a positive correlation with body fat stores. Leptin plays an important role as a signal in the regulation of adipose tissue and body weight. Performance of Leptin is controlling food intake and stimulating energy consumption. However, leptin as the circulating signal is effective in attenuating appetite. There are many questions related to the effect of physical activity (exercise) on the concentration of leptin. Physical activity (exercise) is in effective in reduction of obesity. A study has shown that serum leptin concentration is related to body mass index. Among employees, the issue of an appropriate physical norm and overweight is important. In Iran, if the employee is overweight his / her next promotion is delayed until reaching the ideal weight. Therefore, investigating the effectiveness of exercise in reducing the risk factors of obesity can help the employees. Given that the effects of strength training on serum leptin concentration and body mass index are less important. Knowledge in this area, in particular, its effects on endocrine system still remain somewhat unknown. In most studies, comparing the two groups of strength and resistance is used without control group and assessment inside the group. This study aims to investigate the Effect of strength and resistance training on changes in total fat, body mass index (BMI), and serum leptin as well as correlation between serum leptin and BMI in obese sedentary employees.

METHODOLOGY

PARTICIPANTS

A public call for the voluntary participation in research design was used and 52 out of 110 people announced their readiness based on completed questionnaires, clinical examination, not having an orthopedic injury history, lack of medicine consumption, not 28 k/m2. After briefing session and filling out the consent form, Physical Activity Readiness Questionnaire (PAR-Q), and Health History Questionnaire, those who had no history or symptoms of infection from a month ago, cardiovascular disease, thalassemia, diabetes, arthritis, and respiratory disorders, insulin resistance, and other disease statuses, medicine consumption and ergogenic supplements were removed from the research. Finally, a total of 22 people dropped out or were forced to quit and 30 people remained. According to the classification by one of the colleagues, these 30 people were randomly categorized into three groups in terms of body mass index, age, and the fat content determined by body composition analyzer. The groups include control (n = 10), resistance (n = 10), and strength (n =10). The selected people were requested to take the commitment to regularly participate in the research plan in due time and the control group was requested not to do any exercise but attend the exercises. Statistical description of characteristics for participants in terms of central tendency and dispersion are given in Table 1.

MEASURING INSTRUMENTS AND METHODS

As scheduled in coordination with blood samples, the participants were requested to take the pre-test. Then, according to program, leptin levels of both the experimental group and the control group were measured by the relevant specialist and his assistant in the laboratory through Leptin ELISA Kit manufactured by the German company sensitivity 0.1 ng per milliliter. Next, they attended the sport conference center and height and weight were measured without shoes on the device

Table 1. Mean and standard deviation of age, height and weight of the participants in three groups

Group	Age (year)		Body weight (kg)		Height (m)	
	Mean	standard deviation	Mean	standard deviation	Mean	standard deviation
Resistance	27.1	3.87	94.29	5.38	1.8	0.046
Strength	26.4	3.71	91.5	7.48	1.76	0.036
Control	26.1	4.25	99.3	8.79	1.81	0.069
Total	26.53	3.83	95.03	7.82	1.79	0.054

(Seca weighing scale, model 220, the accuracy of 0.1 kg, and with height measuring rod). The participants were standing on two legs in order to divide the weight equally and their look was parallel to the horizon after a normal expiration. In this way, the horizontal ruler was placed on the man's head and the end of the ruler was on the graded tape. Body mass index and body fat percentage were measured by Body Composition Analyzer (model GAIA 359 PLUS). 1-Mile Walking Test was used to determine Vo2Max and 1 repetition maximum (1RM). According to this test, the participants in the experimental group of resistance walked a distance of a mile as fast as they could. The distance time and heart rate were recorded after finishing walking. By adding weight and age to these factors, Vo2Max was calculated through the following equation:

Vo2 Max = (6965.2 + 20.02 (Body weight in kg)) - 25.7 × (Age in years) + 595.5 × (1) -224.00 × (Test time in minutes) -11.5 (Heart rate per minute)/ (Body weight in kg)

Weights of fitness equipment (manufactured by IMPLUS) were recorded for the experimental group of strength. The experimental groups did their own exercises at specified dates and times (9 to 11 am). After completion of the training period, height, weight, body mass index, fat percentage, and maximum oxygen consumption were re-measured in the post-test. In addition, previous blood tests in the laboratory were repeated in due date. The amount of blood serum in the posttest was sent to the hormone laboratory for the analysis of changes in levels of leptin. Furthermore, all participants in the pre-test (24 hours before exercise) and in the post-test (24 hours after exercise) attended the laboratory for blood sampling at 9 am after fasting for 12 hours. Before going to the laboratory, participants were announced by a guide about the main points on the nutrition (24-hour dietary recall questionnaire in three days), physical activities, and disease before and after 4 weeks of physical exercises in order to be careful about the mentioned points. In the laboratory, blood samples of 30 ml were taken from a vein in the right arm and blood was slowly poured into the test tube. When blood was clotted, the tubes were balanced. Then, the tubes were placed into Hettich centrifuge. Next, serum was separated from blood clots and was frozen for testing leptin.

TRAINING PROTOCOLS

In this study, the protocol of aerobic exercise (resistance) included two months, 3 sessions per week, 84 minutes in each session, at 2 stations (stationary bike and treadmill), 2 sets of four-minute, training intensity by 60 to 70 percent for the maximum heart rate. To follow the principle of overload, a half minute per session was added to the training time in order that the aerobic exercise time reaches 96 minutes in the last session. Forasmuch as participants did not regularly the exercises, 12 minutes for rest time between two sets and 20 minutes for rest time between two stations were considered as the duration of the break in aerobic exercise. The strength training protocol included Two months for weight training, the 3 session exercise per week, 9 stations, 8 to 12 repetitions in three sets, 60 -75% of one repetition maximum with 45 seconds for the rest time between sets and 1.5 minutes between stations. In the strength training protocol, the total exercise time was 70 minutes per session. The one repetition maximum test was given for the principle of overload at the end of each session. The strength training program was designed according to 60-75 percent of the one repetition maximum test after three training sessions. Statistical methods to compare training groups in the test process include repeated measures ANOVA, the Bonferroni post hoc test whenever a significant difference between three or more sample means has been revealed by an analysis of variance (ANOVA), and Pearson correlation coefficient to investigate the relationship between variables. Spss version 19 software is used to analyze the data and the error rate in all cases is (α = 0.5 %).

RESULTS

Table 2 shows changes of scores from pre-test to post-test for all groups based on their BMI, hormone leptin, and total fat.

The first null hypothesis: there is no significant difference for the leptin level between the training groups (resistance, strength and control). A 2x3 repeated measures ANOVA was used to investigate the data obtained from the effects of exercise on hormone leptin. The results of the Shapiro–Wilk test showed that the blood leptin

Table 2. Mean and standard deviation of the variables in pre-test and post-test

Variables	Body mass index		Hormone leptin		Total fat	
Groups	pre-test	post-test	pre-test	post-test	pre-test	post-test
Resistance	29.08±0.704	28.59±0.875	16.6±4.25	12.69±2.38	46.26±2.08	45.15±1.86
Strength	29.25±1.27	29.2±1.16	14.71±2.91	13.59±2.13	44.01±1.29	44.22±1.18
Control	30.06±1.23	30.02±1.27	13.4±3.91	13.13±3.88	44.94±0.88	44.93±0.84

Table 3. Evaluation of homogeneity of variance between the training groups in the pre-test and post-test (Levin test)

Test/statistics	Levin statistics	df1	df2	Sig.
pre-test	0.621	2	27	0.545
post-test	2.569	2	27	0.95

level has a normal distribution for all training groups in pre-test and post-test sessions (p>0.05). According to Table 3, the Levin test shows that there is homogeneity of variance between the scores of the training group in the pre-test and post-test (p>0.05).

According to Table 4, the results of the repeated measures ANOVA show that the effect of the test is significant. In other words, there is a significant difference between the pre-test and post-test regardless of the type of training. In addition, the interaction effect is significant. However, the results show that the main effect of the group is not significant. It means that there is a significant difference between the different training groups regardless of the type of training. Hence, the null hypothesis is confirmed. Forasmuch as the interaction effect (Test * Group) was significant, the paired sample t-test was used to compare the pre-test and post-test. The results of the paired sample t-test showed that there is a significant difference between the pre-test and post-test in the resistance training group (t=4.960, p= 0.001) but there is no significant difference between the pre-test and post-test in other groups.

The second null hypothesis: there is no significant difference for the Body mass index between the training groups (resistance, strength and control). A 2x3 repeated measures ANOVA was used to investigate the data obtained from the effects of exercise on hormone leptin. The results of the Shapiro–Wilk test showed that the blood leptin level has a normal distribution for all training groups in pre-test and post-test sessions (p>0.05). According to Table 3, the Levin test shows that there is homogeneity of variance between the scores of the training group in the pre-test and post-test (p>0.05).

According to Table 6, the results of the repeated measures ANOVA show that the effect of the test is significant. In other words, there is a significant difference between the pre-test and post-test regardless of the type of train-

Table 4. The repeated measures ANOVA to compare the groups in the pre-test and post-test

Indexes® Sources of Variation¯		Sum of squares	Degrees of freedom	Mean Square	F	P
Intragroup	Test	37.763	1	37.763	23.901	0.000
	Test * group	25.658	2	12.829	8.12	0.002
	Error	42.659	27	1.589		
Intergroup	Group	13.773	2	6.887	0.330	0.721
	Error	562.71	27	20.841		

Table 5. Evaluation of homogeneity of variance between the training groups in the pre-test and post-test (Levin test)

Test/statistics	Levin statistics	df1	df2	Sig.
pre-test	1.005	2	27	0.379
post-test	0.339	2	27	0.716

Table 7. Evaluation of homogeneity of variance between the training groups in the pre-test and post-test (Levin test)

Test/statistics	Levin statistics	df1	df2	Sig.
pre-test	5.97	2	27	0.007
post-test	2.249	2	27	0.012

Table 6. The repeated measures ANOVA to compare the groups in the pre-test and post-test

Indexes® Sources of Variation¯		Sum of squares	Degrees of freedom	Mean Square	F	P
Intragroup	Test	0.574	1	0.574	7.352	0.012
	Test * group	0.663	2	0.332	4.246	0.025
	Error	2.109	27	1.078		
Intergroup	Group	15.181	2	7.591	3.179	0.05
	Error	64.468	27	2.388		

Table 8. The repeated measures ANOVA to compare the groups in the pre-test and post-test

Indexes® Sources of Variation¯		Sum of squares	Degrees of freedom	Mean Square	F	P
Intragroup	Test	1.368	1	1.368	8.176	0.008
	Test * group	5.105	2	2.552	15.288	0.000
	Error	4.558	27	0.167		
Intergroup	Group	25.193	2	12.597	3.179	0.048
	Error	106.973	27	3.962		

ing.. Hence, the null hypothesis is rejected. Because of differences between groups Bonferroni post hoc test was used to determine the location of difference. The results showed that there was a significant difference between resistance and control groups. Forasmuch as the interaction effect (Test * Group) was significant, the paired sample t-test was used to compare the pre-test and post-test. The results of the paired sample t-test showed that there is a significant difference between the pre-test and post-test in the resistance training group (t=2.985, p= 0.015) but there is no significant difference between the pre-test and post-test in other groups.

The third null hypothesis: there is no significant difference for the total fat between the training groups (resistance, strength and control). A 2x3 repeated measures ANOVA was used to investigate the data obtained from the effects of exercise on hormone leptin. The results of the Shapiro–Wilk test showed that the blood leptin level has a normal distribution for all training groups in pre-test and post-test sessions (p>0.05). According to Table 3, the Levin test shows that there is homogeneity of variance between the scores of the training group in the pre-test and post-test (p>0.05).

Table 9. correlation between the variables of blood leptin level and body mass index in the post-test in the resistance training group

		blood leptin level	body mass index
blood leptin level	R P	1	0.675 0.032
body mass index	R P	0.675 0.032	1

Table 10. correlation between the variables of blood leptin level and body mass index in the post-test in the strength training group

		blood leptin level	body mass index
blood leptin level	R P	1	0.183 0.613
body mass index	R P	0.183 0.613	1

According to Table 6, the results of the repeated measures ANOVA show that the effect of the test is significant. In other words, there is a significant difference between the pre-test and post-test regardless of the type of training. Hence, the null hypothesis is rejected. Because of differences between groups Bonferroni post hoc test was used to determine the location of difference. The results showed that there was a significant difference between resistance and control groups. Forasmuch as the interaction effect (Test * Group) was significant, the paired sample t-test was used to compare the pre-test and post-test. The results of the paired sample t-test showed that there is a significant difference between the pre-test and post-test in the resistance training group (t=4.418, p= 0.02) but there is no significant difference between the pre-test and post-test in other groups.

The fourth null hypothesis: there is no significant relationship between the blood leptin level and body mass index of the participants in the resistance training group.

Pearson correlation test was used to examine the relationship between these two variables. Table 9 shows the correlation between variables. The results showed that there is a significant positive relationship between two variables of the blood leptin level and body mass index in the posttest. Hence, the null hypothesis is rejected.

The fifth null hypothesis: there is no significant relationship between the blood leptin level and body mass index of the participants in the strength training group.

Pearson correlation test was used to examine the relationship between these two variables. Table 10 shows the correlation between variables. The results showed that there is a significant positive relationship between two variables of the blood leptin level and body mass index in the posttest. Hence, the null hypothesis is rejected.

DISCUSSION AND CONCLUSION

This study investigated the effect of strength and resistance training on changes in total fat, body mass index (BMI), and serum leptin as well as correlation between serum leptin and BMI in obese sedentary employees.

Although many researches have done on serum leptin concentration and its relationship with body mass index, Factors such as intensity, time, type of training, physical conditions of the people, their sex and age, and ways of measuring body mass index lead to different reactions in the body. In addition, there are a few studies on the effects of strength training on leptin and body mass index. Strength and resistance training has no significant effect on serum leptin concentrations in obese and overweight men. This result can affect the leptin level due to changes in hormones concentration affecting leptin such as insulin, cortisol, testosterone, growth hormone, and catecholamine (Hamedinia *et al.* 2011). Other studies showed that lack of reduction in serum leptin in spite of decreasing the body fat percentage is because of high cortisol levels and creating conditions for overtraining due to the exercise protocol in athletes (Noland *et al*, 2001). In another study, despite a significant decrease in fat mass, and serum testosterone, there was no change in serum leptin concentrations after six weeks of strength training in physical education students because of an increase in serum leptin concentrations in comparison with body fat mass (Jones *et al*, 2009). Furthermore, the results of some studies showed that in spite of a decrease in percentage of body fat, there was no change in the serum leptin level resulting from exercises (Thong and Hudson, 2002; Lau *et al*, 2010; Kraemer *et al*, 2002). Some studies concluded that the reason for the reduction of the leptin level is a decrease in percentage of the body fat (Kraemer *et al*, 1998). Some others concluded that the effect of exercise on the leptin level is positive and independent from changes in the body fat (Gaini *et al*, 2000; http://www.ensani.ir/fa/content/303352/default.aspx). We can say that the apparent differences in training protocol and type of participants and their individual characteristics can explain the difference in the percentage of the body fat and leptin. In a study, it was concluded that the lack of changes in leptin was the limitation of the leptin performance (Maestu *et al*, 2008; Erikson *et al*, 2008).

In the present study, the volume of exercises such as the intensity and duration of exercise was not enough to affect the leptin level. There may also be another possibility that explains the lack of changes in the leptin level in this study. Leptin is either free (possibly active) or protein bound. The free leptin level is greater in obese people and concentration of free leptin decreases after weight loss even more than total leptin concentration (Unal *et al.* 2005). Exercise in spite of no reduction in total leptin is effective in changing in the ratio of free leptin to protein bound leptin (resulting in changes in leptin activity). Measuring the amount of leptin binding protein requires the measurement of leptin receptor in plasma. This issue was not measured in the present study.

It seems that there are many other factors involved in the effect of training on the serum leptin level. These factors include enzymes involved in the biosynthesis of testosterone as a result of stress caused by exercise (Nidle *et al.* 2002), the inhibitory effect of cortisol on LH receptors in Leydig cells of the testes, and reduction in the secretion of testosterone (Cooke *et al*, 1999). Therefore, high cortisol levels may decrease the secretion of testosterone and LH receptors (Gotshalk *et al*, 1997). Researches have shown a strong inverse relationship between leptin and testosterone (Dohem and Louis, 1978). Leptin also affects the production and secretion of cortisol (Lowndes *et al*, 2008) and cortisol is stimulus of leptin gene expression. There is a direct correlation between leptin and cortisol resting levels (Smilios *et al*, 2003). With regard to the inverse relationship between cortisol and testosterone, an increase in the hormone cortisol results in increasing stress (Cooke *et al*, 1999). It leads to decreasing testosterone and the emergence of a factor in line with the lack of a significant effect of the exercises, including strength training and resistance training protocol, on the hormone leptin. Kraemer *et al* investigated the effect of the resistance exercises on cyclists. Glucocorticoids play an important role in the physiological regulation of leptin and cortisol is simultaneously effective in the production and disposal of leptin (Kraemer *et al*, 2002).

There was a significant difference between different groups in relation to the effects of two methods of exercise training on body mass index. According to the results of the Bonferroni post hoc test in the present study, there is a significant difference between the control and resistance groups. It can be concluded that this change occurs due to an increase in fat oxidation for the control of body composition in the resistance training group.

This issue is consistent with the control of the variable of fat in the present study. According to the reduction in body mass index in strength and resistance groups in this research, it seems that the way of training in this study has the required intensity and energy cost threshold for changing the weight levels of the participants. Given that there was a significant change in body mass index and height is stable according to the middle age range of the participants, the weight loss occurred for the participants. The overall conclusion indicated that both of the exercises lead to the similar results. Most changes in body mass index were related to the resistance training.

Therefore, it is suggested that the resistance exercises are further used to prevent obesity and many diseases caused by inactivity and obtain the desired effect of exercises based on physical preparation and reducing overweight.

REFERENCES

Cooke RR, McIntosh JEA, and McIntosh RP. (1999): Is cortisol an important factor in the serum binding of testosterone? Proceed Endo Soci Aus, 33: 53-59.

Dohem GL, and Louis TM. (1978): Change in androstendion `testosterone and protein metabolism as a result of exercise. Proc Soc Exp Biol Med. 158:622-25.

Eriksson M, Johnson O, Boman K, Hallmans G, Hellsten G, Nilsson TK,Soderberg S. (2008): "Improved fibrinolytic activity during exercise may be an effect of the adipocyte – derived hormones leptin and adiponectin". Thrombosis research. 122: PP: 701-708.

Gaini, A. A., Rahmani Niya, F., Hosseini, S. M. (2000): The relationship between aerobic capacity and body size in female non-athletes students, Research Center of National Olympic Committee.

Gotshalk LA, Loebel CC, Nindl BC, Putukian M, Sebastianelli WJ, Newton RU, and Häkkinen K. (1997): Hormonal responses of multiset versus single-set heavy - resistance exercise protocols. Canad J Appl Physio, 22:244-55.

Hamedinia, M.R., Davarzani, Z., Hosseini Kakhk, S. A. (2011): The effect of one session of swimming and running on hunger rate and ghrelin, insulin and cortisol in healthy girls, Journal of Endocrinology and Metabolism of Iran, 13 (1): 82-89.

Http://www.ensani.ir/fa/content/303352/default.aspx

Jockehovel F , Blum WF , Vogel E , Engalro P , Muller – Weiland D , Reinwein D , Rascher W , krone W. (1997): Testosterone substitution normal izes elevated serum leptin levels in hypogonadal males . J. clin Endocrinol Metab. 82: 2510 – 2513.

Jones T, Basilio JL, Brophy PM, McCammon MR, Hickner RC. (2009): Long-term exercise training in overweight adolescents improves plasma peptide YY and resistin. Obesity. 17: 1189–1195.

Kraemer R,Hongnun CR, Castracane VD. Leptin and exercise. Exp Biol Med. (2002): 227:701-8.

Kraemer WJ, Ha¨kinen K, NewtonRU, McCormick M, Nindl BC, Volek JS, *et al.* (1998): Acute hormonal responses to heavy resistance exercise in younger and older men. Eur J Apl Physiol. 7: 206-1.

Lau PWC, Kong Z, Choi C, Yu CCW, Chan DFY, Sung RYT, *et al* (2010): Effects of Short-Term Resistance Training on Serum Leptin Levels in Obese Adolescents. Journal of Exercise Science & Fitness; 8(1): 54-60.

Lowndes J, Zoeller RF, Caplan JD, Kyriazis GA, Moyna NM, Seip RL, *et al.* (2008): Leptin responses to long-term cardiorespiratory exercise training without concomitant weight loss: A prospective study. J Sports Med Phys Fitness. 48: 391-7.

Maestu J, Jurimae J, Valter J, Jurimae T. (2008): "Increases in ghrelin and decreases in leptin without altering adiponectin during extreme weight loss in male competitive bodybuilders". Metabolism, 57: PP: 221-225.

Nindle BC, Kraemer WJ, Arciero PJ, Samatalle N. (2002): Leptin concentratio ons experience a delayed reduction after resistance in men. Med Sci Sport Exerec. 34: 608-613.

Noland RC, Baker JT, Boudreau SR, Kobe RW, Tanner CJ, Hickner RC, *et al.* (2001): Effect of intense training on plasma leptin in male and female swimmers. Medicine and science in sports and exercise, 33: PP: 227-231.

Smilios I, Pilianidis T, Karamouzis M, Tokmakidis SP. (2003): Hormonal responses after various resistance exercise protocols. Med Sci Sports Exerc. 35: 644-54.

Thong fsi , Hudson Rahd at al. (2002) Plasma Leptin in moderately obese moles Independent Effects of weight Loss and Aerobic Exercise AM ,] physiol . Endocrinol, Metab. 279 E 307 – E 313.

Unal M, Unal DO, Baltaci AK, Mogulkoc R. (2005): Investigation of serum leptin levels and healthy males. Acta Physiol Hung. 92:173-9.14- Cohen PG.