

Changes of Serum Adiponectin and Testosterone Concentrations Following Twelve Weeks Resistance Training in Obese Young Men

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Abstract

Background: Circulating levels of adiponectin and testosterone decrease in obese men and this increases risks of cardiovascular disease and diabetes.

Objectives: The purpose of this study was to survey changes of serum adiponectin and testosterone concentrations following twelve weeks resistance training in obese young men.

Patients and Methods: In a semi-experimental study, twenty one obese young men were randomly placed in two groups: resistance training (26.5 ± 2.8 years) and control (27.4 ± 2.9 years). General characteristics of subjects and serum levels of adiponectin and testosterone were assessed before and after training. Resistance training protocol consisted of twelve weeks weight training (3 sessions per week, 10 exercises, 3 sets of 8-12 repetitions in each exercise, intensity 60%-80% of one repetition maximum, rest between sets 1 minute and between exercises 2 minutes, duration of main training 20-40 minutes per each session).

Results: Resistance training had no significant effect on body weight and body mass index ($P > 0.05$), whereas it decreased body fat percent ($P = 0.017$). Also, serum adiponectin (8.1 ± 1.8 vs. $10.5 \pm 2.3 \mu\text{g/mL}$) and testosterone concentrations (6.9 ± 2.4 vs. $8.2 \pm 1.7 \text{ ng/mL}$) were increased after resistance training ($P = 0.033$, $P = 0.018$ respectively), while there were no significant changes in serum levels of these hormones in control group ($P > 0.05$).

Conclusions: Twelve weeks of resistance training increased serum concentrations of adiponectin and testosterone in obese young men. With respect to inverse associations between changes of adiponectin and testosterone with BFP and insulin level variations after resistance training, it is recommended that obese young men do resistance training to benefit useful decreasing/preventive effects of this type of training against the risks of cardiovascular diseases and diabetes.

Keywords: Resistance Training, Adiponectin, Testosterone, Obesity

1. Background

Adiponectin is one of the adipocytokines secreted by adipose tissue that is an important protective factor in pathogenesis of metabolic syndrome and cardiovascular disease, because of its anti-diabetic and anti-atherogenic roles (1). In other words, decreased serum adiponectin concentrations predict development of diabetes and cardiovascular disease (2). Also, testosterone plays a role in pathogenesis of type 2 diabetes. In men with type 2 diabetes, serum testosterone reduces, while it increases in women with this condition. It is believed that testosterone reduces risk of type 2 diabetes in men, but increases it in women (2). With regard to anti-diabetic and anti-atherogenic actions of adiponectin and potential anti-diabetic role of testosterone in men, decreased adiponectin and testosterone concentrations in men may be partly responsible for high incidence of cardiovascular disease in them, due to the decreased protective effect of the mentioned hormones (2). Adiponectin levels decrease with obesity (3). Also, cross-sectional studies (4-6) have indicated that testosterone levels have reverse

correlation with central adiposity rate in men and that testosterone therapy reduces visceral adiposity in them (7). Therefore, due to their lower levels of adiponectin and testosterone, obese men may be at higher risk for cardiovascular disease (2).

One of the influencing factors on hormone levels can be exercise training. Some researchers have studied the effect of endurance training on circulating adiponectin concentration (8-11). Most of these studies (9-11) have indicated no changes in adiponectin levels after exercise training, while some (8) have reported an increase. Of course, in most of the previous studies the effect of endurance training has been studied (9-11), and resistance training has been less investigated (1, 12, 13). Ahmadizad et al. (1) considered the effect of both resistance and endurance training on adiponectin concentration in sedentary men. In their study, none of training protocols had effect on adiponectin levels (1). Klimcakova et al. (12) also found that resistance training improved insulin sensitiv-

ity, without changing the plasma levels and gene expressions of adipokines in subcutaneous adipose tissue. In contrast, Fatouros et al. (13) indicated that high and moderate intensity resistance training can increase adiponectin levels. Even more recent studies have failed to show consistent findings (14, 15). Asad et al. (14) found that resistance training didn't alter adiponectin resting levels in overweight untrained men. While, Akbarpour (15) showed that regular resistance training increases plasma levels of adiponectin in obese men.

It is believed that the male reproductive endocrine system, like female reproductive system, can be affected by endurance training; particularly serum testosterone levels reduce and hypothalamus-pituitary-testes axis, that regulates production of testosterone, changes in trained men (16-18). However, Hiruntrakul et al. (19) indicated that twelve weeks endurance training had no effect on resting testosterone levels, although it was sufficient to increase endurance fitness in sedentary young men. About the effect of resistance training on circulating levels of testosterone, while some studies have demonstrated an increase in resting testosterone levels (20-24), others have not observed any significant difference (25-27).

While it has been reported that serum testosterone levels reduce in endurance trained men (18), the few available findings about the effect of resistance training on circulating testosterone levels are controversial (20-27). Also, various and inconsistent findings are available about the effect of resistance training on serum levels of adiponectin (1, 12, 13). On the one hand, according to the previous studies, circulating levels of adiponectin and testosterone reduce in obese men (3-7) which elevates the risk of cardiovascular disease and diabetes (2) while on the other hand, the increasing tendency to the resistance training turns it into an important component of physical fitness program (28). According to this, and with regard to ever-increasing prevalence of obesity in the young population of the society (29, 30), the question is whether resistance training can alter serum levels of adiponectin and testosterone in obese young men? If yes, what are the health aspects of the possible changes?

2. Objectives

The purpose of this study was to survey changes of serum adiponectin and testosterone concentrations following twelve weeks resistance training in obese young men.

3. Patients and Methods

3.1. Subjects

The research method of the study was semi-experimental including training and control groups with pre and post-tests, and obese young men were studied. Sampling was performed regarding age and body mass index (BMI) values, and subjects were randomly assigned to the groups. Initially, for voluntarily participation of subjects, objectives,

methods and uses of research data were advertised via notices in sports, medical, and educational centers of Boukan and Saghez cities. Only volunteers with BMI ≥ 30 kg/m² could be included in the study (31). All volunteers completed health history questionnaires (HHQs). Exclusion criteria were as: history of cardiovascular diseases, diabetes, and thyroid diseases, drug consumption, being under any diet or medication, addiction to any narcotic substances, smoking, alcoholism, and caffeine. Participants didn't have history of regular physical activity in previous year (1). Number of volunteers matching the inclusion criteria was 21 which were randomly divided into two groups: training (n = 10) and control (n = 11). All of the participants signed the written informed consents and physical activity readiness-questionnaire (PAR-Q) forms. Experimental procedures and study protocols were approved by the Ethical Committee of Islamic Azad University of Saghez (Saghez, Iran).

3.2. Study Design and Protocol

Before beginning training protocol, through an explanatory session, training, training (gym for physical fitness), objectives, study design, training protocol and laboratory experiments (such as blood sampling), and research schedule were explained for participants. Also, manner of working with weights were explained to participants and one repetition maximum (1RM) tests were completed for determining intensity (resistance load) of exercises. 1RMs were determined individually and separately for each muscle group via the Equation 1 (32):

$$(1) \quad \text{Predicted 1RM} = \text{Lifted weight} + [1.0278 - (0.0278 \times \text{Repetitions})]$$

General characteristics of subjects such as age, height, weight, body fat percent (BFP), BMI, and muscle strength were recorded. Resistance training protocol consisted of twelve weeks weight training, 3 sessions per week. 10 exercises for major muscle groups of upper and lower body were performed, 3 sets of 8 - 12 repetitions per each exercise, intensity 60% - 80% of 1RM, rest between sets 1 minute and between exercises 2 minutes, and duration of main training 20 - 40 minutes per each session (33). In each session, subjects performed jogging and stretching exercises before and after main training in order to warm-up (10 minutes) and cool-down (10 minutes), respectively (1).

It was requested that subjects of the training group avoid doing any physical activity other than prescribed exercises during study. The exercises were performed under supervision of researchers. Subjects of control group continued daily routine living without doing any excess physical activity. Before and after twelve weeks of training, subjects went to Shafa laboratory for medical diagnosis (Boukan City) and 10 CC blood was taken from the brachial vein. Serum samples were preserved at -20°C until measurement of hormones. It was requested that subjects avoid consuming caffeine, cigarettes, and drugs and doing excess physical activity during the three days before blood sampling, and also avoid eating or drinking during last 12 hours before

blood sampling. For controlling nutritional effect during the three days before blood sampling, it was requested that subjects record any nutrients consumed during 3 days before pre-test blood sampling in daily diet record forms and repeat this diet during 3 days before post-test blood sampling. Also, for partial nutritional control during 12 weeks training, subjects were consulted to follow, as much as possible, standard diet. To control the effects of time of day on physiological variables under study, blood sampling (8 to 9 am) and training sessions (5 to 7 pm) were performed at the same time of day (34).

3.3. Data Collecting Tools

Weight and height of subjects was measured using calibrated digital weighing machine (minimum accuracy 0.1 kg, model ws 80, made by Switzerland) and height-measuring (minimum accuracy 0.1 cm, model Maschinen AG, made by Switzerland), respectively. BMI was calculated via dividing weight (kg) by height square (m²). Body density was predicted by measuring three-point skinfolds (chest, triceps, and subscapular) by caliper (minimum accuracy 0.1 mm, Harpenden, made by England) and values are used in Equation 2 (35):

$$(2) \quad \text{Bod density} = 1.1125025 - 0.0013125 (X_1) + 0.0000055 (X_1)^2 - 0.0002440 (X_2)$$

Where X_1 = sum of chest, triceps, and subscapular skinfolds, and X_2 = age in years.

The body density values obtained are used in the following equation to calculate BFP (Equation 3) (36):

$$(3) \quad \text{BFP} = \frac{495}{\text{Density}} - 450$$

Muscle strength was determined using chest press 1RM and leg press 1RM tests. Exercise training was performed using weights (dumbbells and halters) and body-building machines in the physical fitness gym of Islamic Azad University of Saghez. Standard diet consisted of 15 % protein, 30% fat, and 55% carbohydrate. For controlling percent combination of this diet, subjects were educated through consulting sessions to control their diet according to nutritional favorites and availability of foods so that standard diet as far as possible is followed. For this purpose, subjects received written nutritional guidelines with caloric values and percentages of carbohydrate, fat, and protein of 208 routine foods. Meals (breakfast, lunch, dinner, and night snack) were also explained (a similar method has been previously used) (37). Also, Harris-Benedict standard equation with activity factor of 1.55 was used for estimating total daily energy expenditure of subjects (Equations 4 and 5) (38):

$$(4) \quad \text{Basal metabolic rate (kcal)} = 66 + (13.7 \times \text{Weight (kg)}) + (5 \times \text{Height (cm)}) - (16.8 \times \text{Age (y)})$$

$$(5) \quad \text{Total daily energy expenditure (kcal)} = \text{Basal metabolic rate (kcal)} \times 1.55$$

Serum concentration of adiponectin (Human Aiponectin ELISA, BioVendor, Czech Republic, sensitivity 26 ng/mL, intra-assay CV 3.9%, inter-assay CV 6.3%) was measured using ELISA method and serum concentrations of testosterone (Testosterone AccuLite™ CLIA, Monobind Inc., USA, sensitivity 0.026 ng/mL, intra-assay CV 4.4 %, inter-assay CV 4.2 %) and insulin (Insulin CIATM kit, MONOBIND INC., USA, intra-assay CV 6.8 %, inter-assay CV 8.8 %) were measured by Chemiluminescence method.

3.4. Statistical Analysis

All results are expressed as means \pm SD. Paired sample t-tests were used to compare between pre and posttest means in each group and independent student's t-tests were used to compare between post-test means of two groups. Before statistical analyses were performed, Kolmogorov-Smirnov test was used to test normality of data distribution. P value of less than 0.05 was considered statistically significant. Statistical analyses were performed using SPSS software version 16.0.

4. Results

General characteristics of subjects at baseline and after resistance training are presented in Table 1. There were no significant differences in pre-test values of age, weight, BMI, BFP, chest press 1RM, and leg press 1RM between two groups ($P > 0.05$). Resistance training had no significant effect on body weight and BMI ($P > 0.05$), whereas it decreased BFP ($P = 0.017$). Also, chest press 1RM and leg press 1RM were increased in training group ($P = 0.08$ and $P = 0.023$, respectively). In control group, no significant differences were seen between pre and posttest means of weight, BMI, BFP, chest press 1RM, and leg press 1RM ($P > 0.05$). Serum adiponectin and testosterone concentrations of subjects at baseline and after resistance training are reported in Table 2. No significant differences were seen in pretest values of serum adiponectin and testosterone concentrations between two groups ($P > 0.05$). Serum adiponectin and testosterone concentrations were increased after resistance training ($P = 0.033$, $P = 0.018$, respectively), while there were no significant changes in serum levels of these hormones in control group ($P > 0.05$). Also, comparison of posttest means of two groups indicated that there were significant differences in serum adiponectin and testosterone concentrations, BFP, chest press 1RM, and leg press 1RM ($P < 0.05$), but no significant differences were observed about weight and BMI ($P > 0.05$).

In the trained group, change in serum adiponectin concentration correlated with changes in BFP ($r = -0.51$, $P = 0.047$) and fasting insulin ($r = -0.27$, $P = 0.023$). Also, change in serum testosterone concentration inversely correlated with changes in BFP ($r = -0.40$, $P = 0.019$) and fasting insulin ($r = -0.21$, $P = 0.014$). The average total daily energy expenditures for training and control groups were 2810.3 ± 193.2 and 2198.6 ± 175.2 kcal, respectively.

Table 1. General Characteristics of Subjects^a

Variable	Training Group (n = 10)		Control Group (n = 11)	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Age, y	26.5 ± 2.8	-	27.4 ± 2.9	-
Weight, kg	94.3 ± 8.9	92.9 ± 7.8	93.6 ± 9.2	94.2 ± 8.4
BMI, kg/m ²	30.8 ± 2.4	30.2 ± 2.8	31.1 ± 3.7	31.3 ± 3.1
BFP, %	29.1 ± 3.2	26.6 ± 3.4 ^{b,c}	30.9 ± 3.2	31.5 ± 2.8
Chest press 1RM, kg	88.1 ± 21.1	96.6 ± 22.7 ^{b,c}	84.2 ± 23.3	85.5 ± 20.5
Leg press 1RM, kg	257.6 ± 65.1	298.4 ± 71.4 ^{b,c}	267.8 ± 56.2	260.7 ± 62.8

^aData are presented as mean ± SD.^bSignificant difference between pre and posttest means at level 0.05.^cSignificant difference between posttest means of two groups at level 0.05.**Table 2.** Biochemical Characteristics of Subjects^a

Variable	Training Group		Control Group	
	Pre-Test	Post-Test	Pre-Test	Post-Test
Adiponectin, µg/mL	8.1 ± 1.8	10.5 ± 2.3 ^{b,c}	8.8 ± 2.1	8.3 ± 1.8
Testosterone, ng/mL	6.9 ± 2.4	8.2 ± 1.7 ^{b,c}	6.7 ± 1.9	6.4 ± 1.7
Fasting glucose, mmol/L	4.8 ± 0.2	4.7 ± 0.3	4.7 ± 0.2	4.8 ± 0.3
Fasting insulin, µU/mL	14.1 ± 1.8	10.0 ± 1.7 ^{b,c}	14.3 ± 1.9	14.2 ± 1.7

^aData are presented as mean ± SD.^bSignificant difference between pre and posttest means at level 0.05.^cSignificant difference between posttest means of two groups at level 0.05.

5. Discussion

Circulating levels of adiponectin and testosterone increase after twelve weeks of resistance training in obese men. Although, weight and body mass index didn't change after resistance training, but body fat percent decreased. Since adiponectin and testosterone have anti-diabetic and anti-atherogenic effects, resistance training can reduce risk of cardiovascular disease and diabetes in obese young men. Before training, body weight, body mass index, body fat percent, muscle strength (chest press 1RM and leg press 1RM) and also serum adiponectin and testosterone concentrations were similar in two groups, while after resistance training circulating adiponectin and testosterone levels and muscle strength were higher and body fat percent was lower in training group in comparison to control group. However, body weight did not differ between the two groups.

Results of the present study indicated that twelve weeks of resistance training increases serum adiponectin concentration in obese young men. This is consonant with findings of Fatouros et al. (13), but not with Ahmadizad et al. (1) and Klimcakova et al. (12). It appears that various factors are influencing changes of circulating adiponectin after exercise training that intensity and duration of training are among them (1, 12, 13, 39, 40). For example, in the study of Fatouros et al. (13) resistance training with high or moderate intensities resulted in elevation in circulating levels of adiponectin, but low-intensity re-

sistance training didn't cause any change. Also, duration of training in research of Ahmadizad et al. (1) was twelve weeks, but in the study of Brooks et al. (40) found that high-intensity resistance training increased adiponectin concentrations, it was more (fourteen weeks). However, comparison of various studies on the effects of endurance and resistance exercise on adiponectin levels suggest that, in addition to volume of training (frequency, intensity, time), the effect of a combination of resistance and endurance training has been shown in some researches (12, 41, 42), other factors such as age domain (1, 13), gender (12, 13), physical fitness level (8, 43), and health condition of subjects (9-11, 44) may also be influencing the quality of adaptation of circulating levels of adiponectin to exercise training.

Some studies on endurance training have demonstrated the weight loss and body composition improvement as main mechanisms of gene expression and increases of adiponectin concentration after long-term physical activities (43, 45, 46). Rokling-Andersen et al. (10) are so focused on these mechanisms that have justified the lack of change in adiponectin levels reported in some studies through insufficient weight loss, wide individual differences in plasma concentration of adiponectin, limited number of subjects, or gender differences. Likely, it appears that we can explain increases of adiponectin levels after resistance training in the present study via

the mentioned mechanism, because mean body fat percent was decreased, although mean body weight didn't change in training group. Also, change in serum adiponectin concentration after training inversely correlated with change in BFP. However, some researchers have not observed significant changes in adiponectin concentrations, despite decrease in fat mass (47, 48). Even, Mohebbi et al. (49) observed that plasma adiponectin concentration increased significantly in response to endurance training, despite no significant decrease in body weight. Therefore, it appears that the change of serum adiponectin concentration may also be mediated through other pathways in addition to decrease in fat/weight mass.

Also, findings of the present study indicated that serum levels of testosterone in obese young men increase following twelve weeks of resistance training. In comparison to previous endurance training studies, fewer researches have engaged in the effect of resistance training on serum levels of testosterone. Whereas some studies report increase of testosterone levels after resistance training (20-24), others have not observed any changes (25-27). Available data indicate that only young people are susceptible to change in their resting testosterone levels (24, 50, 51), while middle-aged and older subjects don't show any significant change in this hormone (20, 52-55). It appears that increases in resting testosterone levels occur during high-volume (19, 53) and high-intensity training periods (23, 50, 56). Such changes may occur in response to long-term (50, 57) or short-term (51, 56) training in men (50) and women (57). Effect of volume of resistance training on chronic adaptations of basal testosterone has been explained in the study performed by Marx et al. (57) that assessed women before and after completion of a 24-week resistance training protocol. In their study, resting testosterone levels were measured to compare groups performing single-set or poly-set resistance exercises. Their findings showed increases in testosterone in both groups, and in agree with our results, first adaptations were occurred after twelve weeks (57).

According to the findings of the present study, increased levels of adiponectin and testosterone after resistance training in obese young men, is associated with lower body fat and fasting insulin. Study of Kim et al. (58) showed concurrent improvement in adiponectin and insulin resistance in obese adolescents. These researchers believe that exercise training that can reduce body fat levels may also lead to further changes in adipokine levels and thus cause to further improvement in insulin sensitivity (58). Blaslov et al. (59) also indicated insulin sensitivity improvements proportionally with the increases in plasma adiponectin levels. However, unlike the findings of the present study, Ahmadizad et al. (1) demonstrated no association between changes in adiponectin levels with percent body fat and insulin resistance variations following exercise training. Also, the inverse relationship between the measures of body fat and testosterone levels in different age groups is shown (60, 61). Furthermore,

Tsai et al. (61) found that testosterone levels are inversely correlated with insulin resistance. It is believed that the inverse relationship between testosterone and insulin resistance is mediated by body fat. Low number of subjects under study, the short duration of exercise training, and lack of sufficient confidence of dietary control during training period are the most significant limitations of this study.

In conclusion, twelve weeks of resistance training increased circulating adiponectin and testosterone levels in obese young men. With regard to inverse relations between changes of adiponectin and testosterone with BFP and insulin level variations after resistance training, it is recommended that obese young men perform resistance training to benefit useful decreasing/preventive effects of this type of training against the risks of cardiovascular diseases and diabetes.

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Footnote

Authors' Contribution: Fatah Moradi (the author) designed and supervised the study. The author carried out all experiments, analyzed the data, interpreted the findings, and finally prepared the manuscript.

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