



The Effect of Resistance Training and Vitamin D on Leptin and HDL-C in Overweight Women

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Abstract

Background: Exercise training and vitamin D consumption are separately reported to be effective on improving health. However, the simultaneous effect of resistance training and vitamin D is not clear yet. However, there is no information available on the resistance training and the amount of vitamin D prescription. In addition, it is important to examine this issue in women who are known as an active and effective part of society.

Methods: The participants (n = 40) of this study were randomly divided into four groups as follows: (1) placebo, (2) resistance training, (3) vitamin D, and (4) resistance training + vitamin D. In this study, interventions were performed for an 8-week period (3 D/W) consisting of resistance training protocol (60% 1-RM) and daily consumption of vitamin D (1000 IU). Anthropometric and laboratory measurements were collected 48 hours before and after the intervention.

Results: Changes in HDL-C (P = 0.001, F = 6.3), total cholesterol (P = 0.001, F = 7.8), and leptin concentration (P = 0.001, F = 11.4) were significant. Accordingly, these changes in the study variables showed a better improvement in the resistance training + vitamin D group compared to the other groups (P = 0.001).

Conclusions: Probably the most important factor for the observed changes was the reduction of adipose tissue caused by resistance training, as well as the enhancement of signaling pathways resulting from the consumption of vitamin D. However, maintaining muscle tissue caused by resistance training can be effective. Moreover, HDL change due to resistance training and its effect on reverse cholesterol transport may occur faster than LDL-C changes. Also, the improvement in LDL-C appears in response to longer periods of exercise along with drug therapy.

Keywords: Obesity, Dyslipidemia, Resistance Training, Vitamin D

1. Background

Obesity and vitamin D deficiency are associated with an increased risk of metabolic syndrome (1). However, the attitude toward adipose tissue has changed as an endocrine tissue, due to playing an important physiological role in controlling energy homeostasis in addition to the secretion of adipokines (2).

Although caloric restriction and dietary control as well as the use of vitamin D are included in the main therapeutic interventions in controlling weight and improving metabolic syndrome (3, 4), several studies have shown that exercise program also plays a role in improving lipid profile, reducing adipose tissue, and increasing cardiorespiratory fitness under obesity condition (5-13). Regular physical activity can have different benefits such as reducing visceral fat, reducing insulin resistance, regulation of fasting blood glucose, and reducing waist circumference fat,

besides the fact that, these changes coincide with the improvement of vitamin D levels (14-16). Accordingly, it seems that, the presence of other factors such as different training practices or other factors at the cellular level can better reflect the effects of the exercise. In addition, extensive studies have focused on the physiological responses to exercise training. Also, the effects of resistance training on neuromuscular responses and improvement of lipid profile have been reported in some studies (5-9, 17). In this regard, one of the reasons for studying the effects of resistance training is that the public has chosen resistance training as their exercise mode. In addition, women find training at gym more convenient, which reduces the intake of sunlight and consequently results in vitamin D deficiency condition.

The adipose tissue plays an important role in managing energy balance by secretion of some adipokines (2). The adipokine that plays an important role in energy bal-

ance is leptin (10, 18). Accordingly, leptin is a hormone with an effect on regulating energy homeostasis, which acts as an adiposity signal for long-term body weight control through appetite controlling by affecting its receptors in the brain (2, 18). Increasing leptin secretion has a close correlation with body mass index changes. So, based on this role, leptin levels increase with obesity and are also related to the percentage of body fat in men and women (19). In this regard, there is a direct relationship between serum leptin levels and obesity in children and adults (18-21).

In addition, it has been shown that, lipid profile changes including an increase in total cholesterol (TC), LDL-C, and triglyceride (TG) levels along with a decrease in HDL-C play important roles in the progression of the complications of diabetes (5, 6). Lipid profiles have always been considered as risk factors for cardiovascular diseases (5). Accordingly, in fact, HDL-C reduces inflammation and prevents cardiovascular diseases by preventing LDL-C oxidation (5, 6). Numerous reports have shown the lipid profile improvement including the increased HDL-C and the decreased cholesterol and LDL-C in response to exercise rehabilitation (5-9, 17). Therefore, improvement of lipid profile should be controlled through performing nutritional and exercise interventions.

It is reported that, vitamin D can be used to regulate the leptin and lipid profiles functions (22-27). Explaining, vitamin D is one of the fat-soluble vitamins discovered in the 1930's, which is called Calciferol. This vitamin essentially is a hormonal precursor whose ultimate form is made in the body. Notably, Ergocalciferol (vitamin D₂) and Cholecalciferol (vitamin D₃) are its metabolites. Several meta-analysis studies have reported that, increase in serum levels of vitamin D is associated with a reduction in cardiac and metabolic disorders (25, 26). Evidence also suggests that, obese people are more likely to be deficient in vitamin D (26).

2. Objectives

Briefly, nutritional interventions and resistance training can be effective on preventing or improving metabolic syndrome. In this regard, among various nutritional factors affecting health, it has been shown that, there is a correlation between vitamin D deficiency and metabolic syndrome under different conditions like obesity (22, 23). In fact, the increased levels of vitamin D may reduce the symptoms of metabolic syndrome. Also, there are a few studies conducted on the simultaneous effect of resistance training and vitamin D on lipid profiles and leptin concentrations among overweight women. Therefore, it is important to examine this issue in women's societies because

of their important role in maintaining the pillars of society and also family. Accordingly, this is important because of the reduced exposure to sunlight, especially due to the environmental contamination. Therefore, the aim of this study was to investigate the effects of resistance training and vitamin D on lipid profile and leptin in overweight women.

3. Methods

In the present study, 40 inactive overweight healthy women were randomly divided into four groups equally as follows: (1) placebo, (2) vitamin D, (3) resistance training (RT), and (4) resistance training (RT) + vitamin D (Table 1). The participants were overweight (Table 1) and their vitamin D levels were in the normal range in the lower extremities (Table 1) (reference range minimum for health bone: 20 - 32 ng/mL), so they needed consumption of daily vitamin D, according to doctor prescription. Afterward, the participants were familiarized with the interventions steps, how to do the exercise protocols, taking vitamin D supplementation, exercise program for the training groups, and blood sampling process. Familiarization program was held two weeks before the interventions. Moreover, the anthropometric measurements were taken in a separate session before the start of the interventions.

Resistance training lasted for 8 weeks (3 sessions per week). Exercise training covered the chest, triceps, and shoulder muscles (for the first session), abdomen and dorsalis (the second session), and leg muscles (in the third session). Correspondingly, each session consisted of 8 selected movements that were performed based on a post-fatigue system. At first, larger muscles were used with multiple joint movements and single muscle movements were then applied at the end of each session. The protocol was implemented at 50% - 60% 1-RM (3 courses, 10 repeats, and 2-minute rests between the end of each movement and the start of another one). Vitamin D supplementation (produced by the United Kingdom-Health Aid Company) groups received 1000 IU/day, which was administered for 8 weeks. Also, blood samples were collected 48 hours before and after the intervention. The participants rested for 30 minutes in the laboratory before each blood sampling procedure.

To prevent hemolysis, the blood samples were evacuated to the tubes containing EDTA. The obtained samples were then centrifuged for 15 minutes at 4°C at a speed of 10,000 rpm. Afterward, the plasma was kept at -70°C and used to measure the variables of research. Also, Plasma leptin was measured by ELISA kit (commercial laboratory kits, human samples from EASTBIOPHARM Company, made in

China). Moreover, Lipid profiles including TG, TC, LDL-C, and HDL-C were measured by photometric method using Pars Azmoon company kits (Immuno FS, Pars Azmoon, Tehran, Iran).

The Kolmogorov-Smirnov test was used to analyze the normal distribution of data. One-way analysis of variance (ANOVA) was used to test the research hypotheses after determining the difference between the pre-test and post-test. In addition, Tukey's post hoc test was used for inter-group comparisons. Statistical analysis was performed using SPSS 21 software at a statistical significant level ($P \leq 0.05$).

4. Results

In summary, the changes in HDL-C among the studied groups were significant ($P = 0.001$, $F = 6.3$). The training groups showed a more significant increase in HDL-C compared to other groups. Furthermore, a significant difference was observed between the resistance training + vitamin D group and vitamin D group ($P = 0.001$) (Table 1). TC changes were reported to be significant among the studied groups ($P = 0.001$, $F = 7.8$). Also, significant differences were between the resistance training + vitamin D group and the vitamin D group ($P = 0.03$), resistance training + vitamin D group and the placebo group ($P = 0.001$), and resistance training group and the placebo group ($P = 0.004$) (Table 1). Significant leptin changes were also reported in the studied groups ($P = 0.001$, $F = 11.4$). Moreover, the post hoc test showed significant differences between resistance training + vitamin D group and the resistance training group ($P = 0.001$), resistance training group + vitamin D group and the vitamin D group ($P = 0.001$), and resistance training + vitamin D group and the placebo group ($P = 0.001$) (Figure 1). Despite the reduction, no significant difference was observed in LDL-C, TG, weight, and BMI among the studied groups (Table 1). Also, the significant differences for vitamin D levels were reported among the studied groups after performing the interventions ($P = 0.03$, $F = 8.62$). Accordingly, these changes showed a difference among the vitamin D and RT + vitamin D groups compared to the RT ($P = 0.03$) and control ($P = 0.02$) groups (Table 1).

5. Discussion

The purpose of the present study was to investigate the effect of resistance training and vitamin D supplementation on lipid profile and leptin in overweight women. In this regard, the changes in HDL-C, TC, and leptin were reported to be significant among the studied groups. Moreover, these changes were significant between the resis-

tance training + vitamin D group and other groups. Previous studies have shown that, there is a relationship between the decreased leptin concentration and the improvement of lipid profile as well as a decrease in the adipose tissue (11-13). In addition, regular exercise not only improves lipid profiles and diabetes indices by improving insulin resistance and also lowering blood glucose amount, but it also affects the vitamin D tissue receptors (16). Therefore, in this study, one of the most important reasons for the observed changes can be the reduction of adipose tissue. In the present study, the body weight and body composition of the participants did not significantly decrease, which could be due to maintaining or increasing muscle mass resulted from resistance training. In addition, the participants of this study were not only overweight and inactive women, but they were also physically healthy. Accordingly, this can be considered as one of the reasons for the observed changes and their difference or similarity with the other studies. On the other hand, although levels of vitamin D have not been measured, most of the findings have shown that under the conditions of obesity or overweight, especially in women, there are several problems with vitamin D.

Theodorou et al. (27) examined the effects of aerobic exercise, resistance training, and the combined exercises in 56 elderly people with coronary artery disease. Notably, performing the resistance training led to a significant increase in muscle strength, whereas aerobic training led to a significant improvement in lipid profile and apolipoproteins. The combined exercises resulted in the improvements in both physiological (muscle strength) and biochemical variables (lipid profile, apolipoprotein, and inflammation) (27). Zanetti et al. (28) also reported that, after 12 weeks of nonlinear resistance training, TC, TG, and LDL-C levels decreased in the exercise group, while HDL-C levels in this group increased. Ribeiro et al. (29) also showed that resistance training improved lipid profile. Reports have also indicated a greater LDL-C efficacy over the longer periods of aerobic exercise (5). Although some studies have shown a significant effect on exercise for a 12-week period with complete dietary control compared to the control group (30), some studies showed that shorter exercise (9 weeks) has only a few effects (31).

The comparison between aerobic and resistance training as well as their effects on metabolic syndrome have also been studied; however, there is no absolute finding showing that, which training method has the most impact. In this regard, some studies have found that aerobic activity is better than resistance training due to its direct effect on adipose tissue lipolysis. However, the use of resistance training is highly recommended because of the stimulation of intracellular signaling pathways, stimula-

Table 1. Anthropometric Characteristics of the Subjects and the Measured Variables Among the Studied Groups^a

Groups	RT + Vitamin D		Resistance Training (RT)		Vitamin D		Placebo	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Age	27.9 ± 3.8	-	29.2 ± 3.3	-	29.2 ± 3.2	-	27.4 ± 1.4	-
Height	162.2 ± 4.8	-	161.4 ± 4.08	-	162.2 ± 3.4	-	163.8 ± 6.1	-
Weight, kg	71.4 ± 3.7	70.4 ± 4.05	70.9 ± 4.2	70.2 ± 5.3	69.1 ± 4.8	68.9 ± 3.1	72.6 ± 6.1	72.4 ± 6.2
BMI, kg/m ²	27.9 ± 1.3	27.5 ± 1.4	27.2 ± 1.8	27 ± 2.4	26.2 ± 0.7	26.2 ± 0.7	27.4 ± 1.5	26.9 ± 1.5
LDL-C, mg/dL	152.7 ± 15.4	144 ± 16.7	150.6 ± 11.1	143 ± 13.8	141.9 ± 11.7	136.5 ± 13.8	145 ± 11.9	144.4 ± 17.5
HDL-C, mg/dL	38.7 ± 2.8	46.4 ± 2.06	38.5 ± 2.2	44.4 ± 2.5	40.1 ± 3.9	44 ± 3.3	39.7 ± 3.4	40.8 ± 3.8
TG, mg/dL	174.9 ± 15	140.5 ± 13.5	180.3 ± 18.9	152.9 ± 16.4	176.8 ± 18.1	158.9 ± 17.5	178.8 ± 10.8	171.2 ± 19
TC, mg/dL	184.9 ± 23.2	165.1 ± 29.7	184.9 ± 22.8	180.8 ± 22.3	195.6 ± 27.4	191.3 ± 27.8	181.7 ± 20.3	179.7 ± 22.9
Leptin, ng/mL	19.06 ± 3.7	11.2 ± 2.5	20.2 ± 4.7	16.6 ± 4.5	18.4 ± 5.7	17.9 ± 5.4	16.3 ± 4.8	18.8 ± 4.5
25-OH-vit D, ng/mL	23.7 ± 1.3	28.2 ± 1.6	22.9 ± 1.2	24.7 ± 1.8	23.6 ± 1.7	27.2 ± 1.5	22.8 ± 1.4	23.4 ± 1.3

^aValues are expressed as mean ± SD.

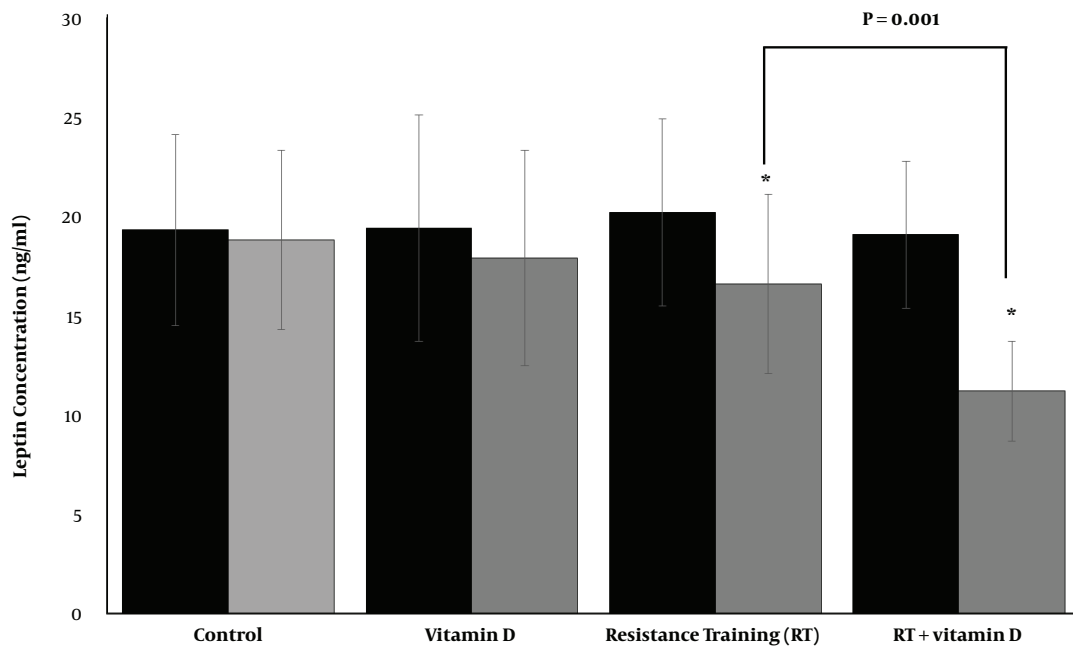


Figure 1. Leptin changes among the studied groups. The highest decrease was observed in the resistance training groups. Data are presented by mean and standard deviation. *, A significant difference with other groups.

tion of intramuscular calcium pumps, the concurrent reduction of adipose tissue, and increasing or maintaining muscle mass. In addition, the importance of this topic increases muscular function as well as sports performance even in the elderly (32) It is argued that, if the course of resistance training is progressive with a longer period, the effect of the combination of these two types of training will be greater (31).

The participants of the present study were physically healthy. It has been shown that, due to the differences in the baseline levels of vitamin D, the healthy participants have shown better improvements in taking low, moderate, and high-dose vitamin D compared to those with obesity (33). Even some studies have shown that, vitamin D supplementation in overweight or obese groups indicate no effect on leptin changes and lipid profiles (26). In some

cases, the relationship between vitamin D and leptin was observed only in the women group (19). Moreover, Vitamin D is known as a major cellular and molecular factor in leptin gene expression in the adipose tissue, which can also affect energy homeostasis (34). Increasing leptin is one of the factors regulating appetite, followed by weight loss in obese and overweight people (34). Therefore, an important signaling pathway for nutritional and exercise training controls probably is the use of vitamin D supplements. Accordingly, this point in the present study can explain the difference between the resistance training + vitamin D group and other groups, including the training group.

Several mechanisms have been proposed to justify the inverse relationship between obesity and vitamin D, which include the roles of adipokines, epigenetics, calcium, and types of adipose tissues (1). Collaboration between calcium and vitamin D has been reported as a major contributor to improve glucose levels in obese and overweight women with ovarian problems and vitamin D deficiency (35). In another similar study, 8 weeks vitamin D supplementation (50000 IU, each week) improved the lipid profiles and insulin indices (36). Notably, one of the effective mechanisms of physical activity on regulating glucose is increasing the calcium pump of the reticulum sarcoplasmic. This is likely to cause GLUT4 to be transmitted to the cell surface, which facilitates the transfer of glucose without any interference of insulin (5, 35). Also, it is noteworthy that, in the elderly, daily use of vitamin D (400 IU) as well as calcium supplementation (800 mg per day) would have positive effects (32, 37). The coincidence of the effects of vitamin D and calcium on the reduction of metabolic syndrome indices has also been confirmed (37). One-year period of vitamin D treatment, despite an improvement in metabolic syndrome, has shown the insufficient effect of vitamin D treatment alone (4). In contrast, an improvement even in shorter periods was reported in obese healthy subjects (38).

5.1. Conclusions

Metabolic syndrome develops in the cases with signs of obesity, diabetes, hypertension, and dyslipidemia, which can be reduced by supplementation with vitamin D (24). It was shown that, vitamin D also affects adipokines (3). It is likely that, the condition of the studied groups is important in terms of health, disease, basal vitamin D status, and obesity. Overall, there is a significant relationship among the improvement of vitamin D levels, adipokine levels, and lipid profiles (3). Accordingly, this effect has been observed in different doses. Moreover, regular physical activity along with these interventions will multiply the effect of vitamin D supplementation (15, 32). A one-year

course of lifestyle modification with no vitamin D treatment has shown some positive effects on vitamin D levels and metabolic syndrome (14). In fact, regular physical activity reduces adipose tissue mass and decreases leptin secretion. Therefore, designing a comprehensive study including an examination of different exercise mode, various doses of vitamin D, body composition, and basal vitamin D status seems essential. In addition, because of the role of sunlight on vitamin D status, it is important to compare sport clubs for exercise training (indoor environments) and outdoor exercise training like natural environments.

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Footnotes

Authors' Contribution: Maryam Najafi did investigation, methodology, project administration, resources, and software. Hoseyn Fatolahi did investigation, methodology, project administration, resources, software, formal analysis, conceptualization, supervision, data collection, writing-original draft, writing-review, and editing.

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Ethical Approval: The experimental protocol in the present study (based on MSc thesis) was approved by the ethics committee of Islamic Azad University, Central Tehran Branch (no.: 10121436962028). The researchers' Ethics Committee initially approved the experimental procedures and the study protocols, which were fully explained to all the participants. The research was also conducted in terms of the principles stated in the Declaration of Helsinki.

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