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Original Article

Effects of aerobic exercise and spirulina supplementation on the lipid profile, and body's functional variables, and composition in overweight women

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Abstract

Background: Obesity leads to various chronic conditions, and investigating its causative factors is of health and clinical significance to humans. Doing physical exercises regularly and consuming a proper diet are frequently recommended for achieving health benefits and resolving the various complications of obesity. This study examined whether performing moderate-intensity aerobic exercises combined with *spirulina*, a seaweed rich in probiotics and antioxidants, can improve the lipid profile, body composition, and function in overweight women.

Methods: We examined the associated variables linked to obesity in 20 volunteer women in a pre-and post-test design over eight weeks of intense aerobic exercises based on an established protocol compared to the controls. We assessed cardiovascular endurance and variables like lipid profile, weight, body mass index, and lean muscle mass in response to exercising plus spirulina consumption versus the controls.

Results: The exercise and spirulina significantly reduced blood triglycerides and LDL while raising the HDL. The treatment significantly reduced body weight, fat, and BMI while increasing muscle strength and Vo_2max compared to the control group.

Conclusions: Combining moderate-intensity aerobic exercises with spirulina supplements significantly reduced body weight, fat deposits, and BMI while increasing muscle strength and Vo_2max in overweight and obese women.

Keywords: Aerobic exercise; Blood lipid profile; Body composition; Female obesity; Spirulina supplement

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Introduction

Obesity is the major cause of various chronic conditions; therefore, its investigation is of major importance in human health. Thus, research into the factors that lead to reduction in the body fat is warranted (1). It is clear that accumulation of fat in bodily tissues and organs is responsible for the development of various diseases and even death. By comparison to non-obese women, overweight and obese women are twice as much at risk of the associated health conditions (2). To protect against the complications in humans caused by obesity, regular physical activity are highly recommended. In addition to the maintenance of health and well-being, doing regular physical activities is an effective solution against many chronic conditions (3).

Based on reliable evidence, performing physical exercises regularly improves the functional variables that contribute to health, especially in overweight patients. Studies have demonstrated the negative effect of obesity on such fitness variables as: body composition, flexibility, muscle strength and endurance (4, 5). Obesity is also associated with inflammatory conditions as the main mechanisms behind arteriosclerosis and insulin resistance. Obesity leads to increased levels of pathological markers in the blood, such as cytokines and proteins of the chorionic stage (6). The common lipid disorders in overweight and obese individuals include having high blood levels of triglycerides (TG), low-density lipoproteins (LDL) while having reduced high-density lipoproteins (HDL) (7).

Blood HDL at normal level is known as a powerful metabolic factor for preventing cardiovascular conditions (8). This compound protects LDL from oxidative damages (9). Moderate intensity aerobic exercises, if performed 3-5 time per week for at least 45 minutes, can significantly improve the person's health and well-being. Physical fitness and well-being are mainly determined by the quality of bodily organs, and the intellectual and psychological health status (10). By performing physical exercises properly, it is possible to improve upon bodily weaknesses, even those originated from hereditary factors.

Dietary supplements are considered complementary treatments that are traditionally used by the general public for their beneficial effects (9). *Spirulina* is a seaweed from the family of blue-green algae that is rich in probiotics, antioxidants and other nutrients, such as phycocyanin, chlorophyll, polysaccharides and sulfolipids (11). These natural compounds are known to support and improve the body's energy levels significantly (12). Spirulina contains natural elements, high quality proteins, and is rich in essential fatty acids and

minerals required for the body (11). These nutrients are highly digestible and absorbed easily from the gastrointestinal tract (10, 11). Also, spirulina is an important source of a photosynthetic protein called phycocyanin C, with excellent anti-inflammatory and antioxidant properties (13).

Based on ample research, aerobic exercise is one of the commonly used interventions in the clinical management of individuals with obesity. The positive effects of aerobic exercise at moderate intensity have been established in numerous populations. However, the efficacy is not quite clear in overweight women when combined with dietary supplementation (14). Considering the above facts, it is essential to investigate the effect of moderate intensity exercises combined with spirulina consumption in obese women, focusing on lipid profile, functional variables, and body composition.

Aim of the Study: The main question of this study is whether performing moderate intensity aerobic exercises combined with spirulina consumtion can have a significant impact on the lipid profile, functional variables and body composition in overweight and obsess women.

Materials and methods

Study Design: This experimental study was conducted based on a pre-test and post-test design versus a control group. The study population was made up of overweight women, referred to clubs and health clinics in Isfahan, Iran. We carefully selected 20 women from among these referrals who met the requirements and were willing to participate in the study voluntarily for eight weeks.

The inclusion criteria for entering this study were: 1) having a body mass index (BMI) above 25; 2) female gender at the age range of 30-35 years old; 3) absence of cardiovascular, respiratory, skin, and neuromuscular diseases; 4) ability to participate in the training sessions as scheduled, and 5) lack of prescribed participation in rehabilitation and sports clinics other than the ones required by this study.

The exclusion criteria were: 1) Absence of more than five training sessions during the current study; 2) Recurrence of disease conditions during the study; 3) Suffering from certain health conditions, such as skin disorders that would be aggravated by participating in the study;

4) Failure to participate in the required clinical tests (15).

Study Participants: Upon completion of the initial evaluation, 20 overweight and obese

women were selected and randomly assigned to the following two groups:

- **Group 1** (n=10) were given moderate-intensity aerobic exercises for eight weeks combined with spirulina suplements.
- **Group 2** (n=10) were given the same exercise protocol plus a placebo.

One week before conducting the study and 48 hours after the last training session, we assessed the study variables as follows: Body weight, body mass index (BMI), lean body mass (LBM), soft tissue mass (STM) and skeletal muscle mass (SMM). These variables were measured using a body composition analyzer (model #: X-CONTACT 356; Jawon Medical, South Korea) set at three frequencies of 5, 50, and 250 kHz. We also assessed the participants' lipid profiles, i.e., TG, HDL and LDL in both groups. Finally, the participants' cardiovascular endurance was also examined. The variables consisted of step test and strength based on the equation of one maximum repetition and lipid profiles in both groups (16).

Aerobic Exercise Protocol: In this study, the aerobic exercise protocol was performed based on moderate-intensity Tabata program. For each session, the exercises lasted four minutes and each was performed for 20 seconds with a 10-sec resting interval in between. The exercises included: 4 abdominal sets; functional lunges; butterfly belly with dumbbell, foot balance side spread, squat head, lying on abdomen (17).

Spirulina Supplement: The spirulina supplements were provided by the supplier for consumption by the experimental group at 4-gram twice a day per participant over the eight weeks of the study period (18).

Statistical Analyses: After collecting the data, we used Kolmogorov-Smirnov test to check for the normal distribution at baseline and at the end of the study. To determine the effects of 8-week activities on the dependent variables in each group, we used dependent *t*-test to make comparisons between the two groups and to analyze the covariance. All statistical analyses were performed on SPSS software version 23 at a significance level of $P \leq 0.05$.

Results

Lipid Profiles: The results of the dependent *t*-test showed that the amount of TG and LDL in the combined exercise and spirulina group decreased significantly. However, the results of the covariance analysis between the two groups showed that there were no significant differences in their TG and LDL levels. The results of the *t*-test indicated that the blood HDL levels in the group given combined exercise and spirulina increased significantly. However, the covariance test of the data did not show significant difference between the HDL levels of the two groups.

Body Composition: The results of the *t*-test showed that the percentage of body fat, weight and BMI in the exercise plus spirulina group decreased significantly. The covariance test demonstrated that there were significant differences in the fat percentage, body weight and BMI between the two groups. Also, the results of the same *t*-test demonstrated that the Vo_2max level in the combined exercise and spirulina group had a significant increase. However, the covariance test results showed that there was no significant difference between the Vo_2max values between the two groups. Also, the results of the same *t*-test showed that the mean muscle strength level in the combined exercise and spirulina group increased significantly. However, the covariance test results indicated no significant difference in the muscle strength between the two study groups.

Table 1: Physiological characteristics of the subjects per group.

Variables	Exercises Alone (n=10)	Exercises + Spirulina (n=10)
Age (years)	32/49 ± 7/14	**31/50 ± 7/14**
Height (cm)	163/22 ± 7/05	**163/30 ± 6/50**
Weight (Kg)	80/41 ± 8/30	**79/66 ± 8/21**
BMI (Kg/m2)	31/68 ± 5	**32/44 ± 4/4**
Percent Body Fat	36/34 ± 6/47	**37/61 ± 6/57**

Table 2: Group comparisons based on covariance.

Variables	Groups	Pre-test	Post-test	F	P
TG	Training +Supp	171/11± 5/65	155/11± 8/75	0/651	**0/31**
	Training	166/22± 4/71	153/20± 4/64		
HDL	Training +Supp	44/1± 6/61	49/5± 9/64	0/94	**0/32**
	Training	45/45± 4/71	47/6± 8/31		
LDL	Training +Supp	91/14± 5/09	87/15± 6/64	0/521	**0/83**
	Training	90/14± 6/71	88/14± 8/52		
BMI	Training +Supp	31/68± 5	30/40± 4/54	4/32	**0/008***

	Training	32/44± 6/61	30/61± 5/51		
FAT	Training +Supp	37/61± 6/57	35/21± 7/54	4/42	**0/001***
	Training	36/34± 6/61	35/11± 6/14		
Weight	Training +Supp	79/66± 8/21	76/10± 8/24	0/97	**0/01***
	Training	80/41± 7/61	78/81± 10/54		
Vo2max	Training +Supp	29/65± 4/48	32/05± 3/68	0/52	**0/22**
	Training	29/35± 3/68	31/30± 4/31		
Strength	Training +Supp	32/05± 4/57	34/40± 5/54	0/035	**0/85**
	Training	31/15± 4/60	33/80± 4/15		

*Significance of groups with training group. Supp = Spirulina supplement.
Training = Moderate-intensity exercises once daily x 8 weeks.

Discussion

The present study aimed to investigate the effect of a protocol of eight weeks of moderate-intensity exercises, with or without spirulina supplementation, on the lipid profile, functional variables and body composition in overweight women. The primary finding of this study revealed no difference between the TG levels between the two study groups. However, the group that performed only experienced a greater decrease in the average than the group that underwent exercise + spirulina supplementation. Our findings are consistent with those reported earlier by Eskandari, *et al* (19) and Dehghani, *et al*. (20). These authors investigated the effect of aerobic exercise combined with the concurrent use of blue-green algae on the anthropometric indicators and cardiovascular risk factors of diabetic men. They suggested that the group that used spirulina supplement demonstrated decreased TG level (19, 20). In another study, Dehghani, *et al*. investigated the effect of spirulina supplement and circuit training on the lipid profile of men. They suggested that spirulina supplementation combined with resistance exercises had a greater effect on reducing the blood TG level than the exercises alone (20). No significant difference was found in the serum HDL level of the participants who performed the exercise protocol alone and those who combined the exercises with spirulina supplements. However, the group that performed exercises and took spirulina supplement had a greater increase in HDL than the control group who only performed exercises The results of the present research are consistent with those reported by Badri, *et al*. (21) but were inconsistent with those of Haji Ghorbani, *et al* (22). The reason for the conflicting results may be attributed to the differences in the intensity or the type and duration of exercise protocols performed by the participants in various studies.

Another finding of our study was the lack of significant differences on the serum LDL levels of the participants between the two groups. However, the group that was given

exercise plus spirulina demonstrated a greater decline in the mean serum LDL level than those who completed the exercise protocol alone. These results are consistent with those reported by two earlier studies (19, 23). As previously suggested by a number of other studies, a marked reduction in serum LDL parallels similar changes in the body's weight loss. Conversely, some studies have suggested that changes in the lipid profile due to effective exercises might be independent of body weight, exercise intensity and/or duration. Although, it is believe that low consumption of saturated fats and observing balanced diets are effective factors for a healthy lipid profile and body weight (19-23).

With respect to changes in the BMI, the results of the current study showed that performing the 8-week moderate intensity exercise protocol and concurrently taking the spirulina supplements had a significant impact on lowering body weight, body fat and BMI in overweight women compared to those in the control group. These results are consistent with those reported earlier by similar studies (19, 24-26). It is; therefore, likely that consuming spirulina concurrently with performing moderate intensity exercises can effectively lead to significant weight loss in overweight people. It is also possible that spirulina supplement can protect against oxidative damages to human cells by free radicals, especially in overweight and obese people.

It may also be suggested that mitochondrial volume and lipase activities may rise due to exercises in the presence of spirulina, leading to improved fat catabolism and ultimately to a significant weight loss (18). Some researchers believe that the consumption of spirulina supplements increases the blood hemoglobin, thus supporting the notion that it may contribute to oxygen transport, especially considering its essential and non-essential amino acids, and iron contents. These elements are known to have a significant role in the improvement of the Vo2max (28). Finally, the combination of spirulina and moderate-intensity exercise is likely to increase the health indices and positively impact the body composition, which in turn improves the variables involved in the person's physical fitness and healthy muscle strength (29).

Conclusions

The findings of this study provide experimental evidence that combining moderate intensity aerobic exercises with spirulina supplements, tentatively over an 8-week period, significantly reduces the body weight, fat deposits, and BMI but significantly increases the

muscle strength and Vo_2max capacity in overweight and obese women. Changes in these variables were significantly less when measured in the overweight women in the control group who performed similar exercises but were not given the spirulina supplements.

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Conflict of Interests:

The authors declare no conflict of interests with any internal or external entity in conducting this research.

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