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Effects of High-Protein, Low-Energy Diet on Body Composition in Overweight and Obese Adults: A Clinical Trial

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***Abstract*—**Background: In addition to reducing body weight, the low-calorie diets can reduce the lean body mass. It is hypothesized that in addition to reducing the body weight, the low-calorie diets can maintain the lean body mass. So, the current study aimed at evaluating the effects of high-protein diet with calorie restriction on body composition in overweight and obese individuals. Methods: 36 obese and overweight subjects were divided randomly into two groups. The first group received a normal-protein, low-energy diet (RDA), and the second group received a high-protein, low-energy diet (2×RDA). The anthropometric indices including height, weight, body mass index, body fat mass, fat free mass, and body fat percentage were evaluated before and after the study. Results: A significant reduction was observed in anthropometric indices in both groups (high-protein, low-energy diets and normal-protein, low-energy diets). In addition, more reduction in fat free mass was observed in the normal-protein, low-energy diet group compared to the high -protein, low-energy diet group. In other the anthropometric indices, significant differences were not observed between the two groups. Conclusion: Independently of the type of diet, low-calorie diet can improve the anthropometric indices, but during a weight loss, high-protein diet can help the fat free mass to be maintained.

***Keywords*—**Diet, high-protein, body mass index, body fat percentage**.**

I. Introduction

OBESITY is mainly defined as excess fat tissue in the body, and factors such as environment, genetic predisposition, and personal behavior can contribute to its development [1], [2]. According to the World Health Organization report in 2005, approximately 1.6 billion people are overweight, 400 million adults are obese, and the high prevalence of obesity has also been reported in Iran [3]-[6]. Obesity or being overweight body is associated with diseases such as type 2 diabetes, cardiovascular disease, nonalcoholic fatty liver [7]. On the other hand, the evidence suggests that weight loss can improve obesity-related risk factors such as blood pressure [8], [9]. There are various methods such as diet, physical activity, behavior modification, drug therapy, and surgery for weight loss [10], [11]. Given that dietary pattern is associated with obesity and many other diseases [12]-[14], a variety of weight-loss diets have been proposed for control and treatment of obesity. Weight loss diets are generally associated with lower body weight. While the health status of individuals can be improved due to the weight loss, an important percentage of active tissues such as muscle tissue is destroyed by weight loss as well [15]. Loss of muscle tissue can cause weight regain (reduced) and reduced physical function [16]. Weight-loss management programs should be targeted at decreased fat mass and preservation of muscle mass loss. Several studies have suggested that a reduction in muscle mass is facilitated by decreased dietary protein intake [17], [18]. The recommended dietary allowance of protein has been 0.8 g/kg/day; however, a meta-analysis suggested that protein needs can be more than the recommended amount (0.8 g/kg/day) [19]. On the other hand, the diet prescribed for weight loss can affect the rate of muscle loss [20], [21]. Low-calorie, high-protein diets are one of the diets that have recently been considered. Weight loss along with taking of high protein will prevent loss of the body muscle mass [22]. Recent studies suggest that high-protein diets, in addition to maintaining fat-free mass (FFM) during weight loss, have positive effects on anabolic hormones [23].

Considering the hypothesis that a low-calorie diet can decrease FFM, and high-protein diets can help to prevent from muscle loss, this study has been designed and conducted to investigate the effect of low-calorie high-protein diet on body composition in obese and overweight.

II. Materials and Methods

This clinical trial study was conducted on 36 obese and overweight (Body Mass Index> 25 kg/m^2). Participants were selected from among the clients referred to the dietary clinic in Ahvaz, Iran. Based on inclusion and exclusion criteria, subjects were enrolled. Inclusion criteria for the study were: lack of many physical activities (such as athlete), no smoking, no alcohol, no use of herbal remedies, vitamins and protein supplements, the lack of weight loss in the past three months. Exclusion criteria were as follows: pregnancy and breastfeeding, use of medications affecting metabolism, heart, renal, gastrointestinal, thyroid diseases, and cancer.

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Participants received necessary details regarding the study. Written informed consent was obtained from qualified individuals. Participants were divided into two groups: 1) receiving low-calorie and high- protein diet (n = 18); and 2) receiving low-calorie with normal protein diet (n = 18). The order in which they consumed their normal or high protein diet was randomized.

Both groups underwent weight loss diet for two months (with a limit of 500 kcal per day). Protein intended for groups was based on the Recommended Dietary Allowance (RDA). The high- protein diet group received on a daily basis by 1.6 grams of protein per kilogram of body weight (RDA × 2), and the group with normal protein received on a daily basis 0.8 grams of protein per kilogram of body weight (RDA). Anthropometric assessments (Weight, BMI, FFM, fat mass, and body fat percentage) of participants were performed before and after the intervention. Weight and composition of body were measured by using bioelectrical impedance (Inbody 230, Biospace, Korea). Standing height without shoes was performed using a height gauge strip. BMI was calculated by dividing weight (kg) by height squared (m). Each subject was tested at least twice per visit. All testing was done with each subject at approximately the same time of day for each of the five testing sessions.

Statistical analysis was performed using SPSS version 19 (SPSS Inc., Chicago, IL, USA). Normal distribution of data was assessed using the Kolmogorov-Smirnov test. To compare variables between the two groups, t-test (for variables with normal distribution) and Mann-Whitney test (for variables with non-normal distribution) were used. For comparison before and after the intervention in the groups, the paired t-test was used for variables with normal distribution, and Wilcoxon was used for variables with non-normal distribution. Data were expressed as mean±SD. A P-value<0.05 was considered as significance level. The study protocol was approved by the Ethics Committee of Jundishapur University of Medical Sciences (Ethical code.IR.AJUMS.REC.1393.396).

III. Results

Table I shows that there is no significant difference between the two groups in terms of general characteristics, including age, gender, weight, height, BMI, and body fat percentage (P>0.05).

Table II shows that the anthropometric parameters (weight, BMI, body fat mass, FFM, and body fat percentage) were significantly decreased in both groups (P< 0.05). In addition, FFM in the group receiving low- fat, high-protein diet showed a significantly lower loss compared to the group receiving low-calorie with normal protein diet (P<0.05). Other anthropometric indices between the two groups showed no significant difference.

TABLE I
General Characteristics of the Participants in the Study

Variables	Low-calorie - normal-protein diet	Low-calorie - high-protein diet	p-value
Age (years)	44.44±11.98	44.77±9.64	NS
Gender (male/female)	12/6	12/6	NS
Weight (kg)	77.37±7.05	76.80±9.29	NS
Height (cm)	162.77±7.95	164.46±162.77	NS
BMI (kg /m^2)	29.41±3.53	28.31±1.97	NS
BF (%)	38.51±8.03	37.10±6.10	NS

BMI: Body Mass Index, BF: body fat, NS: non-significant. Data are presented as mean±SD. A P-value<0.05 was considered as significance level. T- test for normally distributed variables and Mann-Whitney for variables with non-normal distribution.

TABLE II
Anthropometric Characteristics at the Beginning and End of the Study in the Two Groups

Variables	Low-calorie – high-protein diet		Low-calorie – normal-protein diet		Δ
	Start	End	Start	End	
Weight (kg)	76.80± 9.29	71.97± 8.37*	77.37± 7.05*	71.07± 6.32	1.47± 1.14
BMI (kg /m^2)	28.31± 1.97	26.54± 1,66*	29.41± 3.53*	26.90± 2,52*	0.73± 0.52
FFM (kg)	47.85± 10.28*	46.65± 9.72*	46.20± 10.12*	43.45± 9.03	-1.54± 0.81**
FM (kg)	28.05± 2.38*	24.85± 3.06*	29.55± 6.09*	26.00± 5.43	0.32± 0.77
BF (%)	37.10± 6.10*	34.59± 6.29*	38.51± 8.03*	36.96±8.96	0.96± 0.82

* P-value < 0.05 at the end of the study compared with baseline in both groups
** p-value < 0.05 to compare differences between changes in the two groups
BMI: Body Mass Index, FFM: fat-free body mass, FM: fat mass, BF: Body Fat.
Data are presented as mean ± SD.
A p-value < 0.05 was considered as significance level.
The paired t-test (for variables with normal distribution) and Wilcoxon (for variables with non-normal distribution) were used for comparison within groups; t-test (for variables with normal distribution) and Mann-Whitney (for variables with non-normal distribution) were used for comparison between groups.

IV. Discussion

Our results showed that the both diets under intervention improved the situation anthropometric parameters in obese and overweight. The results of this study showed that low- fat, high-protein diet compared with low-calorie with normal protein diet can cause less reduction in FFM (maintaining more muscle tissue). Although there are still no standard definitions for high-protein diets [24], we propose that the daily protein intake of 2×RDA at baseline in our study may be defined as relatively high compared with the RDA as currently recommended in dietary allowances to exclude protein deficiency [25].

High-protein diet promotes more weight loss through several mechanisms. These factors include: increasing the

feeling of satiety, maintaining the rate of metabolism and fat-free body mass during weight loss, and a higher thermic effect [26]-[28]. A better preservation of lean body mass during high-protein diets has been reported in studies aimed to reduce body weight. This result was ascribed to higher rates of net protein synthesis, increased accretion of tissue protein, and restrained body protein breakdown [29]-[31]. Petzke et al. [32] reported an increase in FFM (0.7 kg) during eating low-fat meat in addition to their habitual diet (protein intake 25.2% of energy) and a decrease in FFM (−0.8 kg during exclude meat products from their diet (protein intake 14.0% of energy).

A study conducted by Mettler et al. showed that the increased protein intake (2.3 g to 1 g per kg of body weight per day) during weight-loss diets, can help to preserve fat-free body mass in young athletes [33]. In a study conducted by Pasiakos et al., the effects of high-protein diets on body composition were studied. In that study, it was found that during the weight loss period, high-protein diets (RDA × 3 and RDA × 2) to a balanced diet of protein (RDA) cause significantly greater decreases in fat mass and less decrease in FFM [34]. Longland et al. examined the effect of protein intake on body composition in athletes. Their results showed that a high protein diet (2.4 kg body weight per day) compared to the low-protein diet (1.2 kg body weight per day) combined with exercise causes significantly more increase in muscle mass and more reduction in body fat mass [35]. Antonio et al. examined the effect of an eight-week high-protein diet on body composition in strength athletes. Their results showed that consumption of high-protein diet (4.4 kg body weight per day) compared to the recommended diet for athletes cannot make significant differences in athletes' body composition (body weight, fat mass, FFM, body fat percentage) [36]. A few studies examined changes in habitual protein intake. In the study of Soenen et al. [37], participants increased habitual protein intake 16%, from 1.13 g/kg/day to 1.31 g/kg/day. Over three months, this FFM of the protein group increased by 0.9 kg, and fat mass had decreased by 0.6 kg, while the control group did not change. In another study, Petzke et al. [38] reported a positive correlation between change in habitual protein (meat) intake and change in fat-free body mass.

Different results in the studies could be due to factors such as differences in the population studied, duration of intervention, intervention of diet with or without physical activity, amount of caloric restriction, and the type of protein used in the diets (ratio of animal and vegetable protein) in the studies.

In summary, the present study suggests that protein intake during weight loss can lead to further improvement of people anthropometric status. More and more comprehensive studies in this area are recommended.

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