



RESEARCH ARTICLE

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# The effects of modified alternate-day fasting diet on weight loss and CAD risk factors in overweight and obese women

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## Abstract

**Background:** Obesity is a worldwide health problem with increasing prevalence. Decrease in energy intake has been shown to lower the risk of coronary artery disease in obese subjects. The common form of dietary restriction is daily calorie restriction (CR). Another form is alternate-day fasting (ADF). This study examined the ability of modified ADF to facilitate weight loss and lower cardiovascular risk factors in overweight and obese women.

**Methods:** 15 adult subjects completed an 8 weeks trial (2 weeks observed and 6 weeks ADF). All women consumed very low calorie diet on the fast day and usually diet in every other day. Body weight (BW), fat mass and blood pressure (BP) were measured. Fasting blood samples were collected at the first and 57<sup>th</sup> day of trial for biochemical analysis.

**Results:** During the course of the trial, BW of the subjects decreased ( $p < 0/0001$ ) from  $84/3 \pm 11/44$  kg to  $78/3 \pm 10/18$  kg. Waist Circumference decreased from  $87/87 \pm 9/74$  to  $82/86 \pm 9/68$  ( $p < 0/001$ ). Reduction in systolic BP was seen from  $114.8 \pm 9.16$  to  $105.13 \pm 10.19$  mmHg ( $p < 0/001$ ) and diastolic BP changed from  $82.86 \pm 10.6$  to  $74.5 \pm 10.8$  ( $P < 0.05$ ). Total cholesterol decreased from  $227/73 \pm 49/96$  to  $214/67 \pm 43/27$ , TG from  $160/5 \pm 46/18$  to  $143/9 \pm 22/77$ , LDL from  $149/46 \pm 49/81$  to  $131/3 \pm 50/97$ , and FBS from  $102 \pm 14/7$  to  $96 \pm 11/79$  mg/dl but were not significant. HDL increased from  $42/32 \pm 18/01$  to  $50/58 \pm 19/46$  and was not significant.

**Conclusion:** These finding suggest that short time ADF is a viable dietary option to help obese individuals lose weight and decrease some CAD risk factors. More and longer-term studies in human subjects are needed to support this important result.

**Keywords:** Alternate-day fasting, Weight loss, Serum lipids

## Introduction

Obesity has become an important worldwide health problem, with a rapidly increasing prevalence. The World Health Organization has estimated that by 2015 approximately 2.3 billion adults will be overweight and more than 700 million obese [1]. Obesity is associated with an increased risk of diabetes, cardiovascular events, stroke and cancer [2]. Moreover, a decrease in energy intake has been shown to lower the risk of Cardiovascular Diseases (CVD) such as Coronary Artery Diseases in obese populations [3]. The most common form of dietary restriction implemented is daily calorie restriction

(CR), which requires individuals to decrease their energy intake by 15 to 40% of baseline needs - while maintaining adequate nutrient intake each day. Another form of dietary restriction used, although far less commonly, is alternate day fasting (ADF) [4]. The ability of modified alternate day fasting [ADF; i.e., consuming 25% to 40% of energy needs on the fast day and ad libitum food intake on the following day [5] to facilitate weight loss and lower vascular disease risk in human subjects has yet to be investigated. This form of dietary restriction may be more feasible in practice than daily CR. The relation between ADF and cardio protection in human studies remains uncertain. Accordingly, the objective of the present study was to examine the effects of modified ADF diet on body weight, BMI, waist circumference,

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total body fat mass and cardiovascular risk factors such as systolic and diastolic BP, FBS, serum TG, LDL, HDL and total cholesterol in obese women.

### Material and methods

This study was approved by the research ethics committee of the Golestan University of Medical sciences, Gorgan-Iran. A written consent form was signed by each participant.

### Subjects

Of the 30 overweight or obese women screened, 15 participants completed a 8-wk trial, that includes 2 weeks observed and 6 weeks ADF diet. Baseline characteristics of the participants are shown in Table 1. Inclusion criteria were age 20 – 45 y, BMI  $\geq 25$  kg/m<sup>2</sup>, normotensive (<140/90 mm Hg), no weigh changes more and less than 10% for 3 months before the beginning of study, no history of cardiovascular, renal and metabolic disease; non-smoker. None of the subjects was taking any medication that is known to influence lipid, or glucose metabolism in last 6 months. All women had regularly cycling with menses appearing every 27–32 days. Pregnant women or those trying to become pregnant were excluded. The subjects had similar level of physical activity: less than 3 hours walking in week.

### Diet protocol

During the baseline control period (for 2 weeks), each subject was required to keep their body weight stable by maintaining their usual eating and activity habits, then, during 6-week ADF period, all subjects consumed very low calorie diet (25 to 30% energy needs) on the 3 fast day (Saturday, Monday, Wednesday) and then consumed usual diet based on the “Key Recommendations of Dietary Guidelines for Americans” [6] includes about 1700–1800 Kcal/d in every other days (3 days a week). In Friday subjects consume ad libitum without limitation. All foods were prepared in the home and served in 3 meal and 2 or 3 snacks. Energy free beverage (such as water, tea, green tea, coffee without sugar), non starchy vegetable (such as lettuce, cucumber, green leaf, tomato) and sugar free gums were free. Daily dietary carbohydrate,

fat and protein accounted for 55, 25, and 20% of ingested energy, respectively.

### Measures

Body weight, BMI, waist circumference, blood pressure and fat mass were measured in first visit and each 2 week throughout period of trial. Body weight was measured with a Seca Digital scale (Clara 803 - Germany) to the nearest 0.1 kg in the evening of fast day, without shoes, and in light clothing. BMI was assessed as the weight in kilograms divided by the square of the height in meters. Fat mass and fat-free mass were assessed using a tetrapolar bioelectrical impedance analyzer (Omron HBF-510). The instrument recorded impedance from hand to foot and consequently, calculated fat mass and skeletal muscle percentage from the impedance value and the personal particulars (weight, height, age, and sex). Waist circumference was measured in triplicate in standing subjects at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Blood pressure was measured with the Omron upper arm blood pressure monitor in a seated position after a 10 minutes rest.

Twelve-hour fasting blood samples were collected (at 8.00 – 9.00 am) at the first day of ADF diet and after 6 weeks diet for biochemical analysis. Blood was centrifuged to separate plasma from RBCs, and was stored in freeze (–70°C) until analyzed. Plasma total cholesterol, HDL-C, and triacylglycerol concentrations were measured in duplicate using enzymatic kits, standardized reagents, and standards (Pars Azmoon Co., Tehran, Iran). LDL-C concentration was calculated using the Friedewald equation [7].

### Statistical analysis

Data were analyzed by using SPSS software (version 16). Results are presented as means  $\pm$  SEM. Compare between results before and after the trial were assessed by paired *T*-test.

### Results

15 participants completed an 8-wk trial. Baseline characteristics of the participants are shown in Table 1.

During the baseline control period (2 wk) body weight of the subjects was not changed. After the course of the alternate-day fasting diet (6 wk), body weight decreased ( $P < 0.0001$ ) from mean  $84.3 \pm 11.44$  kg to  $78.3 \pm 10.18$  kg. Mean BMI of the subjects at baseline was  $33.16 \pm 5.02$  kg/m<sup>2</sup>. At the end of the modified ADF course, BMI decreased ( $P < 0.0001$ ) to  $30.72 \pm 4.62$  kg/m<sup>2</sup>, waist circumference from  $87.87 \pm 9.74$  cm to  $82.86 \pm 9.68$  cm ( $P < 0.001$ ). Fat mass was significantly reduced from baseline in all of the subjects. Systolic blood pressure decreased ( $P < 0.002$ ) from  $114.8 \pm 9.16$  mm Hg to  $105.13 \pm 10.19$  mm Hg

**Table 1** Baseline characteristics of the participants (n = 15)

Age (y)	33.46 $\pm$ 5.9
Weight (kg)	84.3 $\pm$ 11.44
BMI (kg/m <sup>2</sup> )	33.16 $\pm$ 5.02
Waist circumference	87.87 $\pm$ 9.74
Fat mass (%)	45.82 $\pm$ 4.16
Systolic blood pressure (mm Hg)	114.8 $\pm$ 9.16
Diastolic blood pressure (mm Hg)	82.86 $\pm$ 10.6

All values are presented as Mean  $\pm$  SD.

and diastolic BP ( $P < 0.02$ ) from  $82.86 \pm 10.6$  mm Hg to  $74.5 \pm 10.8$  mm Hg.

Changes in mean blood lipid and fasting blood sugar concentrations were not significant after 6 weeks of modified ADF. The anthropometric and biochemical changes are presented in Table 2.

## Discussion

This study shows that modified ADF is an effective, short term dietary intervention to help obese individuals lose weight and total body fat mass. Specifically, we show here that an ADF regimen resulted in a mean 7.1% weight loss of subjects from baseline after 6 wk of diet. Although CR is often used to facilitate weight loss [8,9], many obese patients find it difficult to continue because food intake must be limited every day [10,11]. The ADF is a new strategy that is capable for subject of self-selecting foods to continue their individual feed and fast day energy goals with the help of a dietitian for long time.

Our weight loss findings after 6 wk ( $6 \pm 1.2$  kg) are comparable to those of Varady et al. ( $5.6 \pm 1$  kg) [4] and Eshghinia et al. ( $4.7 \pm 2.5$  kg) findings [12]. Some researcher reported less weight loss due to shorter time of trial. Johnson et al. [13] were shown 4 kg weight loss after 4 wk of ADF in overweight individuals.

According to these effects on body weight, ADF may be considered a suitable alternative to CR to help obese individuals lose weight in short period.

Waist circumference is associated with visceral obesity. Elevated intra-abdominal fat area is associated with elevated risk of coronary heart disease and type 2 diabetes [14,15]. The ability of diet to reduce visceral fat mass has a protective role against these chronic diseases. In our study, after 6 weeks of ADF diet, waist circumference as the visceral fat mass was reduced by 5.7% ( $p < 0.001$ ) from baseline. In other studies visceral fat

mass was reduced by 4–10% from baseline, that positively associated with body weight loss [4,12,16].

Body composition changes only reported in three of the intermittent calorie restriction human trials with different methods [4,17,18]. In our study, percentage body fat mass declined from  $45.82 \pm 4.16\%$  at baseline to  $42.98 \pm 4.01\%$  ( $p < 0.001$ ) after 6 weeks. Varady et al. [4] assessed fat mass with the same method (tetra-polar bioelectrical impedance analyzer) and reported decreasing of fat mass from  $45 \pm 1.6\%$  to  $42.1 \pm 2\%$  ( $P < 0.05$ ) following 8 weeks ADF. Other trials had used dual-energy X-ray absorptiometry [17,18].

The effects of 6 wk diet on blood pressure were also assessed. Systolic and diastolic BP were lowered ( $p < 0.05$ ) by 9.7% and 8.3% respectively. Varady et al. [4] reported 5.1% reduce in systolic BP after 8 wk intervention, whereas diastolic BP did not change. Eshghinia et al. findings suggested decrease in systolic and diastolic BP following 4 wk ADF intervention in mild to moderate hypertensive women [12]. Results from another human study indicated that after 3 wk of intervention, neither systolic nor diastolic BP changed in subjects [16].

However, animal data indicate that ADF is effective in decreasing fasting glucose and insulin concentrations, Human trials have noted mixed findings with ADF regarding gluco-regulatory function [19]. In this study, fasting glucose concentration decreased following 6 weeks ADF diet but was not statistically significant. Eshghinia et al. found that fasting glucose significantly reduces from baseline following 4 wk ADF in obese women [12]. Heilbronn and colleagues [17] noted a decrease in fasting insulin but no difference in fasting glucose after 22 days of ADF. In another study by the same group [20] men on an ADF diet experienced a reduced insulin response to the test meal, but this effect was not observed in women. In addition, Halberg et al. [18] found no change in fasting glucose or insulin concentrations in men following a 14-day ADF trial. Taken together, these findings about blood glucose concentration suggest that men and women may respond differently to ADF. It seems that in future studies should examine causes of the sex-specific differences noted above.

As a means of assessing cardiovascular response to ADF, trials in this area have examined heart rate, blood pressure, circulating lipids, and ischemic injury. In our study serum TG, total cholesterol and LDL concentration were lowered and HDL increased after 6 weeks. It is possible; these effects resulted from the decreases in body weight and fat mass. However these changes were not statistically significant. Heilbronn et al. [17] examined the effect of ADF on CVD risk in both sex. When subjects fasted on alternate days for 3 wk, circulating concentrations of HDL cholesterol increased in the women, whereas triacylglycerol concentrations decreased in the

**Table 2 Anthropometric and Biochemical indexes at baseline and at the end of the trial**

Index	Before	After	P value
Weight (kg)	$84.3 \pm 11.44$	$78.3 \pm 10.18$	$P < 0.001$
BMI (kg/m <sup>2</sup> )	$33.16 \pm 5.02$	$30.72 \pm 4.62$	$P < 0.001$
Waist circumference	$87.87 \pm 9.74$	$82.86 \pm 9.68$	$P < 0.001$
Fat mass (%)	$45.82 \pm 4.16$	$42.98 \pm 4.01$	$P < 0.001$
Systolic blood pressure (mm Hg)	$114.8 \pm 9.16$	$105.13 \pm 10.19$	$P < 0.001$
Diastolic blood pressure (mm Hg)	$82.86 \pm 10.6$	$74.5 \pm 10.8$	$P < 0.05$
FBS (mg/dl)	$102 \pm 14.7$	$96 \pm 11.79$	NS
Total cholesterol (mg/dl)	$227.73 \pm 49.96$	$214.67 \pm 43.27$	NS
LDL cholesterol (mg/dl)	$149.46 \pm 49.81$	$131.3 \pm 50.97$	NS
HDL cholesterol (mg/dl)	$42.33 \pm 18.01$	$50.58 \pm 19.46$	NS
Triacylglycerols (mg/dl)	$160.5 \pm 46.18$	$143.9 \pm 22.77$	NS

P < 0.05 is statistically significant.

men. There is no clear explanation for these sex-based differences.

Other study reported different result. Varady et al. [4] showed 21.2%, 24.8% and 32% reduction in total cholesterol, LDL and TG respectively but no changes in HDL after 8 wk ADF program. In Eshghinia et al. findings, fasting TG was not changed but total cholesterol, LDL and HDL decreased ( $P < 0.01$ ). This lack of benefit effect of ADF on HDL cholesterol is not surprising because this cardioprotective lipid parameter is generally increase in response to exercise training [16,21].

It should be noted that this trial and many of other ADF trials had not control groups, included limited subjects and less than 8 weeks duration. A randomized controlled trial with larger groups in longer time needs to test these findings. The next step in the ADF field will be to incorporate an exercise program into this diet to test more benefits effects in lipid profile.

## Conclusion

Our study was shown efficacy of 6 weeks ADF diet to improve several key biomarkers of CAD risk, such as obesity, waist circumference, fat mass, systolic and diastolic blood pressure. The ADF method may be able to modify serum lipid profile. These findings suggest that ADF is a viable diet option to help obese individual loss weight and decrease some CAD risk factors.

## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

SE, FM carried out this research, participated in the sequence alignment and drafted the manuscript. We read and approved the final version of manuscript.

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