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Calorie Restriction with or without Time-Restricted Eating in Weight Loss

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ABSTRACT

BACKGROUND

The long-term efficacy and safety of time-restricted eating for weight loss are not clear.

METHODS

We randomly assigned 139 patients with obesity to time-restricted eating (eating only between 8:00 a.m. and 4:00 p.m.) with calorie restriction or daily calorie restriction alone. For 12 months, all the participants were instructed to follow a calorie-restricted diet that consisted of 1500 to 1800 kcal per day for men and 1200 to 1500 kcal per day for women. The primary outcome was the difference between the two groups in the change from baseline in body weight; secondary outcomes included changes in waist circumference, body-mass index (BMI), amount of body fat, and measures of metabolic risk factors.

RESULTS

Of the total 139 participants who underwent randomization, 118 (84.9%) completed the 12-month follow-up visit. The mean weight loss from baseline at 12 months was −8.0 kg (95% confidence interval [CI], −9.6 to −6.4) in the time-restriction group and −6.3 kg (95% CI, −7.8 to −4.7) in the daily-calorie-restriction group. Changes in weight were not significantly different in the two groups at the 12-month assessment (net difference, −1.8 kg; 95% CI, −4.0 to 0.4; P=0.11). Results of analyses of waist circumferences, BMI, body fat, body lean mass, blood pressure, and metabolic risk factors were consistent with the results of the primary outcome. In addition, there were no substantial differences between the groups in the numbers of adverse events.

CONCLUSIONS

Among patients with obesity, a regimen of time-restricted eating was not more beneficial with regard to reduction in body weight, body fat, or metabolic risk factors than daily calorie restriction. (Funded by the National Key Research and Development Project [No. 2018YFA0800404] and others; ClinicalTrials.gov number, NCT03745612.)

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Obesity is a major global public health challenge.[1] Weight loss by means of lifestyle modification has been documented to be the cornerstone of weight management.[2] Daily calorie restriction is a well-established primary weight-loss strategy for obese patients.[3] However, most trials of dietary approaches to weight loss have reported modest (<5%) mean weight loss after 12 months,[4] and long-term maintenance of weight loss remains a challenge. Thus, identification of alternative and feasible dietary interventions for weight loss is a major public health priority.

Time-restricted eating is an intermittent-fasting regimen that involves a shortened period of time for eating within each 24-hour period. The method has gained popularity because it is a weight-loss strategy that is simple to follow, which may enhance adherence. Observational studies have suggested that the practice of eating meals later in the day was associated with weight gain and influenced the success of weight-loss therapy.[5,6] Several pilot clinical studies showed that time-restricted eating resulted in reduction over time in the body weight and fat mass in patients with obesity.[7-10] Lowe and colleagues tested the short-term effect of time-restricted eating on weight loss (in which food was eaten only during the period from 12:00 p.m. to 8:00 p.m.) in 116 obese patients. They found that weight loss with time-restricted eating was similar to that with ad libitum calorie intake.[11] However, these studies did not provide information that was sufficiently conclusive to support evidence-based clinical guidelines for obesity. In addition, the long-term efficacy and safety of time-restricted eating as a weight-loss strategy are still uncertain, and the long-term effects on weight loss of time-restricted eating as compared with daily calorie restriction alone have not been fully explored. We conducted a randomized clinical trial to assess time-restricted eating with calorie restriction as compared with daily calorie restriction alone for the effects on weight loss and metabolic risk factors in obese patients.

Methods

Trial Design and Oversight

Eligible trial participants in Guangzhou, China, were randomly assigned to either a time-restricted–eating regimen or a daily-calorie-restriction regimen for 12 months. Observers (trial personnel) were unaware of group assignments.

The trial was overseen by a steering committee. The protocol (available with the full text of this article at NEJM.org) was approved by the institutional review board at Nanfang Hospital of Southern Medical University. All the participants provided written informed consent. The last author designed the trial, and the first and last authors wrote the first draft of the manuscript. All the authors participated in the revision of the manuscript and vouch for the completeness and accuracy of the data and for the fidelity of the trial to the protocol.

Trial Participants

We recruited all the trial participants from the general public by distributing promotional leaflets and posters, posting recruitment information on the internet, and conducting community screenings. Participants were eligible if they were 18 to 75 years of age and had a body-mass index (BMI, the weight in kilograms divided by the square of the height in meters) that was between 28 and 45. Among the criteria for exclusion were acute or chronic viral hepatitis, malignant tumors, diabetes, serious liver dysfunction or chronic kidney disease, current smoking, serious cardiovascular or cerebrovascular disease within 6 months before randomization, severe gastrointestinal diseases or gastrointestinal surgery in the 12 months before randomization, active participation in a weight-loss program, use of medications that affect weight or energy balance, and current or planned pregnancy.

Intervention Programs

During the 12 months of the trial, the men were instructed to follow a diet of 1500 to 1800 kcal per day and the women to follow a diet of 1200 to 1500 kcal per day. Both diets included a combination of 40 to 55% of calories from carbohydrates, 15 to 20% from protein, and 20 to 30% from fat;[12] this regimen represented approximately 75% of the participants' daily caloric intake at baseline. Participants were provided with one protein shake (Nutriease [Zhejiang Nutriease], a diet-appropriate convenience food) per day for the first 6 months to help improve adherence to the permitted calorie intake, and all the participants received dietary counseling for the duration of the

trial. Participants in the time-restricted–eating group were instructed to consume the prescribed calories within an 8-hour period (from 8:00 a.m. to 4:00 p.m.) each day. Only noncaloric beverages were permitted outside of the 8-hour daily eating period. Participants in the daily-calorie-restriction group were instructed to consume the prescribed calories without time restriction.

Dietary counseling was conducted by trained health coaches. Participants received written dietary information booklets that provided portion advice and sample menus that included dietary caloric restrictions similar to those described in current dietary guidelines for macronutrient intake.[12,13] Participants were encouraged to weigh foods to ensure they accurately reported their caloric intake. During the first 6 months of the trial, all the participants were required to write in a daily dietary log, photograph the food they ate, and note the time at which they ate with the use of a custom mobile study application (app). Using each participant's log and their photographic identification of the food they ate, two researchers assessed participants' mealtimes and their dietary intake each day on the basis of the nutrient content shown on the Chinese Food Composition Table.[14] Participants received follow-up telephone calls or app messages twice per week and met with a health coach individually every 2 weeks for assessment of their adherence to the program and for aid in reaching their caloric targets for weight loss in the first 6 months. During the second 6 months of the trial, participants were instructed to maintain their diet regimens and to fill out their dietary logs and record food pictures and meal times 3 days per week. During this time, they received a follow-up telephone call and an app message once per week and met with a health coach monthly. All participants attended health-education sessions monthly and were instructed to maintain their usual daily physical activity throughout the trial.

Adherence to the dietary program was defined according to the number of days that a participant met the requirements of the assigned diet. Participants in the daily-calorie-restriction group were required to limit their food consumption to the prescribed daily calories; participants assigned to the time-restricted–eating group were required both to eat within the prescribed daily time period for eating and to meet the daily caloric-intake goal.

TRIAL OUTCOMES

The primary outcome was the difference between the two groups in the change from baseline in body weight at 12 months. The secondary outcomes included changes in waist circumference, body fat, body lean mass, and metabolic risk factors, including levels of plasma glucose, insulin sensitivity, serum lipids, and blood pressure. The body fat mass and lean mass were quantified with the use of a whole-body dual radiography system (Lunar iDXA, GE Healthcare). Area measurements of the abdominal visceral fat and subcutaneous fat were obtained by means of computed tomography (Revolution, GE Healthcare) at the level of the fourth and fifth lumbar vertebrae.[15] We assessed liver fat with transient elastography (FibroScan 502 Touch, Echosens). Metabolic risk factors were measured with the use of standard methods over 12 months, and insulin-resistance status was measured with the use of the homeostasis model assessment of insulin resistance (HOMA–IR). The insulin-disposition index (a measure of pancreatic beta-cell function) was estimated as the change in insulin level divided by the change in glucose level from 0 to 30 minutes after administration of a glucose product. Quality of life was measured according to the 12-item Short-Form Health Survey Questionnaire (SF-12).

STATISTICAL ANALYSIS

Assuming an anticipated dropout rate of 20%, we estimated that an enrollment target of 138 participants (69 per group) would provide the trial with greater than 90% statistical power to detect a significant difference of 2.5 kg in body weight (±2.4) between the time-restricted–eating group and the daily-calorie-restriction group at a significance level of 0.025 using a two-tailed test. The proposed group difference and the standard deviation of reduction in body weight were determined on the basis of preliminary data obtained from a comparison of the time-restricted eating regimen plus calorie restriction with a regimen of calorie-intake restriction without time restriction.[9,16]

Data were analyzed according to the intention-to-treat principle. We obtained point estimates and standard errors of the treatment effects and tested for differences between treatments using the PROC MIXED procedure in SAS statistical software, version 9.4 (SAS Institute). Group dif-

ferences in the trial outcomes were evaluated with the use of the general linear model for continuous variables and the chi-square test for categorical variables. We used a mixed-effects model with an autoregressive correlation matrix to correct for the correlations of repeated measurements to assess the effects of each diet program on changes in the trial outcomes. Missing data were handled by multiple imputations with the use of the Markov chain Monte Carlo method. Subgroup analyses were conducted according to sex, BMI, insulin sensitivity, and adherence to diet. Data were presented as least-squares means with 95% confidence intervals for continuous variables. The 95% confidence intervals are not adjusted for multiple comparisons and should not be used to infer definitive treatment effects. A two-sided P value of less than 0.05 was considered to indicate statistical significance for the primary outcome.

RESULTS

TRIAL PARTICIPANTS

From November 30, 2018, through July 28, 2021, a total of 139 patients were randomly assigned to either time-restricted eating (69 participants) or daily calorie restriction (70 participants). Of the total number who underwent randomization, 135 participants (97.1%) completed the 6-month intervention and 118 (84.9%) completed the 12-month intervention (Fig. S1 in the Supplementary Appendix, available at NEJM.org). The mean (±SD) age of the participants was 31.9±9.1 years, and the mean weight was 88.2±11.6 kg. The characteristics of the participants at baseline were similar in the two diet groups and typical of obese patients (Table 1 and Table S1). Physical activity was similar in the two groups over the 12 months of the trial (Table S2).

ADHERENCE AND CALORIE INTAKE

During the 12-month intervention, the mean (±SD) percentage of the days that participants adhered to both the prescribed calories and eating period was 84.0±16.1% in the time-restricted–eating group and 83.8±12.6% in the daily-calorie-restriction group (Table S2 and Fig. S2). The average caloric deficit and percentages of caloric intake from fats, carbohydrates, and protein were similar in the two groups over 12 months. By design, the mean daily eating time prescribed for the time-restricted–eating group was shorter than that prescribed for the daily-calorie-restriction group. Scores on the SF-12 physical and mental components were similar in the two groups.

WEIGHT LOSS

The mean weight change from baseline to 12 months was −8.0 kg (95% confidence interval [CI], −9.6 to −6.4) in the time-restricted–eating group and −6.3 kg (95% CI, −7.8 to −4.7) in the daily-calorie-restriction group (Table 2 and Fig. 1). There was no significant difference between the two groups in weight change (net difference, −1.8 kg; 95% CI, −4.0 to 0.4; P=0.11).

The percentages of participants with a weight loss of more than 5%, 10%, and 15% at 12 months were similar in the two groups. Weight changes were similar for the two regimens when assessed according to subgroups (i.e., sex, BMI at baseline, insulin sensitivity, and adherence to the prescribed diet) (Table S3 and Fig. S3). In addition, participants in the two groups had similar reductions from baseline in waist circumference and BMI (Table 2, Table S4, and Fig. S4).

BODY COMPOSITION

The body fat mass at 12 months was reduced by 5.9 kg (95% CI, −7.1 to −4.7) from baseline in the time-restricted–eating group and by 4.5 kg (95% CI, −5.6 to −3.3) in the daily-calorie-restriction group, with no substantial differences between the groups (Table 2 and Table S4). Both the time-restricted–eating and daily-calorie-restriction diets led to loss of lean mass, abdominal visceral fat, subcutaneous fat, and liver fat; there were no differences between the groups. In addition, the groups had similar measures of trunk fat and appendicular lean mass at 12 months (Table S5).

BLOOD PRESSURE, LIPIDS, GLUCOSE, AND CARDIOMETABOLIC RISK FACTORS

Both time-restricted eating and daily calorie restriction were associated with reduced systolic and diastolic blood pressure over 12 months, with no substantial between-group differences (Table 3 and Table S6). Fasting glucose levels, 2-hour postprandial glucose levels, scores on the insulin disposition index and HOMA–IR, and lipid levels were similar in the two groups during the 12 months of the trial.

Table 1. Characteristics of the Participants at Baseline.*

Variables	Time-Restricted Eating (N=69)	Daily Calorie Restriction (N=70)
Male sex — no. (%)	36 (52.2)	35 (50.0)
Age — yr	31.6±9.3	32.2±8.8
Body weight — kg	88.4±10.2	87.9±12.8
Body-mass index	31.8±2.9	31.3±2.6
Body fat mass — kg	33.0±7.3	33.2±6.3
Body lean mass — kg	51.2±7.8	50.9±9.1
Body fat — %	38.3±5.5	38.4±5.3
Waist circumference — cm	99.4±7.8	99.2±9.1
Median (IQR) abdominal fat area — cm^2		
Visceral	122.3 (97.2–159.7)	124.9 (91.4–160.0)
Subcutaneous	312.8 (264.5–386.3)	302.9 (248.0–360.4)
Blood pressure — mm Hg		
Systolic	125.3±12.0	124.8±12.2
Diastolic	73.1±9.5	74.5±9.6
Pulse — beats/min	78.6±11.7	79.1 ±10.3
Glucose — mg/dl	90.9±11.0	92.1±17.1
Glycated hemoglobin — %	5.3±0.4	5.4±0.8
Median (IQR) HOMA–IR index value†	3.4 (2.4–5.1)	3.3 (2.0–4.4)
Cholesterol — mg/dl		
Total	194.5±32.9	198.0±37.8
High-density lipoprotein	46.1±10.2	45.1±12.7
Low-density lipoprotein	130.7±29.9	129.6±33.7
Median (IQR) triglycerides — mg/dl	130.2 (86.8–173.7)	137.3 (107.2–185.2)
Dyslipidemia — no. (%)	48 (69.6)	53 (75.7)
Hypertension — no. (%)	11 (15.9)	12 (17.1)
Total caloric intake — kcal/day	2052.5±341.7	2075.7±391.5
Daily eating window — hr:min	10:23±01:25	10:24±01:34
Median (IQR) physical activity — METs per wk	12.0 (8.3–23.6)	15.0 (8.0–23.1)
SF-12 score‡		
Physical component summary	45.3±7.1	46.4±6.6
Mental component summary	53.2 ±7.1	53.2±6.9

* Plus–minus values are means ±SD. Patients were assigned to time-restricted eating (eating only between 8:00 a.m. and 4:00 p.m.) or daily calorie restriction. Percentages may not total 100 because of rounding. To convert values for glucose to millimoles per liter, multiply by 0.05551. To convert values for cholesterol to millimoles per liter, multiply by 0.0259. IQR denotes interquartile range, and METs metabolic equivalents.

† The value on the homeostasis model assessment of insulin resistance (HOMA–IR) index is calculated as the level of fasting glucose (measured in millimoles per liter) times the level of fasting insulin (measured in microunits per milliliter) divided by 22.5.

‡ The physical component summary and mental component summary of the 12-item Short-Form Health Survey Questionnaire (SF-12) are interpreted as standardized T-scores, with a mean of 50±10 and with higher scores indicating better health.

ADVERSE EVENTS

No deaths or serious adverse events were reported during the trial. Occurrences of mild adverse events, such as fatigue, dizziness, headache, decreased appetite, upper abdominal pain, dyspepsia, and constipation, were similar in the two groups (Table S7).

Table 2. Effects of Diets on Weight Loss and Body Composition.*

Variable	Time-Restricted Eating (N=69)	Daily Calorie Restriction (N=70)	Difference between Groups (95% CI)
	Change from baseline (95% CI)		
Body weight — kg			
6 mo	−9.4 (−10.8 to −7.9)	−8.9 (−10.3 to −7.4)	−0.5 (−2.6 to 1.6)
12 mo	−8.0 (−9.6 to −6.4)	−6.3 (−7.8 to −4.7)	−1.8 (−4.0 to 0.4)
Body-mass index			
6 mo	−3.4 (−3.9 to −2.9)	−3.2 (−3.7 to −2.7)	−0.2 (−1.0 to 0.5)
12 mo	−2.9 (−3.5 to −2.3)	−2.3 (−2.8 to −1.7)	−0.7 (−1.5 to 0.1)
Waist circumference — cm			
6 mo	−9.4 (−11.0 to −7.9)	−8.7 (−10.2 to −7.3)	−0.7 (−2.8 to 1.4)
12 mo	−8.8 (−10.4 to −7.1)	−7.0 (−8.5 to −5.4)	−1.8 (−4.0 to 0.5)
Body fat mass — kg			
6 mo	−6.9 (−8.0 to −5.7)	−6.4 (−7.5 to −5.3)	−0.5 (−2.0 to 1.1)
12 mo	−5.9 (−7.1 to −4.7)	−4.5 (−5.6 to −3.3)	−1.5 (−3.1 to 0.2)
Body lean mass — kg			
6 mo	−1.9 (−2.4 to −1.4)	−1.7 (−2.2 to −1.2)	−0.2 (−0.9 to 0.5)
12 mo	−1.7 (−2.3 to −1.1)	−1.4 (−2.0 to −0.9)	−0.3 (−1.1 to 0.5)
Body fat percent — %			
6 mo	−4.7 (−5.6 to −3.8)	−4.4 (−5.3 to −3.5)	−0.3 (−1.6 to 1.0)
12 mo	−4.3 (−5.3 to −3.3)	−3.0 (−3.9 to −2.0)	−1.3 (−2.7 to 0.1)
Area of abdominal visceral fat — cm^2			
6 mo	−32.9 (−41.1 to -24.8)	−31.3 (−39.2 to −23.4)	−1.7 (−13.0 to 9.7)
12 mo	−26.0 (−35.0 to −17.1)	−21.1 (−29.5 to −12.8)	−4.9 (−17.3 to 7.5)
Area of abdominal subcutaneous fat — cm^2			
6 mo	−70.1 (−85.2 to −55.1)	−49.2 (−64.1 to −34.4)	−20.9 (−42.0 to 0.2)
12 mo	−53.2 (−71.9 to −34.6)	−37.0 (−52.1 to −21.9)	−16.2 (−39.2 to 6.8)

* Analyses were conducted with the use of a mixed-effects model, with randomized treatment as a factor and the use of a multiple imputation approach for missing data.

DISCUSSION

In this 12-month trial, we found that the 8-hour time-restricted–eating regimen did not produce greater weight loss than the regimen of daily calorie restriction, with both regimens resulting in similar caloric deficits. In addition, time-restricted eating and daily calorie restriction produced similar effects with respect to reductions in body fat, visceral fat, blood pressure, glucose levels, and lipid levels over the 12-month intervention period. These results indicate that caloric intake restriction explained most of the beneficial effects seen with the time-restricted–eating regimen. Even so, our findings suggest that the time-restricted–eating regimen worked as an alternative option for weight management. We speculate that these data support the importance of caloric intake restriction when adhering to a regimen of time-restricted eating.

Several small clinical trials have assessed the effects of short-term time-restricted eating on weight loss in obese populations.[7,11,17,18] Cai et al. reported that a 12-week time-restricted eating program with ad libitum calorie intake resulted in modest weight loss in 97 patients with nonalcoholic fatty liver disease.[17] Cienfuegos et al. found that time-restricted eating reduced caloric

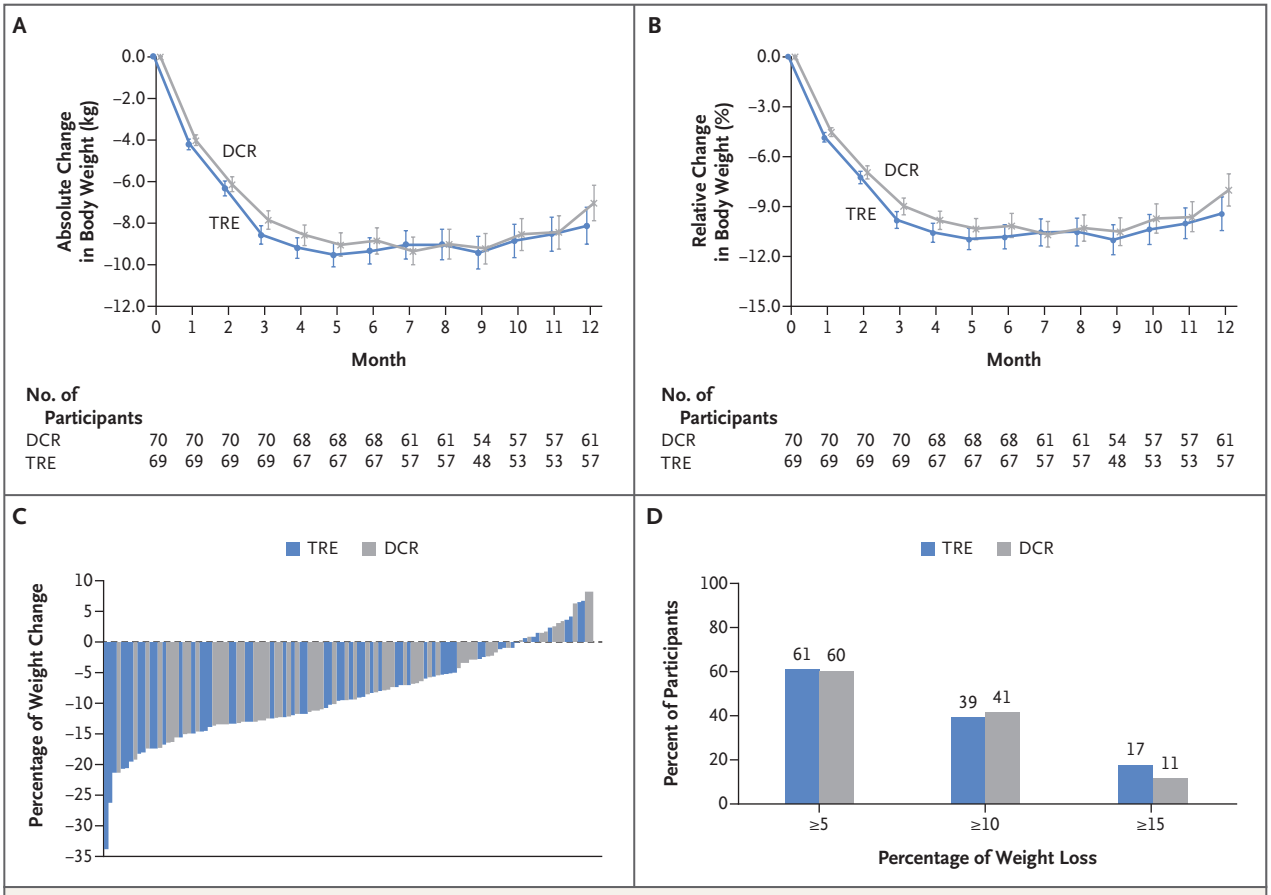

Figure 1. Effects of Time-Restricted Eating and Daily Calorie Restriction on Body Weight.

Panels A and B show the changes from baseline in body weight for patients who were assigned to time-restricted eating (TRE, eating only between 8:00 a.m. and 4:00 p.m.) or daily calorie restriction (DCR) who had available data for each analysis. I bars indicate mean ±SE. Panels C and D show observed data from the in-trial time period from participants who underwent randomization and had a 12-month assessment.

intake from baseline by 550 kcal per day and produced a 3% weight loss in 20 obese patients over a 10-week intervention period.[7] In contrast, Lowe and colleagues tested the effects of time-restricted eating with ad libitum intake among 116 obese adults and documented that time-restricted eating had no favorable benefits with respect to body weight and waist circumference over a 12-week period.[11] The protocols for time-restricted eating regimens have varied in previous trials; some assessed time-restricted eating regimens that imposed a shortened time period for eating while maintaining participants' usual caloric intake[19,20] or prescribed a caloric intake that was lower than participants' regular diets.[10,21] In a 12-week clinical trial involving 54 obese patients with type 2 diabetes, Kahleova and colleagues reported that a regimen of eating two meals (between 6:00 a.m. and 4:00 p.m.) reduced body weight more than a regimen of eating six meals that had the same calorie content as the two meals.[10] Several small clinical studies showed that healthy adults lost body weight and men with prediabetes had improved metabolic levels while consuming their typical amount of calories on a time-restricted regimen.[19,20,22] However, the long-term effect of time-restricted eating on weight loss remains uncertain.

In our design of the time-restricted eating regimen, we selected the time period from 8:00 a.m. to 4:00 p.m. because many Chinese people eat their biggest meal in the middle of the day rather than in the evening (with the latter more likely to increase fat storage).[23] In a randomized

Table 3. Changes in Cardiovascular Risk Factors during 12-Month Trial Period.*

Variable	Time-Restricted Eating (N=69)	Daily Calorie Restriction (N=70)	Difference between Groups (95% CI)
	Change from baseline (95% CI)		
Systolic blood pressure — mm Hg			
6 mo	−10.1 (−12.4 to −7.8)	−8.1 (−10.3 to −5.9)	−1.9 (−5.1 to 1.2)
12 mo	−8.1 (−10.4 to −5.7)	−7.7 (−10.1 to −5.4)	−0.3 (−3.7 to 3.1)
Diastolic blood pressure — mm Hg			
6 mo	−6.0 (−7.8 to −4.2)	−5.1 (−6.8 to −3.3)	−0.9 (−3.4 to 1.6)
12 mo	−5.1 (−7.1 to −3.1)	−3.8 (−5.7 to −2.0)	−1.3 (−4.1 to 1.6)
Pulse — beats/min			
6 mo	−3.1 (−5.4 to −0.9)	−2.4 (−4.5 to −0.2)	−0.8 (−3.9 to 2.4)
12 mo	−1.6 (−4.0 to 0.8)	−1.9 (−4.1 to 0.3)	0.3 (−2.9 to 3.5)
Triglycerides — mg/dl			
6 mo	−44.8 (−60.0 to −29.5)	−31.7 (−46.6 to −16.8)	−13.1 (−34.6 to 8.4)
12 mo	−25.5 (−42.2 to −8.8)	−19.6 (−35.9 to −3.4)	−5.9 (−28.5 to 16.8)
Total cholesterol — mg/dl			
6 mo	−9.0 (−15.9 to −2.2)	−13.7 (−20.2 to −7.2)	4.7 (−4.8 to 14.1)
12 mo	−7.3 (−14.3 to −0.3)	−9.3 (−15.9 to −2.6)	1.9 (−7.9 to 11.7)
High-density lipoprotein cholesterol — mg/dl			
6 mo	4.2 (2.4 to 6.1)	2.7 (0.9 to 4.4)	1.6 (−1.0 to 4.1)
12 mo	4.6 (2.6 to 6.5)	2.9 (1.1 to 4.8)	1.6 (−1.1 to 4.3)
Low-density lipoprotein cholesterol — mg/dl			
6 mo	−5.9 (−12.0 to 0.1)	−11.3 (−17.1 to −5.6)	5.4 (−2.9 to 13.7)
12 mo	−8.4 (−14.7 to −2.1)	−8.9 (−15.1 to −2.8)	0.5 (−8.5 to 9.5)
Glucose level — mg/dl			
6 mo	−5.0 (−8.5 to −1.6)	−4.1 (−7.4 to −0.7)	−1.0 (−5.8 to 3.8)
12 mo	−3.5 (−7.6 to 0.5)	−3.0 (−6.7 to 0.7)	−0.6 (−6.1 to 4.9)
2-hour postprandial glucose — mg/dl			
6 mo	−15.4 (−23.7 to −7.1)	−10.6 (−18.6 to −2.6)	−4.8 (−16.3 to 6.6)
12 mo	−10.8 (−19.7 to −2.0)	−12.1 (−20.2 to −3.9)	1.3 (−10.8 to 13.3)
HOMA–IR index value			
6 mo	−1.4 (−1.9 to −0.8)	−1.2 (−1.8 to −0.6)	−0.2 (−1.0 to 0.6)
12 mo	−1.0 (−1.7 to −0.4)	−0.5 (−1.1 to 0.1)	−0.5 (−1.4 to 0.4)
Insulin disposition index†			
6 mo	−4.6 (−11.4 to 2.2)	−3.3 (−10.0 to 3.5)	−1.3 (−10.9 to 8.2)
12 mo	−6.7 (−18.5 to 5.1)	0.6 (−8.6 to 9.8)	−7.3 (−20.8 to 6.2)

* Analyses were conducted with the use of a mixed-effects model, with randomized treatment as a factor and a multiple imputation approach for missing data. To convert values for triglycerides to millimoles per liter, multiply by 0.01129.
† Values on the insulin disposition index (a measure of pancreatic beta-cell function) are estimated as the change in insulin divided by change in glucose from 0 to 30 minutes.

clinical trial that involved 58 obese women, de Oliveira and colleagues compared the effect of a 12-hour time-restricted eating regimen with a regimen that prescribed the same calorie-restricted diet without time restriction.[21] At 12 months, no significant weight loss was reached in either of the two groups, probably owing to the relatively small differences between the groups

in the time periods for eating and the poor adherence to the diet in both groups.

Our randomized clinical trial differed from others in that we assessed a year-long effect of 8-hour time-restricted eating as compared with daily calorie restriction on weight loss. Our trial showed that the two diet regimens had similar effects on weight loss and that it was feasible for participants to adhere to their assigned calorie-intake restrictions. Consistent with the findings in previous studies,[7,24,25] our data suggest that caloric intake restriction explained most of the beneficial effects of a time-restricted eating regimen. However, our results support a strategy of time-restricted eating combined with caloric intake restriction (prescribed according to current dietary guidelines) as a viable and sustainable approach for obesity management.[12,26] Because results could differ according to sex,[27] further studies are needed to determine the effects of time-restricted eating on weight loss among men and women separately.

In addition, we found that the two dieting regimens in our trial had similar efficacy in reducing the levels of body fat and visceral fat from baseline in obese patients, a finding that is consistent with several short-term pilot studies[7,17,28] but not others.[11,21] Previous trials showed that time-restricted eating led to reduced calorie intake and prevented gains in body lean mass.[11,22,29] In contrast, our data showed no significant differences between the groups in gains in body lean mass over the 12-month intervention period, indicating the importance of a balanced diet and adequate protein consumption in patients who are adhering to a diet regimen of time-restricted eating. In addition, our findings that time-restricted eating did not provide additional benefits with regard to blood pressure as compared with daily calorie restriction were consistent with the findings in previous clinical trials.[11,21] Finally, participants in both diet groups had improvement in glucose and lipid levels and in HOMA–IR index values, with no differences between the groups. Previous clinical trials have shown short-term time-restricted eating had inconsistent effects on glycemic control, insulin sensitivity, and lipids in obese persons.[7,19]

The strengths of our trial included a culturally sensitive, prescription-based intervention, similar caloric restriction and attention to dietary quality in the two groups, the relatively long duration of the trial, and the high percentage of participants who adhered to the assigned regimen.

Our trial also has certain limitations. First, our findings could not be generalized to patients with diabetes or cardiovascular disease, to different periods of time-restricted eating, or to persons of other races or ethnic groups. Second, total energy expenditure was not assessed in this trial. Energy expenditure as measured by the double-labeled water method would have helped to explain differences among patients in weight loss in response to the diet interventions. Third, physical activity was not controlled in this trial because we aimed to examine the effects of diet regimens on weight loss in isolation.

In our trial, we found that the two weight-loss regimens that we evaluated had similar success in patients with obesity, regardless of whether they reduced their calorie consumption through time-restricted eating or through calorie restriction alone.

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