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RESEARCH

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The modulation of carbohydrate intake and intermittent fasting in obese Saudi women: a pilot study

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Abstract

Background In recent years, the prevalence of overweight and obesity has increased, leading to the development of various dietary interventions as potential treatments. Two popular diets are time-restricted feeding and low-carbohydrate diets, but there is limited research on the effects of combining them. This study assessed the effects of pairing an eight-hour time-restricted feeding window with a moderate-carbohydrate diet and compared to a paired eight-hour time-restricted feeding window with a regular diet.

Results The study involved 52 obese women divided into three groups: the first group followed an 8 h time-restricted feeding with a moderate low-carbohydrate diet (8-hTRF+mLCD), the second group followed an 8 h time-restricted feeding with a regular diet (8-hTRF), and the third group was the control group. Both 8 h TRF+mLCD and 8 h TRF groups had a decrease in TG levels compared to the control group. The HDL levels in both TRF groups were significantly higher than the control group, while LDL levels remained statistically insignificant in both TRF groups.

Conclusions This suggests that an 8 h TRF with or without mLCD can effectively treat obesity without a change in physical activity, and combining it with a low-carbohydrate diet gives better and more rapid results.

Keywords Time restricted feeding, Intermittent fasting, Body weight, Body composition (fat mass, fat-free mass, visceral fat, fat mass), Moderate low-carbohydrate diet

Background

Obesity is a significant public health concern that has been linked to a variety of issues, including type 2 diabetes, heart disease, stroke, and other health problems (Cohen and LeRoith 2012; Gaggini et al. 2013). The World Health Organization (WHO) established BMI categories in 1993, and the results were published in 1995 as underweight (15 to 19.9 kg/m^2), normal weight (20 to 24.9 kg/m^2), overweight (25 to 29.9 kg/m^2), and obese ($\geq$30 kg/m^2) (WHO 1995). Female gender is a significant risk factor for obesity, with twice the likelihood of being overweight or obese compared to males. Women also face higher risks of obesity-related comorbidities and have a twofold higher mortality risk than overweight men (Kapoor et al. 2021). Abdominal fat and overall adiposity should be considered when assessing weight because they are strongly associated with an increased risk of health problems. Waist circumference has been shown to be a reliable indicator of metabolic disorders. Structured dietary interventions are essential for preventing and managing cardiometabolic disorders. Clinical practice guidelines often recommend reducing total calorie intake and losing more than 5% of body weight (Kim et al. 2021; Shim et al. 2020).

The use of intermittent fasting (IF) as a weight loss strategy for overweight or obese individuals is supported by evidence of moderate to high

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quality demonstrating positive associations between IF and anthropometric and cardiometabolic outcomes (Patikorn et al. 2021). Time-restricted feeding (TRF) can be an effective weight loss strategy for those who are overweight or obese because it has been associated with an increase in insulin sensitivity and a decrease in body weight, total cholesterol, triglycerides, glucose, insulin, interleukin-6, and tumor necrosis factor concentrations, even if there is no loss of weight (Schroder et al. 2021). In the Cienfuegos et al. (2020) study, eight-week TRF fasting regimens of four and six hours effectively reduced body weight by 3% and also resulted in decreased levels of oxidative stress and insulin resistance, which is positive for preventing cardio metabolic diseases. Schroder et al. (2021) found that TRF is effective in inducing weight loss and altering body composition, but did not observe any significant changes in metabolic and cardiovascular biomarkers. These preliminary findings suggest that TRF may be able to alter a number of risk factors for metabolic illnesses (Sutton et al. 2018).

Intermittent fasting with low-carbohydrate diet are gaining popularity among the general population and individuals with cardio metabolic disorders like obesity, diabetes, and hypertension, but there is a lack of expert guidance available (Choi et al. 2022). Intermittent Fasting (IF) has been shown to result in significant weight loss (5–10% of baseline body weight) within a short period of time (8–12 weeks) (Hatori et al. 2012). Dyslipidemia is defined by low levels of high-density lipoprotein (HDL) cholesterol and high levels of circulating LDL cholesterol and triglycerides (Pencina et al. 2009). After 8 weeks of 8-h TRF, there were noticeable decreases in fasting blood sugar, insulin, and insulin resistance (Ludwig 2020). Although some studies have reported a decrease in triglycerides and LDL cholesterol values, many studies have found that controls did not differ in comparison to any lipid measure (Moro et al. 2016; Wilkinson et al. 2020). Cienfuegos et al. (2020) reported that a 4- and 6-h TRF may be a promising weight loss strategy that can lead to gradual drops in body weight over eight weeks while also improving certain cardiometabolic health aspects.

Time-Restricted Eating (TRE) is an appealing weight loss approach as it does not require meticulous calorie tracking or specialized diets. Brown et al. (2016) revealed that weight loss has a significant impact on cardiac risk factors, with lowered levels of triglycerides, total cholesterol, and LDL in patients who lost 5–10% of their body weight. The production of less insulin due to reduced carbohydrate intake in LCD during negative energy balance promotes fat oxidation and lipolysis (Gower and Goss 2015; Hjorth et al. 2017).

Ebbeling et al. (2022) also found that low-carb diets have potential benefits for reducing diabetes and cardiovascular disease in the context of widespread obesity and insulin resistance. In a feeding study, Yanai and Yoshida (2019) demonstrated that restricting carbohydrates improved insulin-resistant dyslipoproteinemia without negatively affecting total cholesterol, LDL- cholesterol, LDL-P size, or markers of chronic inflammation. Sasakabe et al. (2011) found that patients with type 2 diabetes may benefit from losing preferred visceral adipose tissue through a mild low-carbohydrate diet. Low carbohydrate diets can be defined by either a proportion of daily macronutrient intake or the total daily carbohydrate load, as indicated by previous studies (Oh et al. 2023). A moderately low-carbohydrate diet (mLCD) or low-carbohydrate diet (LCD) can help overweight or obese people lose weight better than commonly recommended diets (Choi et al. 2022). He et al. (2022) reported that both LCD and 8 h TRE can effectively reduce body weight and subcutaneous fat. However, TRE was found to be more effective than LCD in reducing visceral adiposity and improving cardiometabolic outcomes. When TRE was combined with LCD, it resulted in a greater overall weight loss. This study compares moderate-carbohydrate and regular diets in time restricted dieting, following He et al. (2022). It replicates their trial in Saudi Arabia, where obesity is a major issue and soft drinks and fast foods (e.g., burgers, sausage, pizza, or Arabic shawarma) cause it (Alsulami et al. 2023). Considering the preceding observations, this study aimed to compare an 8 h time-restricted diet with a moderate-carbohydrate diet to an 8-h time-restricted diet with a regular diet.

Materials and methods

During an 8-week trial, the impact of time-restricted eating on body weight and cardiometabolic risk factors was investigated in overweight females. The study compared a time-restricted feeding program with one that included both time-restricted feeding and a low-carbohydrate diet. The experimental protocol was authorized by the King Saud University for Research Ethics Committee, and all participants provided written informed consent before taking part in the study.

Subject selection

Between January 2022 and March 2022, individuals residing in Riyadh city were recruited as participants through social media advertisements. A total of 100 women with obesity (BMI > 30 kg/m^2) between the ages of 20 to 45 provided consent and were assessed for eligibility. Following this, they were divided into three groups (Fig. 1), but 8 participants withdrew during the study as indicated in Fig. 1. The three groups were categorized as follows:

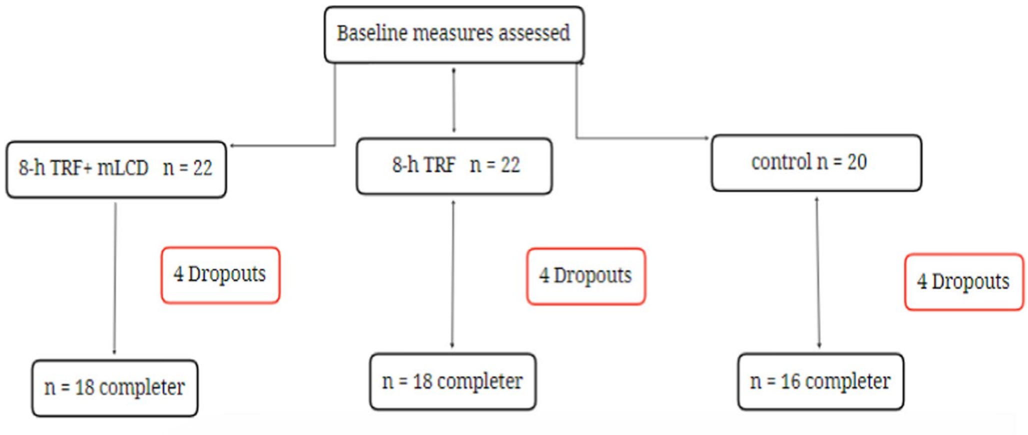

Fig. 1 Study flow chart

Group 1 (n = 22) underwent time-restricted eating (TRE) along with a low carbohydrate diet, Group 2 (n = 22) followed TRE with their regular diet,

Group 3 (n = 20) served as the control group.

The inclusion criteria

Eligible participants for the trial were women aged 22–45 with obesity (BMI > 30 kg/m2) and a stable weight for three months prior to the trial.

The exclusion criteria

Exclusion criteria for the study included women with a history of chronic diseases, pregnancy or nursing, medication use, irregular menstrual cycles, and the use of birth control tablets.

Study design and intervention

This study examined the effects of time-restricted eating (8 h TRF), a form of intermittent fasting (IF), and its combination with a moderately low carbohydrate diet to decrease calorie intake. The term "low carbohydrate" has been defined in studies as either the total daily carbohydrate load or a percentage of daily macronutrient intake. For instance, low-carb is defined as less than 26% carbohydrates or fewer than 130 gm/day; extremely low-carb is less than 10% carbohydrates or 20 to 50 gm/day; and moderately low-carbohydrate is 26–44% (135–180g). IF (time-restricted eating 8–16) has been investigated in previous studies by Moro et al. (2020), Gabel et al. (2019), and Schroder et al. (2021). The timing of the diet was determined based on each person's preferences for food intake during an eight-hour period, which included sleep time. During the fasting period, participants were allowed to consume plenty of water and energy-free beverages such as black tea and coffee. Throughout the study, participants maintained their regular physical exercise routines.

Dietary intervention

Group 1: TRF with low carb diet

The participants in this group followed two rules for 8 weeks. First, they ate a moderate carbohydrate diet (mLCD) that had 35–40% of calories from carbs. This meant that they avoided foods with added sugars and refined carbs, and only ate four servings of carbs per day. Second, they fasted for 16 h every day, from 4 p.m. to 8 a.m., and only ate during the remaining 8 h (see Fig. 2). This is called time-restricted feeding (TRF).

Group 2: TRF with regular diet

The participants in this group also followed the time-restricted feeding (TRF) method for 8 weeks, but they did not change their usual diets. They ate whatever they normally ate, but only within an 8-h window from 8 a.m. to 4 p.m. every day (see Fig. 2). They did not eat anything that had calories for the rest of the day, from 4 p.m. to 8 a.m. the next day (see Fig. 2). They received daily reminders through instant messages about when to start and stop eating. They also used an app to track their fasting hours, shared their experiences with each other, and joined a WhatsApp group for support.

Group 3: control group

The participants in this group did not follow any special rules for 8 weeks. They ate and lived as they normally did, without changing their diets or lifestyles. They were the comparison group for the study.

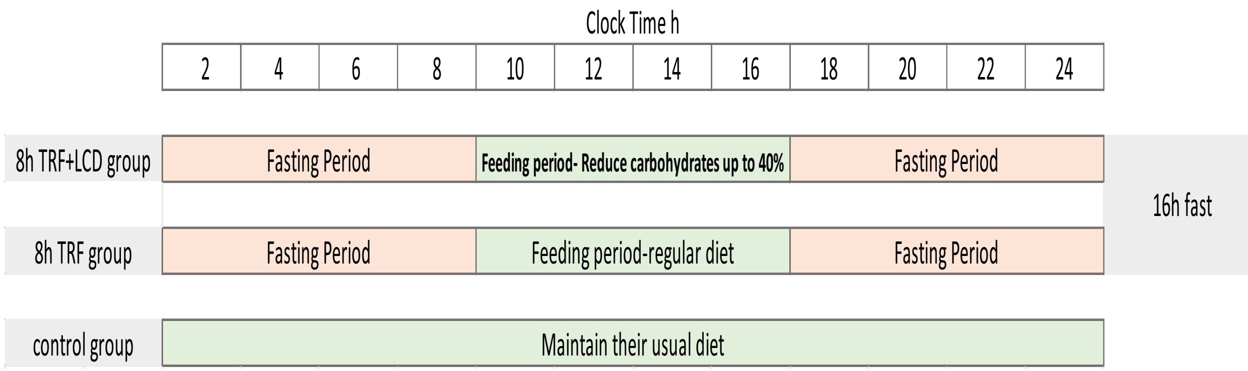

Fig. 2 Time restricted feeding interventions

Anthropometric measurements and body composition analysis

All anthropometric measurements were taken twice during the study, once in the baseline week and once in the eighth week at the end of the study. The subjects' height was measured once during the baseline week using a wall-mounted stadiometer to the nearest 0.1 cm. Body weight was measured twice during the experiment using a balance beam scale to the nearest 0.25 kg, while wearing light clothing and no shoes. The unit of measurement for body weight was kg/m2. The waist circumference (WC) and hip circumference (HC) were measured using a non-stretchable measuring tape (Seca, Hamburg, Germany) to the nearest 1.0 cm to calculate the waist-to-hip ratio (WHR). Body composition, including fat mass, lean mass, and visceral fat mass, was determined using bioelectrical impedance analysis (BIA).

Blood sample collection

During the study, blood samples were collected twice from the subjects—once during the baseline week before the experiment started, and again at the end of the eighth week. The samples were taken between 9 am and 12 pm from subjects who had not eaten for more than 8 h to ensure consistency. The cardiometabolic risk factors were measured, including lipid profiles such as triglycerides, total cholesterol, LDL-cholesterol, and HDL-cholesterol. Blood glucose, insulin, and HOMA-IR were also measured.

Ethical approval and statistical analysis

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the institutional review board at King Saud University approved the study procedures via expedited review (IRB No. E-17–2263). Written informed consent was obtained from all participants. The study ensured that anthropometric measurements across the three groups (8-h TRE + moderate low carbohydrate diet, 8-h TRE + normal diet, and Control) were comparable by conducting a one-way ANOVA test. Paired samples *t*-tests were also conducted for each group to compare the baseline and change in anthropometric parameters, blood glucose levels, and blood lipids. The change in the 8-h TRE baseline and the percentage of this change were calculated for each group. Statistical significance was set at a $p < 0.05$, and graphs were generated to illustrate the results.

Results

In this study, we looked at the impact of intermittent fasting, also known as time-restricted eating, on cardiac risk factors in obese women. This study compared 8 h TRF + mLCD with 8-h TRF with a conventional diet in Saudi obese women to assess weight loss and cardiometabolic risk factors.

Participants

A total of 64 people were randomly assigned to three groups: TRF + LCD (group 1; n = 22), TRF (group 2; n = 22), and control (group 3; n = 20). When 12 participants dropped out of the trial, 52 participants remained (Fig. 1). This trial involved an 8-week intervention. 18 people finished the trial. 16 finished the control, 18 completed the 8-h TRF + LCD, and 18 completed the 8-h TRF. Participants' baseline characteristics are shown in Table 1. In this trial, individuals were free to select one of the two intervention groups.

Adherence

The fasting tracking application was employed in our study, which affected the individuals' commitment to fasting, as the Gabel et al. (2018) study demonstrated the usefulness of mobile applications to stick to fasting. The

Table 1 Baseline characteristics

Items	TRF ± LCD group (n = 18)	TRF group (n = 18)	Control group (n = 16)	P value
Age (years	34.06 ± 6.24	33.89 ± 6.92	34.19 ± 6.27	0.991
Height (cm)	160.44 ± 8.17	158 ± 6	161.38 ± 7.46	0.376
Weight (Kg)	90.65 ± 13.8	87.39 ± 13.1	87.19 ± 13.48	0.695
BMI (kg/m^2)	35.2 ± 4.61	34.94 ± 5.16	33.38 ± 3.91	0.472
Fat Mas(Kg)	52.42 ± 5.8	51.22 ± 5.88	53.63 ± 6.41	0.513
Fat Free mass (Kg)	40.41 ± 10.65	35.5 ± 8.83	33.81 ± 10.62	0.144
Visceral fat	10.11 ± 2.47	9.78 ± 2.29	9.75 ± 1.53	0.859
Waist circumference (cm)	97.33 ± 10.82	96.5 ± 10.17	94.25 ± 12.1	0.706
Hip circumference (cm)	124.78 ± 10.63	124.78 ± 11.05	122.75 ± 8.22	0.801
Waist-to-hip ratio (WHR)	0.78 ± 0.07	0.77 ± 0.04	0.77 ± 0.09	0.828

two groups' adherence, as shown in Fig. 3, was high at 97%.

Anthropometry baseline characteristics

Table 2 includes information on body weight (kg), BMI (kg/m2), fat mass (kg) as determined using Brozek formula's anthropometric equation (Brozek et al. 1963), fat-free mass (kg) as determined using Brozek formula's anthropometric equation (Brozek et al. 1963), VF, waist and hip circumferences (cm), and WHR. There were no statistically significant differences between the clinical and demographic traits of the participants in the three groups, according to the one-way analysis of variance (ANOVA) test ($p > 0.05$, Table 1). This demonstrated that the three groups (TRE + low carb diet, TRE + regular diet, and Control) were all the same for the measured clinical and demographic traits.

TRF + LCD, TRF reduce body weight in obese women

In obese women, TRE with or without mLCD decreased body weight. After an 8-week intervention, all groups showed a significant decrease in body weight when

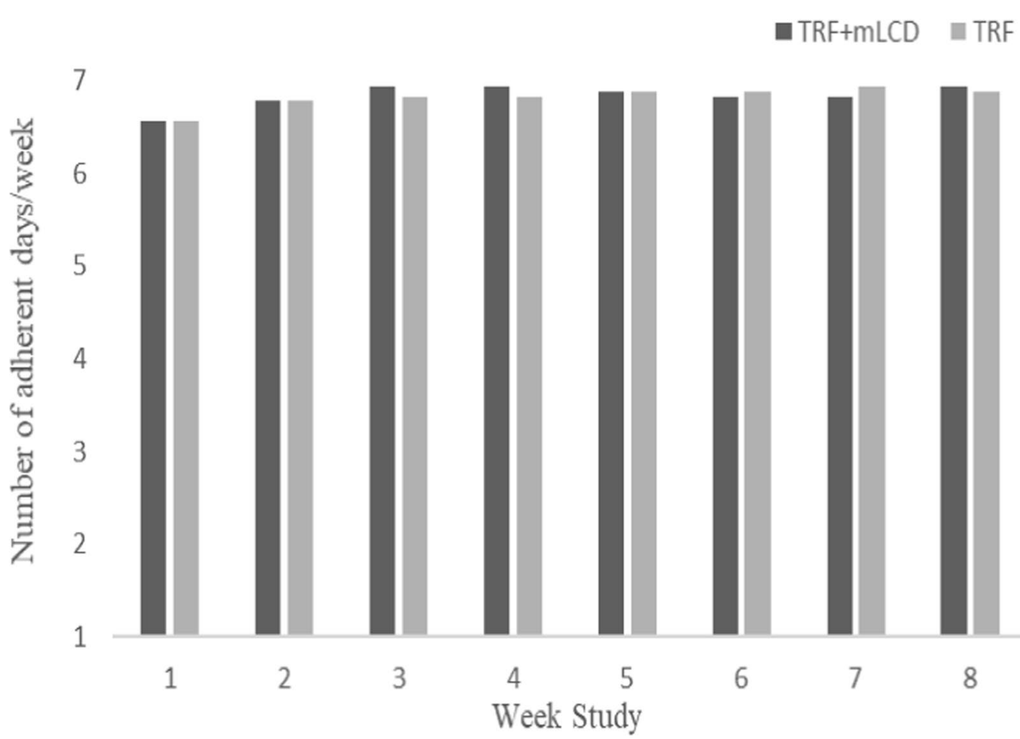

Fig. 3 Adherence to the time restricted feeding window

Table 2 Comparison between the three groups at baseline and after the end of the program (anthropometric measurements, analysis of diabetes, and blood fats

Items	TRF ± LCD group (n = 18)					TRF group (n = 18)					Control group (n = 16)				
	Basel (Mean ± SD)	exp (Mean ± SD)	Change in Basel (Mean ± SD)	Percent Change	P value	Baseline (Mean ± SD)	(Mean ± SD)	Change in Basel (Mean ± SD)	Percent Change	P value	Basel (Mean ± SD)	(Mean ± SD)	Change in Basel (Mean ± SD)	Percent Change	P value
Weight (Kg)	90.65 ± 13.8	86.08 ± 14.08	− 4.57 ± 1.59	− 5.0%	< 0.001	87.39 ± 13.1	84.89 ± 12.7	− 2.5 ± 1.01	− 2.9%	< 0.001	87.19 ± 13.48	87.5 ± 13.31	0.31 ± 0.25	0.4%	0.173
BMI (kg/m^2)	35.2 ± 4.61	33.72 ± 5.2	− 1.48 ± 4.46	− 4.2%	< 0.001	34.94 ± 5.16	33.42 ± 5.11	− 1.52 ± 1.78	− 4.4%	< 0.001	33.38 ± 3.91	33.44 ± 3.86	0.06 ± 0.81	0.2%	0.333
FM(Kg)	52.42 ± 5.8	47.74 ± 7.34	− 4.68 ± 8.79	− 8.9%	< 0.001	51.22 ± 5.88	49.33 ± 5.41	− 1.89 ± 0.62	− 3.7%	< 0.001	53.63 ± 6.41	54.06 ± 6.19	0.43 ± 0 1 0.8% 1 0.048		
FFM (Kg)	40.41 ± 10.65	38.28 ± 10.17	− 2.13 ± 0.89	− 5.3%	0.004	35.5 ± 8.83	35.33 ± 8.51	− 0.17 ± 0.51	− 0.5%	0.269	33.81 ± 10.62	33.81 ± 10.62	0	0	1
VF	10.11 ± 2.47	8.83 ± 2.09	− 1.28 ± 2.79	− 12.7"%	< 0.001	9.78 ± 2.29	9.28 ± 2.24	− 0.5 ± 2.19 − 5.1%		< 0.001	9.75 ± 1.53	9.81 ± 1.42	0.06 ± 1.31 1 0.6%		0.333
WC (cm)	97.33 ± 10.82	90.72 ± 10.37	− 6.61 ± 3.14	− 6.8"%	< 0.001	96.5 ± 10.17	92.61 ± 10.36	− 3.89 ± 3.03	− 4.0%	< 0.001	94.25 ± 12.1	94.88 ± 12.17	0.63 ± 0	0.7%	0.076
HC (cm)	124.78 ± 10.63	118.89 ± 11.85	− 5.89 ± 0.02	− 4.7%	< 0.001	124.78 ± 11.05	121.5 ± 11.61	− 3.28 ± 0.02	− 2.6%	< 0.001	122.75 ± 8.22	122.75 ± 8.22	0	0	1
WHR ratio	0.78 ± 0.07	0.76 ± 0.07	− 0.02 ± 7.69	− 2.6%	< 0.001	0.77 ± 0.04	0.76 ± 0.05	− 0.01 ± 8.15	− 1.3%	0.149	0.77 ± 0.09	0.77 ± 0.09	0	0	1
FBG (mg/dL)	96.39 ± 9.57	91.5 ± 8.18	− 4.89 ± 3.38	− 5.1%	< 0.001	96.37 ± 7.69	90 ± 9.07	− 6.37 ± 6	− 6.6%	< 0.001	88.75 ± 9.02	87 ± 7.78	− 1.75 ± 4.26	− 2.0%	0.323
Insulin OiU/mL)	14.02 ± 6.37	10.18 ± 5.4	− 3.84 ± 0.71	− 27.4%	< 0.001	13.54 ± 5.2	11.56 ± 7.83	− 1.98 ± 1.69	− 14.6%	0.178	13.88 ± 9.38	15.77 ± 10.65	1.89 ± 1.21	13.6%	0.097
HOMA – IR	6.18 ± 12.76	4.94 ± 12.53	− 1.24 ± 48.78	− 20.1%	< 0.001	3.39 ± 1.53	2.46 ± 1.93	− 0.93 ± 61.12	− 27.4%	0.032	3.03 ± 2.3	3.55 ± 2.61	0.52 ± 40.31	17.2%	0.103
Cholesterol (mg/dL)	180.06 ± 22.8	184.28 ± 25.29	4.22 ± 6.45	2.3%	0.001	179.94 ± 30.54	178 ± 22.86	− 1.94 ± 8.73	− 1.1%	0.802	166.38 ± 23.21	179.81 ± 26.15	13.43 ± 9.07	8.1%	0.059
HDL (mg/dL)	50.33 ± 9.37	50.78 ± 6.9	0.45 ± 31.46	0.9%	< 0.001	44.08 ± 8.75	50.28 ± 9.25	6.2 ± 34.33	14.1%	0.008	50.63 ± 9.94	50.31 ± 6.63	− 0.32 ± 22.58	− 0.6%	0.892
LDL (mg/dL)	108.39 ± 21.71	107.56 ± 31.03	− 0.83 ± 27.27	− 0.8%	0.181	105.33 ± 30.22	102.33 ± 25.49	− 3 ± 27.12	− 2.8%	0.715	99.88 ± 21.81	114.06 ± 24.72	14.18 ± 28.05	14.2%	0.024
TR (mg/dL)	86.44 ± 37.75	79.61 ± 29.6	− 6.83 ± 27.27	− 7.9%	0.001	104.61 ± 57.57	83.17 ± 38.64	− 21.44 ± 27.12	− 20.5%	0.004	82.19 ± 30.79	87.31 ± 35.32	5.12 ± 28.05	6.2%	0.476

BMI Body Mass Index, *FM* Fat Mas, *FFM* Fat Free mass, *VF* Visceral fat, *WC* Waist circumference, *HC* Hip circumference, *WHR* Waist-to-hip ratio, *FBG* Fasting blood glucose, *HDL* High Density Lipoprotein, *LDL* Low Density Lipoprotein, *TR* Triglyceride

*P Value < 0.05, **P value < 0.01 , ***P value < 0.001

compared to baseline (Fig. 4A), and TRF + mLCD treatment resulted in an even greater decrease in body weight when compared to TRF. As demonstrated in Table 2, TRF + mLCD caused a greater decrease in body weight than TRF (from 87.3913.1 to 84.8912.7, -2.9% P 0.001).

TRF + LCD, TRF reduce body composition in obese women

One of the main causes of the cardiometabolic risk linked to being overweight or obese is body fat. Table 2, Fig. 4F, G, and C show that all groups significantly reduced waist circumference, hip circumference, and body fat mass as compared to baseline. While there was a considerable decline (40.4110.65 to 38.2810.17, −5.3% P = 0.004), the TRF group maintained the free fat mass Fig. 3D, Table 2 (35.58.83 to 35.338.51, −0.5% $p = 0.269$). However, compared to TRF, Fig. 3H (from 0.770.04 to 0.760.05, −1.3% $p = 0.149$), only TRF + mLCD caused a more pronounced decrease in WHR (from 0.78.07 to 0.76.07, −2.6% P0.001).

As compared to TRF alone (34.94.5.16 to 33.42.5.11, -4.4% P0.001), we discovered that TRE plus LCD reduced BMI mean SD more significantly (35.2.4.61 to 33.72.5.2, −4.2% p 0.001). Metabolic function depends on the visceral fat region (VF). As a result, we used bioelectrical impedance analysis to further analyze the alteration. Although though both groups' VF levels were significantly lower after eight weeks of intervention (see Table 2), TRF + mLCD showed a greater decline (10.11 2.47 to 8.83 2.09, −12.7% p 0.001) than TRF (9.78 2.29 to 9.28 2.24, −5.1% p 0.001).

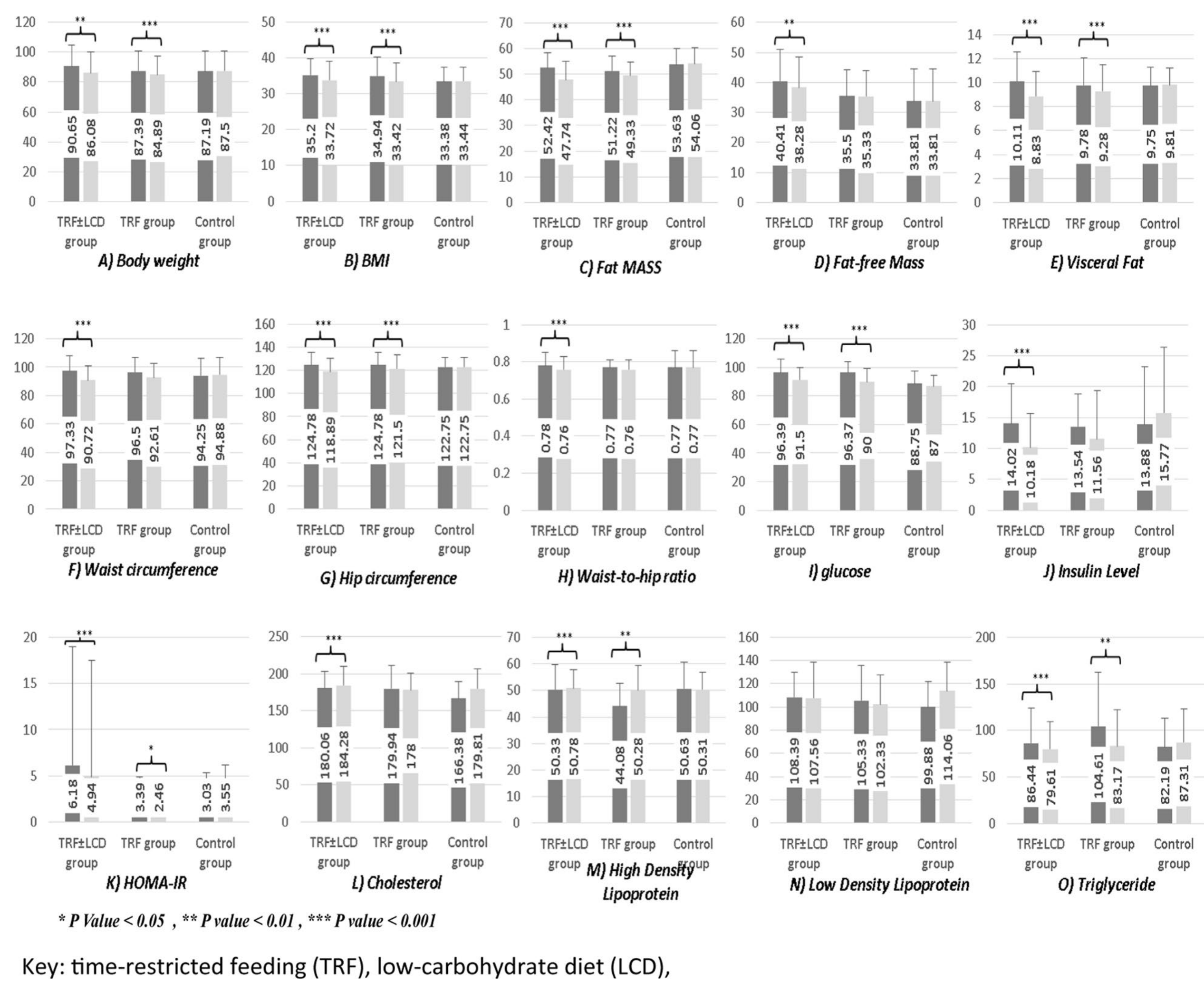

Fig. 4 Comparison between the three groups at baseline and after the end of the program, Key: time-restricted feeding (TRF), low-carbohydrate diet (LCD)

TRF + LCD, TRF reduce Glucoregulatory parameters in obese women

The effects of TRF + mLCD and TRE on glycemic control were compared next. Body composition TRE with or without LCD significantly increased FBG and HOMA IR, which is consistent with studies on body weight (Table 2, Fig. 4L and K). FBG TRF + mLCD (96.399.57 to 91.58.18, 5.1% P 0.001), TRF (96.377.69 to 90.07, 6.6% P 0.001). TRF (3.391.53 to 2.461.93, −27.4%, p = 0.032) and HOMA IR TRF + mLCD (6.1812.76 to 4.9412.53, −20.1% P 0.001). In contrast, TRF + mLCD significantly reduced fasting insulin relative to baseline (14.02 6.37 to 10.18 5.4, -27.4%, P0.001 mmol/L), and TRF (13.54 5.2 to 11.56 7.83, −14.6%, p = 0.178 mmol/L).

TRF + LCD, TRF in lipid profile factors in obese women

Figure 4L, M, and Table 2 show that TRF recorded a lesser decline in plasma cholesterol levels following an 8-week intervention (179.9430.54 to 17,822.86, −1.1% P + 0.802), whereas TRF + mLCD reported a bigger decline (180.0622.8 to 184.2825.29, 2.3%, P = 0.001). TRF + mLCD; HDL (50.339.37 to 50.786.9, 0.9% P0.001), TG (86.4437.75 to 79.6129.6, −7.9% P = 0.001), and TG (104.6157.57 to 83.1738.64, −20.5%, p = 0.004). LDL levels were unaffected by TRE with or without LCD, according to Table 2 and Fig. 4.

Discussion

To our knowledge, this marks the inaugural clinical trial directly comparing the efficacy of two dietary strategies: an 8-h time-restricted feeding (TRF) regimen and a moderately low-carbohydrate diet (mLCD), which necessitates a 16-h fasting period followed by an 8-h eating window. We aimed to assess their impact on weight loss and the reduction of cardiometabolic risk factors. Previous research has highlighted the popularity and feasibility of the 8-h TRF approach, as demonstrated by Gabel et al. (2018) and Lowe et al. (2020), who reported favorable outcomes in obese populations regarding weight loss and cardiometabolic health. Conversely, low-carbohydrate diets have shown promise in enhancing fat loss and insulin sensitivity, crucial factors in cardiometabolic well-being, as emphasized by De Cabo and Mattson (2019). Additionally, conventional diets have proven effective in promoting weight loss and improved body composition, albeit to a lesser extent than low-carb diets, as noted by De Cabo and Mattson (2019).

Our study's innovation lies in harmonizing feeding times with light–dark cycles, a feature highlighted by Moro et al. (2020), which may offer metabolic advantages. Our primary discovery underscores the value of combining straightforward and safe dietary approaches for enhanced efficacy. We observed that the fusion of TRF with an mLCD yielded superior outcomes in the battle against obesity, with carbohydrate consumption limited to 30–40% or approximately 180 g during the 8-h eating window. The potential effects of combining carbohydrate restriction with TRF during fasting remain uncertain.

Our hypothesis posited that the TRF + mLCD group would achieve more substantial weight loss, greater reductions in cardiometabolic risk factors, and improved glycemic control compared to the TRF group and the control group. Our investigation corroborated that both TRF and LCD were effective in reducing body weight and improving metabolic markers. However, the combination of TRF and mLCD demonstrated superior results within the same time frame. In a 12-month study by Bazzano et al. (2014), the LCD group (consuming 40 g/d of carbohydrates) achieved an average weight loss of 3.5 kg. Sasakabe et al. (2011) found significant correlations between visceral adipose tissue, triglycerides, fasting blood glucose, and high-density lipoprotein levels in women following a moderate carbohydrate diet (approximately 38% carbohydrate) for six months. Conversely, He et al. (2022) reported that TRE outperformed LCD in reducing visceral and cardiometabolic obesity, boasting higher adherence rates.

Drawing from multiple studies, we opted for an eight-hour fasting window for TRF, as longer fasting periods yielded more substantial improvements. Gill et al. (2015) observed a 3.6% weight loss over 16 weeks with a 10-h TRF window, and Gabel et al. (2018) achieved similar results over 12 weeks. Li et al. (2021) even recorded an average weight loss of 1.3 kg (equivalent to 1.7% of body weight) within a mere five weeks with less frequent eating confined to an 8-h window. In contrast, limiting food intake to a 4- or 6-h window proved challenging, with Cienfuegos et al. (2020) detecting no significant differences in weight loss between these narrow windows over an eight-week period. Our study documented a modest yet significant reduction in body weight (5% kg; 2.5%) among obese women over eight weeks, with the TRF + mLCD group achieving the most substantial decrease.

In a study by He et al. (2022), the combination of an LCD and TRF led to clinically significant weight loss, amounting to a 5.8% reduction from baseline over three months. Notably, He et al. adhered to a low-carb diet, with carbohydrate intake falling below 130 g, a level akin to the one recommended in our study, which ranged from approximately 180 to 200 g.

Circadian rhythms play a pivotal role in regulating various physiological processes, including metabolism. The timing of food intake can significantly influence these rhythms. Research has indicated that early versus late feeding can impact the internal circadian clock, as demonstrated by Vollmers et al. (2009) and Pavlovski et al. (2018). Moro et al. (2020) found that aligning feeding schedules with the light–dark cycle yielded improvements in lipid metabolism and glucose levels. Time-restricted feeding (TRE) has also exhibited beneficial effects on glycemic control and lipid profiles, as shown by Jamshed et al. (2019). Gill et al. (2015) revealed that a substantial portion of daily calorie intake occurs after 6 pm, potentially disrupting circadian rhythms and metabolic health.

He et al. (2022) demonstrated that both early and late TRE meal windows, whether coupled with a low-carb diet or not, yielded similar positive effects on body weight, abdominal fat, glucose metabolism, and other health parameters. However, no significant differences in fat-free mass were noted among the groups, suggesting that nutrient timing may exert negligible effects on body composition (Moro 2016).

TRF, a form of TRE characterized by daily fasting for a specified duration, has shown potential for supporting cardiometabolic health in addition to promoting weight loss (Jamshed et al. 2019). Early TRF has been associated with increased morning β-hydroxybutyrate levels compared to control conditions, suggesting that even brief daily fasting may enhance the production of circulating ketones, potentially preserving lean mass (Jamshed et al. 2019). Furthermore, fasting can induce ketosis, reduce body fat, and enhance insulin sensitivity, as highlighted by De et al. (2019).

Recent research indicates that both daily calorie restriction (CR) and intermittent fasting have comparable effects in reducing insulin resistance (Gabel et al., 2019). Time-restricted feeding (TRF) has also been linked to notable reductions in fasting glucose, insulin levels, and insulin resistance, as shown by Moro et al. (2016), Sutton et al. (2018), and Chaix et al. (2021). Additionally, a combination of TRF and a low-calorie diet (LCD) has been found to significantly decrease fasting glucose and insulin levels, as reported by He et al. (2012). Fasting may improve glucose regulation through metabolic switches, leading to the production of ketone bodies by hepatocytes. These ketones enhance insulin sensitivity and reduce fat accumulation, consistent with findings by De Cabo and Mattson (2019) and Poggiogalle et al. (2018). These outcomes align with the research by Sutton et al. (2018), which demonstrated that five weeks of early TRF resulted in decreased insulin levels and improved insulin sensitivity during a morning oral glucose tolerance test.

Nonetheless, our study distinguished itself by revealing that TRF, with or without LCD, exerted more significant effects on glycemic control indicators than the study conducted by He et al. (2022), even though insulin levels did not exhibit significant reductions in the TRF group. The difference in carbohydrate intake between the two studies may have influenced the rate at which TRF impacted insulin levels. While the TRF+mLCD group experienced a substantial reduction in total cholesterol, both groups exhibited only a trend toward decreased LDL levels. Conversely, He et al. (2022) reported a negative effect on LDL when combining LCD with TRF after three months. In Suton et al.'s investigation, a 10 h TRF window did not impact triglyceride levels, whereas an 8 h TRF, with or without LCD, significantly reduced triglyceride levels, mirroring the results in He et al.'s study and our own. Additionally, Choi's research (2022) uncovered that an mLCD diet improved the lipid profile, characterized by lower triglycerides and higher high-density lipoprotein cholesterol levels. Similar to our study and Gabel et al.'s (2018) findings over a 12-week period, Moro et al. (2016) did not observe significant changes in the lipid profile with TRF. It should be noted that our study participants had normolipidemia. Overall, research has yielded both congruent and divergent outcomes in this field.

The significance of this study is that it demonstrates the effectiveness of an 8 h time-restricted feeding (TRF) in improving lipid profile and reducing body weight in obese women, regardless of the carbohydrate content of their diet. This means that TRF can be a simple and effective dietary intervention for obesity management, as it does not require counting calories or restricting food choices. Furthermore, the study shows that combining TRF with a moderate low-carbohydrate diet (mLCD) can enhance the benefits of TRF, as it leads to greater weight loss and lower triglyceride levels than TRF alone. This suggests that mLCD can synergize with TRF to optimize metabolic health and prevent obesity-related complications. Therefore, the study provides valuable insights into the potential of TRF and mLCD as complementary strategies for obesity treatment.

This study has some limitations that should be considered when interpreting the results. First, the sample size was relatively small due to the research timelines and deadlines. Second, this study allowed participants to choose their preferred intervention so as to increase their motivation and adherence to the study, and also never expected any significant differences between the two intervention groups in terms of baseline characteristics or outcomes. However, this might have introduced some selection bias and reduced the internal validity of the study. Third, since this study only worked on women based on the data about women and obesity, there may be some differences between women and men in how they respond to intermittent fasting, depending on their hormonal status, body composition, and metabolic profile. For example, women may experience more adverse effects such as menstrual irregularities, mood changes, and binge eating during intermittent fasting. Men may experience more benefits such as increased testosterone levels, muscle mass, and fat oxidation during intermittent fasting. Fourth, the intervention duration was only eight weeks, which may not be long enough to capture the long-term effects of TRE and LCD on weight maintenance and cardiometabolic health. Third, we did not measure other potential confounding factors such as physical activity, energy intake, sleep quality, or stress levels, which may have influenced the outcomes. Therefore, future studies should address these limitations by using larger, using a randomized controlled trial design to eliminate this potential confounding factor, individualized approaches may be needed to optimize the outcomes of intermittent fasting for women and men with chronic diseases, longer intervention periods, and more comprehensive assessments of lifestyle factors.

Conclusions

This study provides valuable insights into the potential for informing dietary recommendations, promoting metabolic health, and offering personalized nutrition strategies within the context of time-restricted eating. Despite the discussed limitations of the study, including its sample size, the results indicate the possibility of achieving reduced body weight, improved lipid profiles, glycemic states, and reduced abdominal visceral obesity through time-restricted eating (TRF) with or without a moderate-carbohydrate diet (mLCD). Notably, the combination of TRF and mLCD showed even more significant improvements within the same timeframe, emphasizing the importance of combining simple and safe regimens for enhanced efficacy. The findings of this study suggest that restricting carbohydrate intake to 30–40% or approximately 180 g during an 8-h eating window can lead to superior outcomes in the fight against obesity. Additionally, the study underscores the impact of nutrient timing and the importance of aligning eating patterns with the natural cycle of light and darkness for enhanced metabolic benefits. However, it is worth noting that further research with larger sample sizes should be considered to provide more generalized recommendations.

Abbreviations

LDL-P	Low-density lipoprotein particle
mLCD	Moderately low-carbohydrate diet
TRF	Time-restricted feeding schedule
TRE	Time restricted eating
IF	Intermittent fasting
HDL	High-density lipoprotein

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Data availability
Not Applicable.

Declarations

Ethics approval and consent to participate
This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the institutional review board at King Saud University approved the study procedures via expedited review (IRB No. E-17–2263). Written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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