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The Effect of Ramadan Intermittent Fasting on Food Intake, Anthropometric Indices, and Metabolic Biomarkers among Pre-and Post-menopausal Women: A Cross-Sectional Study

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The Effect of Ramadan Intermittent Fasting on Food Intake, Anthropometric Indices, and Metabolic Biomarkers among Pre- and Post-Menopausal Women: A Cross-Sectional Study

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Abstract: By shifting eating hours from daytime to nighttime, Ramadan intermittent fasting (RIF) illustrates how religious beliefs influence human dietary behavior and subsequent anthropometric and metabolic measures. This study aimed to investigate socioeconomic characters and to examine how observing RIF affects dietary intake, anthropometric indices, and metabolic markers in healthy premenopausal (PRE-M) and post-menopausal (POST-M) Saudi women. Before starting the study, the authors hypothesized that the RIF improves some nutritional aspects and health in respondents, but not after breaking the fast.. The study includes 62 women (31 PRE-M, 21-43 years, and 31 POST-M, 44-68 years). A structured questionnaire was used to collect socioeconomic data. Physical activity, anthropometric, dietary, and biochemical assessments were undertaken before RIF and at the end of the third week of Ramadan fasting month. Socioeconomic data varied among respondents. Observing RIF was associated with significantly (at either $p \leq 0.01$ or $p \leq 0.05$) lower intake of calories, macronutrients, minerals (except for Na), and vitamins than before RIF for both groups. In terms of body mass index (BMI), and waist-to-height ratio (WHtR) for PRE-M, the percentage of overweight decreased significantly ($p \leq 0.01$) while obesity remained unchanged. In contrast, for POST-M, the percentage of overweight increased significantly ($p \leq 0.05$), but obesity decreased after RIF. Both groups' waist-to-hip ratio (WHR), body fat (BF) and fat mass (FM) decreased after RIF. High-density lipoprotein cholesterol (HDL-C), fasting blood glucose (FBG), triglycerides (TG), and blood pressure (SBP, DBP) were generally maintained at acceptable normal levels in most responders before and after RIF. However, low-density lipoprotein cholesterol (LDL-C) was significantly decreased during RIF than before, especially for POST-M. Age, occupation, and monthly income were the most important factors influencing women's nutritional status and body fat. In conclusion, observing RIF by PRE- and POST-M Saudi women was associated with significant improvements in variable health indicators, with a few exceptions, particularly POST-M, and may help lower risk factors for chronic diseases.

Keywords: intermittent fasting; caloric restriction; time-restricted eating; menopausal; women's health

1. Introduction

Religious fasting has been observed by humans for thousands of years, with variable health implications reported in the literature [1]. According to the Islamic calendar, Ramadan is the ninth lunar month, during which healthy adult Muslims are mandated to fast from dawn to sunset, abstaining from all food and water, with the common practice of having a large meal after dusk and a small meal before dawn [2], with no dietary restrictions between dusk and dawn [3]. During this month, the length of the daily fast varies according to the geographical area and time of year, ranging from 11-22 hours according to the geographical location and season [2]. Fasting has been shown to

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elicit significant changes in dietary habits and food consumption patterns when combined with many lifestyle changes in physical activity [4], sleep patterns, and circadian rhythmic changes [5,6], leading to significant changes in anthroPost-Metric, cardiometabolic, glucoregulatory, and inflammatory [7,8]. However, they discovered that a dietary pattern specific to Ramadan contains unique properties that have not yet been identified as a dietary pattern model [7]. According to Daradkeh et al. [9], during Ramadan, Muslims' dietary pattern change; they eat only two main meals: sahur before dawn and iftar at sunset, and dishes consumed during Ramadan are high in sugar, starch, protein, and fat. Notwithstanding an increase in fat intake, daily energy consumption did not decrease. However, the patients lost weight and reduced their waist circumference [8]. No dietary restrictions on the amount or type of food consumed following the breaking of the daily fast. Ramadan food consumption has been linked to significant changes in dietary patterns and the amount and frequency of food items [10]. Some studies have reported lower energy intake when break fasting [10,11]. In contrast, it was observed that energy consumption was higher during the night hours of fasting days than during regular days [11]. They suggest that this energy can be derived from eating more energy-dense foods such as sweets [8,12] and fats [8,13]. Such dietary changes are significant during this month, particularly among people predisposed to metabolic diseases associated with these changes, such as obesity, diabetes, and hypertension [8]. However, during RIF, any changes in body mass, nutrient intake, and nutritional status may be influenced by the individuals' level of physical activity [14]. Ramadan's effects on energy balance and weight regulation have been thoroughly researched, but the results have been mixed. As a result, while some studies show weight loss (including lean mass and fat) [15,16], body weight and body composition remain stable [17,18] or even increase [19]. A decreased resting metabolic rate and physical activity may occur [20]. However, this appears to be offset by reduced sleep time, resulting in no effect on total daily energy expenditure measured by doubly labeled water [20]. As a result of RIF, body mass index (BMI) may or may not decrease, according to Mazidi et al. [20]. They linked BMI variations to the quality and quantity of foods consumed by Muslims in various countries and subcultures. RIF has been shown to reduce weight, BMI, body fat, and biochemical parameters like triglyceride (TG) and fasting blood glucose (FBG). According to Sadeghirad et al. [21], body weight changes caused by Ramadan fasting are generally reversed after Ramadan and eventually recover to pre-Ramadan state. However, there is a relatively small weight variation throughout Ramadan. Further, Ramadan offers a chance to lose weight, but systematic and persistent lifestyle changes are required to accomplish long-term weight loss [21]. In addition, Sadeghirad et al. [21] noted that there were heterogeneous variations in body weight as a result of Ramadan fasting. They argue that dietary restrictions or energy intake limitations alone cannot account for these variations and that a variety of factors, such as dehydration, dietary changes, physical activity, and even sleeping patterns, may play a role. On the other hand, low-density lipoprotein cholesterol (LDL-C) and fasting insulin increased [22]. There have been conflicting reports on the effect of RIF on blood hematological and biochemical parameters. Fasting blood sugar (FBG) and high-density lipoprotein cholesterol (HDL-C) levels decreased significantly, while TG, total cholesterol (TC), and LDL-C levels increased, according to Jahrami et al. [23]. Rathnayake et al. [24] found a substantial inverse relationship between middle-aged women's quality of life and menopausal symptoms. Despite no differences in calories, protein, fat, and various minerals and vitamins intake between premenopausal and postmenopausal women, postmenopausal women had a significantly greater waist-hip ratio than premenopausal women [25]. Menopause is well known to cause an increase in body weight and fat tissue [26]. This suggests that the loss of estrogen after menopause affects body weight, partly by increasing visceral fat [27]. Bhurosy et al. [28] discovered that post-menopausal women's diets were of higher quality, despite their higher mean BMI, which may be attributed to physiological changes during menopause. On the other hand, Nguyen et al. [29] discovered that post-menopausal women had lower nutrient intake levels (fat, protein, sugar and some minerals) than premenopausal women. Moreover, Bashar et al. [30] used a menopausal-specific quality-of-life questionnaire to conduct a cross-sectional study and discovered that post-menopausal women had a higher risk of depression than premenopausal women. Further they reported those psychological symptoms, as well as "difficulty concentrating" and "fatigue," are highly associated

with depression score and have a greater influence on quality of life in early postmenopausal women than late postmenopausal women [30]. Therefore, the current study aimed to investigate the socioeconomic characters and the effects of RIF on food intake, anthropometric indices, metabolic biomarkers, and the associated factors among healthy premenopausal (PRE-M) and post-menopausal (POST-M) Saudi women.

2. Methods and Methods

2.1. Study Participants

The research was done during Ramadan 2022, from the first of April to the first of May. (1443 Hijri). For those who qualified, an information sheet was made available. The information was collected twice: one week before Ramadan (R1) and once at the end of Ramadan's third week, following 21–30 days of fasting (R2). Participants in Ramadan abstained from all food and drink (including water) from dawn till dusk (approximately 15 h). Participants in the study were not given any additional dietary recommendations and were asked to continue eating and exercising as usual while they weren't fasting. The sample size was determined according to the prevalence of satisfaction and the accuracy of the survey, and participants were chosen based on inclusion and exclusion criteria. Sixty-two women aged 21 to 68 were conveniently recruited using social media from Qassim, Saudi Arabia. Before the study began, all participants provided their written, informed consent. Based on the questionnaire and the clinical information, the participants were split into two groups: PRE-M women (21 - 43 years old) and POST-M women (42 - 68 years old). Healthy women with regular menstrual cycles were classified clinically as PRE-M, whereas those whose menses had stopped at least a year before sample collection were classified as POST-M were included. However, those with a history of smoking, CVD, pregnancy, cancer, high blood pressure, breastfeeding, as well as diabetes and even non-diabetics but taking medications for sugar regulation, and those taking medication to lead to metabolic changes such as antiretroviral, corticosteroids, anti-seizure, psychotropic, insulin, sulfonylurea, and thiazolidinediones [31], or experiencing a weight change of more than 3 kg right before study participants were excluded.

2.2. Socioeconomic data collection

The socioeconomic data was gathered using a structural questionnaire according to Ardawi et al. [32] and approved by a nutritional expert committee. Before beginning the study, the researcher conducted face-to-face interviews with the participants who had signed written informed consent. The questionnaire collected participants' demographic data, including questions about age, educational level, occupation level, income, and physical activity whether low (walking), medium (walking with exercise for short period) or high (intensive exercise) which validated by expert in sport.

2.3. Dietary Intake and Analysis

The daily food record method was employed. To make the best analysis of the dietary intake, the principal researcher and the assistants provided printed records for the participants with instructions, examples, and tables to record food for all days. The next step was to instruct each participant to record her food intake promptly at the provided table. Being exempted from fasting per the Islamic regulations of Ramadan, PRE-M women, during menses, were asked to choose three days in Sha'ban and three days in Ramadan. The three days (triplicate samples) are divided so that two days are in the middle of the week and one day is either of the weekend days, Friday or Saturday. Participants recorded all foods and drinks, including snacks, appetizers, sauces, and seasonings, even for small quantities. Extra sheets of food records were given to the participants when more space to record the foods eaten. The importance of accuracy and details was emphasized, and the researcher's mobile phone number was written on each piece of paper in case the participant had any questions or inquiries. Participants were also asked to continue with their usual eating habits regardless of the outcome, as the goal was to guide them to the best based on the results. The researcher gave the

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participants instructions and asked them to accurately describe the food type and amount using common measurements such as a tablespoon, teaspoon, cup, size by gram or liter of canned food, preparation method, and food additives used during cooking. To estimate dietary intakes of macro- and micro-nutrients, a nutrition analyzer software program designed for research and clinical use was used (ESHA Food Processor 11.9.13, 2020). Each type of food, fresh or cooked, was assigned a code using this software. The program then automatically analyzed the foods taken and provided explicit quantities for nutrients such as calories, carbohydrates, protein, and so on for each participant based on daily intake for three dietary days. Nutritional breakdown information for each food item for up to 172 data fields, including water, macro-, and micro-nutrients, are included in the ESHA Master Database, which consists of ingredients, recipes, and other food items. The nutrients obtained before and after RIF were compared using a t-test.

2.4. Anthropometric Measurement

Anthropometric measurements such as percent body fat (PBF), BMI and fat mass (FM) were measured in duplicate using a multiple-frequency ACCUNIQ BC360 body composition analyzer (SELVAS Healthcare Inc., Daejeon, Korea) according to the manufacturer's instructions. Waist circumference (WC), hip circumference (HC), and height (H) were measured with a non-stretchable meter. The waist-to-height ratio (WHtR) was calculated by dividing WC by H, whereas the waist-to-hip ratio (WHR) was calculated by dividing WC by HC. BMI was calculated as a weight ratio in kg to square meter height. The BMI classification was done according to Romero-Corral et al. [33], the WHtR classification was done according to Ashwell et al. [34], and the WHR classification was done according to WHO [35]. According to the body composition analyzer manual, body fat and fat mass standard references were obtained.

2.5. Blood Samples Collection and Analysis

Before and after Ramadan, blood samples were collected. Each subject had a venous blood sample (10 mL) drawn after fasting for at least 8 hours. To eliminate the influence of timing and dietary intake on the measured biochemical parameters and to ensure uniform fasting duration at both times, samples were collected between 11 a.m. and 1 p.m. at both time points. The blood was divided into two aliquots. Within an hour of collection, the aliquot was centrifuged at 3000 rpm for 15 minutes, and the serum was coded and stored at -80 °C until used for biochemical analysis. In the laboratories of King Saud Hospital in Unaizah (Qassim district), respondents' blood parameters were analyzed using the XN1000-Cobas E411 (Sysmex-Rauch-Hitachi, Tokyo, Japan). Regarding the analyses, participants who approved for their menstrual period were asked to fast for 12 hours before blood sample collection to ensure the consistency and validity of the results following all conditions for comparison before and after Ramadan.

2.6. Blood Glucose and Lipid Profile Determination

Colorimetric kits (Office, Shanghai, China) and a Dimension Xpand Plus Chemistry Analyzer were used to determine blood glucose levels and lipid profiles such as total cholesterol (TC), LDL-C, HDL-C, and triglycerides (TG). All measurements were taken following the manufacturer's instructions.

2.7. Ethical Approval

The regional research Ethics committee in Qassim approved the research protocol and registered at the national committee of Bio & Med, Ethics (NCBE) with registration numbers H-04-Q-001 and No. (1109570-1443). The work was carried out under the legal requirements and guidelines for good clinical practice.

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2.8. Statistical Analysis

The Statistical Package for Social Sciences (SPSS, version 2025) was used to peRIForm the statistical analysis (SPSS Inc., Chicago, IL, USA). The study participants' sociodemographic characteristics, anthropometric indices, and blood parameters were expressed as frequencies and percentages. Chi-squared was used to determine whether or not there was a significant difference within the group before and after fasting. Before and after RIF, the average intakes of energy, macro-, and micro-nutrients were calculated as means. In term of food intake and to determine whether or not there are significant differences between participants' intake before and at the end of RIF, paired t-tests was used. Spearman correlation coefficients and simple regression analysis were used to determine the relationship between anthropometric indices and intake of calories, cholesterol, and vitamin D as dependent and socioeconomic characteristics and physical activity as independent variables.

3. Results

3.1. Socioeconomic characteristics

PRE-M and POST-M women frequency distribution according to socioeconomic characteristics is shown in **Table 1**. The frequency distribution by age revealed that most PRE-M women (48.39%) were between 31 and 40 years, while POST-M women (83.87%) were over 50. PRE-M women had a university education at a rate of 64.51%, while POST-M women had a rate of 35.48%. Regarding employment, 35.48% of PRE-M women worked for the government, while 83.87% of POST-M women did not. About half of the PRE-M women (48.38%) had a monthly income of 5000 to 10000 Saudi Riyal (SR), while POST-M women (38.72%) had a monthly income of more than 15000 SR (private sector). Both groups engaged in low physical activity before and during Ramadan, with 61.29% and 67.75% of PRE-M women engaged in low physical activity before and during Ramadan, respectively. However, 96.77% and 90.32% of POST-M women participated in the activity before and during Ramadan, respectively.

3.2. Dietary Intake

Table 2 shows the average daily nutrient intake of PRE-M and POST-M women (daily food record, 3 days) before and after Ramadan. A student pair t-test was used to compare each constituent's calculated average nutrient intake before and after Ramadan for PRE-M and POST-M. The average calorie intake of PRE-M and POST-M women decreased significantly ($p \leq 0.01$) from 1959.13 to 1823 kcal for PRE-M, whereas for POST-M, it decreased from 2111.98 to 1901.31 kcal at the end of RIF. Protein and carbohydrates for both PRE-M and POST-M were not significantly differed between the two periods, while dietary fiber was increased, with no significant difference between the two periods. At the end of fasting, total fat and cholesterol were significantly ($p \leq 0.05$) lower, as was unsaturated fat ($p \leq 0.01$). However, after fasting, saturated fat in PRE-M women was significantly ($p \leq 0.01$) lower, whereas it was significantly ($p \leq 0.01$) higher in POST-M. Most vitamin intakes were significantly lower at either $p \leq 0.01$ or $p \leq 0.05$ during fasting than during the corresponding non-fasting period for both groups. All major and trace mineral intakes were inadequate in both groups and were significantly lower ($p \leq 0.01$) during fasting than the non-fasting period, except for sodium in PRE-M, which increased significantly ($p \leq 0.01$) at the end of the Ramadan fasting month.

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Table 1. Frequency distribution of pre- (*n*=31) and post-menopausal (*n*=31) women according to socioeconomic characteristics and physical activity.

Variable	Premenopausal		*p*-value	Post-menopausal		*p*-value
	F	%		F	%	
Age group (year)						
21-30	12	38.71	0.044	-	-	0.0001
31-40	15	48.39		-	-	
41-50	4	12.90		5	16.13	
>50	-	-		26	83.87	
Educational level						
Illiterate	-	-	0.001	1	3.23	0.0003
Secondary	3	9.68		7	22.58	
Intermediate	1	3.23		1	3.23	
Diploma	4	12.90		10	32.25	
University	20	64.51		11	35.48	
Postgraduate	3	9.68		1	3.23	
Occupation						
Student	4	12.90	0.362	-	-	0.001
Government employee	11	35.48		3	9.68	
Special job	8	25.81		2	6.45	
Not working	8	25.81		26	83.87	
Monthly income (SR)						
Less than 5000	1	3.23	0.005	2	6.45	0.041
5000 to 10000	15	48.38		7	22.58	
10000 to 15000	8	25.81		10	32.25	
More than 15000	7	22.58		12	38.72	

Physical activity level	PRE-M (*n*=31)						POST-M (**n**=31)					
	R1			R2			R1			R2		
	F	%	*p*-value	F	%	*p*-value	F	%	*p*-value	F	%	*p*-value
Low	19	61.29	0.004	21	67.75	0.048	30	96.77	0.001	28	90.32	0.007
Moderate	5	16.13		10	32.25		-	-		-	-	
High	7	22.58		0	0		1	3.23		3	9.68	

The significance level was accepted at* p≤0.05; ** p≤0.01 according to chi-square; F, Frequency; R1, before Ramadan; R2, during Ramadan. physical activity: low (walking), medium (walking with exercise for short period) or high (intensive exercise).

3.3. Anthropometric indices and basic hematological parameters of participants

Table 3 shows the BMI, WHtR, WHR, PBF, and FM for both PRE-M and POST-M women. Table 3 shows a significant (p≤0.01) difference in classification degree for both groups in terms of BMI, using the Chi-Square test. Before fasting, the majority of PRE-M women had a normal BMI (48.39%), followed by overweight (38.71%) and underweight (2%). In contrast, after fasting, normal BMI increased to 64.52%, overweight decreased to 22.58%, and underweight PRE-M women increased to 6%. Furthermore, 48.39% of POST-M women were overweight before fasting, followed by obesity (32.26%), but after fasting, overweight women increased to 54.84%, and obese women decreased to 22.58%. Before fasting, most PRE-M women (51.61%) had normal WHtR, followed by underweight (25.81%); after fasting, the number of normal women did not change. Still, the number of underweight increased to 32.26%. Furthermore, the number of overweight women decreased from 16.12% to 12.90% after fasting, as did those who were extremely overweight. POST-M female obesity

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decreased from 41.94% to 22.58%, as did those who were overweight after fasting. However, overweight people increased from 25.81% to48.39% at the end of the fast. Regarding WHR, most PRE-M women had a low ratio (90.32%), which increased significantly to 96.77% at the end of fasting, as did POST-M women, who increased from 41.94% to 58.07%. At the end of fasting, both groups' normal and high WHR ratios decreased.

Table 2. Average daily intake of macro- and micronutrients (daily record-3 days) before (R1) and at the end of Ramadan (R2) with the pre- and postmenopausal women.

Parameter	Premenopausal		*t*-test	*p*-value	Post-menopausal		*t*-test	*p*-value
	R1	*R2*			*R1*	*R2*		
Macronutrients								
Calories (kcal)	1959.13±27.18	1823.34±22.65	2.95**	0.006	2111.98±21.18	1901.31±17.36	4.68**	0.005
Protein (g)	77.87±12.60	68.17±16.55	1.81	0.081	83.47±12.78	76.21±11.32	1.92	0.065
Carbohydrates (g)	196.22±24.34	186.22±17.83	1.34	0.176	211.77±22.80	190.74±19.52	1.56	0.129
Dietary fiber (g)	7.53±3.40	9.04±5.51	-1.42	0.167	10.35±4.91	11.06±5.14	-0.73	0.473
Total fat (g)	93.53±18.33	82.75±13.32	1.98*	0.050	94.56±10.24	82.13±9.06	2.29*	0.029
Saturated fat (g)	26.55±8.12	18.76±6.91	7.59**	0.003	29.87±8.42	35.95±9.86	-1.80*	0.022
Unsaturated fat (g)	60.45±11.15	48.99±8.17	3.86**	0.001	59.12±14.78	43.24±13.90	5.89**	0.001
Cholesterol (mg)	260.81±26.7	246.08±19.2	0.356*	0.024	336.44±27.91	225.67±15.50	1.84*	0.016
Vitamins								
Vit A μg (RE)	238.96±36.10	145.28±15.40	1.37*	0.018	394.49±74.20	305.42±74.10	0.47*	0.041
Thiamin (mg)	0.54±0.43	0.34±0.18	2.93**	0.006	0.68±0.73	0.36±0.54	2.71*	0.011
Riboflavin(mg)	0.71±0.48	0.40±0.20	3.08**	0.004	1.18±0.50	0.63±0.45	2.00*	0.050
Niacin (mg)	12.27±4.00	11.68±3.7	0.302	0.765	15.42±11.30	10.69±8.70	2.18*	0.037
Vit.B6 (mg)	0.61±0.57	0.55±0.55	0.711	0.482	0.90±1.11	0.63±0.88	1.37	0.180
Vit.B12 (mcg)	1.49±1.30	1.01±1.20	0.985	0.333	2.49±0.53	2.45±0.52	0.03	0.976
Vit..C (mcg)	23.00±8.70	17.11±6.10	1.04	0.308	32.40±4.70	30.31±3.21	0.32	0.754
Vit.E- (mg)	2.23±2.40	1.10±1.52	2.20*	0.035	2.05±1.51	0.96±0.94	4.61**	0.001
Vit.D – (mcg)	1.16±1.20	0.51±0.68	2.90**	0.007	2.11±0.98	0.65±0.30	1.86*	0.037
Vit. K (mcg)	24.87±13.70	30.78±16.80	-0.265	0.793	25.11±3.81	11.41±1.94	2.08*	0.046
Folate (mcg)	143.34±11.10	81.68±7.71	2.87**	0.007	181.80±29.40	95.26±19.91	1.63	0.113

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Minerals								
Calcium (mg)	408.05±23.61	366.84±18.74	0.902*	0.034	564.09±31.90	388.45±21.30	3.09**	0.004
Copper (mg)	0.68±0.64	0.49±0.36	1.69	0.101	0.75±0.19	0.74±0.17	0.03	0.973
Magnesium (mg)	90.84±8.81	79.23±5.93	0.640	0.527	104.77±55.90	80.49±48.71	1.81*	0.048
Iron (mg)	8.69±4.70	7.76±3.40	0.962	0.344	11.42±7.10	9.22±6.20	0.72	0.475
Phosphorus (mg)	326.99±26.72	295.50±19.10	0.480	0.635	383.19±25.42	267.64±17.33	2.95**	0.006
Potassium (mg)	481.43±86.50	322.14±57.91	0.836*	0.013	1459.59±93.51	1366.69±47.81	0.55	0.588
Selenium (mg)	40.79±7.91	31.95±3.73	1.03	0.311	41.22±6.22	27.66±2.80	2.59*	0.014
Sodium (mg)	1834.06±13.80	2482.38±15.31	-1.81*	0.018	2773.80±14.83	2299.28±19.51	0.44*	0.016
Zinc (mg)	3.38±2.93	2.62±2.10	1.17	0.251	5.15±3.73	3.66±3.12	1.06	0.298

The significance level was accepted at* p≤0.05; ** p≤0.01 according to the t-test. R1, before Ramadan; R2, during Ramadan.

PRE-M women with normal PBF increased from about 55%) to about 65% at the end of fasting, as did those with high PBF. However, POST-M women had a very high PBF (45.16%) that decreased to 41.94% at the end of fasting, whereas those with a high PBF increased from 32.26 to 35.48. The FM differed significantly (p≤0.01) between participants. Before fasting, PRE-M women had a high rate of normal FM (51.61%), followed by a high level (45.16%), and after fasting, the percentage of those with normal FM increased to 61.29% and those with a high level decreased to 35.48%. Before fasting, most POST-M women had high FM (87.10%), which decreased to 83.87% after fasting, while those with a normal level (12.90%) before fasting increased to 16.13% after fasting.

3.4. Basic hematological parameters of participants

Table 4 shows the basic hematological parameters of PRE-M and POST-M women before and after fasting. Before fasting, most PRE-M women (96.77%) had low LDL-C, and all had low levels after fasting. The percentage of POST-M women with low LDL-C decreased from 74.19% to 67.74%, while those with normal increased from 25.81 to 29.03%. PRE-M women had normal HDL-C levels before fasting, and only 3.23% had low levels after fasting, whereas POST-M women had normal levels before fasting, and 3.23% had high levels at the end of fasting. The percentage of PRE-M women with low cholesterol levels was found to be 80.65%, while those with high levels had a percentage of 19.35%. However, they were either normal (77.42%) or high (22.58%) after fasting. Before fasting, most POST-M women (61.29%) had high TC levels, which increased to 64.52% after fasting at the expense of those with normal levels. Regarding TG, 96.77% of PRE-M women had normal levels before and 90.33% after fasting, whereas 93.55% of POST-M women had normal levels before and 93.55% after fasting. Before fasting, the percentage of PRE-M women with normal blood glucose levels was 83.87%, and after fasting, the percentage did not change. The percentage of POST-M women with normal levels was 41.93%, and those with high levels were 48.39%, and after fasting, the normal level increased to 64.52%, and the percentage of those with high levels decreased to 25.81%. Before fasting, PRE-M women had either normal BP (77.42%), elevated ((9,68%), or hypertension-I (12,90%), and after fasting, the normal level decreased to 74.19%, elevated to 22.58%, and hypertension-1 percent decreased to 3.23%. Before fasting, most POST-M women (45.16%) had hypertension-II, followed by hypertension-I (25.81%); however, after fasting, the percentage of those with hypertension-II decreased to 38.71, and those with hypertension-I decreased to 16.13%.

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3.5. Factors Associated with some nutritional status of participants

Table 5. Simple linear regression analysis between socioeconomic, physical activity, and BMI and BF before (R1) and at the end of Ramadan (R2) for pre-and post-menopausal women.

Dependent variables/ Independent variables	Premenopausal (n=31)								Post-menopausal (n=31)							
	BMI				*BF*				*BMI*				*BF*			
	R1		R2		R1		R2		R1		R2		R1		R2	
	β	P-value	β	P-value	β	P-value	B	P-value	β	P-value	β	P-value	β	P-value	β	P-value
Socioeconomic factors																
Age	0.03	0.990	0.15	0.558	0.04	0.641	0.06	0.952	0.14**	0.007	0.13*	0.024	0.17**	0.009	0.29*	0.017
Education level	-0.10	0.781	-0.27	0.529	-0.08	0.591	-0.16	0.310	-0.09	0.755	-0.17	0.482	-0.24	0.166	-0.22	0.153
Occupation	-0.31*	0.038	-0.26	0.464	-0.22*	0.050	-0.019	0.894	-0.02	0.898	-0.02	0.901	-0.03	0.973	-0.02	0.837
Monthly income	0.18*	0.042	0.12	0.648	0.13	0.193	0.16	0.127	0.21	0.276	0.01	0.972	0.33**	0.007	0.29**	0.001
Physical activity																
High	-0.16	0.564	-0.37	0.192	-0.02	0.817	-0.09	0.438	-0.06	0.820	-0.02	0.914	-0.12	0.465	-0.11	0.435
Moderate	-0.46	0.089	-0.62*	0.030	-0.05	0.629	-0.08	0.477	-0.05	0.904	-0.03	0.920	-0.38	0.112	-0.37*	0.050
low	-0.16	0.149	-0.21*	0.031	-0.04	0.588	-0.03	0.661	-0.88	0.140	-0.69	0.150	-0.57*	0.018	-0.48	0.125

The significance level was accepted at * p≤0.05; ** p≤0.01.

Table 5 displays the results of a simple linear regression analysis using socioeconomic characteristics and physical activity as independent variables and BMI and BF as dependent variables. The BMI and BF were positively or inversely correlated with the independent variables. According to simple regression analysis, a PRE-M women's occupation was inversely and significantly (p≤0.05) associated with BMI but positively (p≤0.05) associated with monthly income before fasting. However, at the end of the fast, physical activity was inversely and significantly associated with BMI (p≤0.05). The results for POST-M women showed a positive association between age and BMI before and after fasting; however, most other independent variables were inversely associated with BMI but at a non-significant rate. The occupation of a PRE-M female was inversely and significantly associated (p≤0.05) with the BF before fasting, but the association was not significant at the end. The BF of POST-M women was positively associated with age and monthly income but inversely with physical activity before and after fasting.

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Table 6. Simple linear regression analysis between socioeconomic, physical activity, and dietary intake of calories, cholesterol, and vitamin D before (R1) and at the end of Ramadan (R2) for pre-and post-menopausal women.

Dependent variables/ Independent variables	Post-menopausal (n=31)											
	Calories				Cholesterol				Vitamin D			
	R1		R2		R1		R2		R1		R2	
	β	P-value	β	P-value	β	P-value	β	P-value	β	P-value	β	P-value
Socioeconomic factors												
Age	-0.03	0.630	-0.15*	0.012	-0.68	0.120	-0.28*	0.020	-0.54	0.150	-0.34*	0.023
Education level	-0.13*	0.039	-0.19*	0.050	-0.04	0.267	-0.19	0.251	0.18*	0.040	0.21*	0.031
Occupation	0.01	0.494	0.01	0.544	0.20	0.967	0.01	0.824	0.04	0.986	0.03	0.947
Monthly income	0.14**	0.004	0.12*	0.016	0.01	0.564	0.01	0.369	0.19	0.256	0.04	0.990
Physical activity												
High	-0.13*	0.050	-0.24*	0.030	-0.44	0.965	-0.01*	0.027	-0.30	0.360	-0.10	0.863
Moderate	-0.23*	0.048	-0.34*	0.050	-0.02	0.440	-0.03	0.382	-0.19	0.610	-0.11	0.875
Low	-0.02	0.309	-0.03	0.234	-0.04*	0.017	-0.03	0.461	-0.28	0.463	-0.47	0.478
Dependent variables/ Independent variables	Post-menopausal (n=31)											
	Calories				Cholesterol				Vitamin D			
Age	-0.04	0.586	-0.02	0.829	-0.01	0.193	-0.08	0.976	-0.51	0.301	-0.14	0.249
Education level	-0.16*	0.038	-0.14*	0.035	-0.01	0.331	-0.01	0.655	0.04	0.681	0.04	0.897
Occupation	0.01	0.508	0.03	0.436	0.01	0.402	0.12	0.789	0.03	0.589	0.11	0.562
Monthly income	0.14	0.204	0.03*	0.027	0.11	0.975	0.02	0.498	0.04	0.941	0.01	0.477
Physical activity												
High	-0.04	0.832	-0.01	0.473	-0.22*	0.019	-0.01	0.304	-0.09	0.134	-0.18	0.458
Moderate	-0.14*	0.032	-0.02	0.439	-0.02	0.138	-0.03	0.359	0.41**	0.002	0.22*	0.011
Low	-0.06	0.800	-0.01	0.589	-0.02	0.163	-0.05	0.144	-0.07	0.952	-0.32	0.493

The significance level was accepted at *p≤0.05; **p≤0.01.

Table 6 summarizes a simple linear regression analysis of PRE-M and POST-M women's socioeconomic characteristics, physical activity as independent variables, and calorie intake, cholesterol, and vitamin D levels as dependent variables before (R1) and after (R2) Ramadan. The education level, monthly income, and physical activity of PRE-M women were inversely and significantly associated (p≤0.01, p≤0.05) with calorie intake before fasting, but calorie intake was inversely and significantly associated (p≤0.05) with age, educational level, monthly income, and physical activity at the end of fasting.

However, for POST-M women, before fasting, calorie intake was inversely and significantly (p≤0.05) associated with educational level and physical activity, and at the end of fasting was inversely and significantly (p≤0.05) associated with educational level and positively with monthly income.

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Table 3. AnthroPost-Metric measures of pre-and post-menopausal women before (R1) and at the end of Ramadan (R2) fasting month.

Indices	Premenopausal (*n*=31)				*p*-value	Post-menopausal (*n*=31)				*p*-value
	R1		R2			R1		R2		
	F	%	F	%		F	%	F	%	
BMI (kg/m²)										
Underweight (< 18.5)**	2	6.45	2	6.45		-	-	-	-	
Normal (18.5-24.9)	15	48.39	20	64.52		6	19.35	7	22.58	
Overweight (25-29.9)	12	38.71	7	22.58	0.001	15	48.39	17	54.84	0.012
Obesity (≥ 30)	2	6.45	2	6.45		10	32.26	7	22.58	
Total	31	100.0	31	100.0		31	100.0	31	100.0	
Waist-to-height ratio (WHtR)										
Underweight (≤0.41)	8	25.81	10	32.26		2	6.45	2	6.45	
Normal (0.42-0.48)	16	51.61	16	51.61		2	6.45	3	9.68	
Overweight (0.49-0.53)	5	16.12	4	12.90	<	8	25.81	15	48.39	0.005
Very overweight (0.54-0.57)	1	3.23	-	-	0.001	6	19.35	4	12.90	
Obesity (≥0.58)	1	3.23	1	3.23		13	41.94	7	22.58	
Total	31	100.0	31	100.0		31	100.0	31	100.0	
Waist-to-hip ratio (WHR)										
Low (≤0.80)	28	90.32	30	96.77		13	41.94	18	58.07	
Normal (0.81-0.85)	2	6.45	1	3.23	<	9	29.03	7	22.58	0.008
High (≥ 0.86)	1	3.23	-	-	0.001	9	29.03	6	19.35	
Total	31	100.0	31	100.0		31	100.0	31	100.0	
Body fat (BF, Kg)										
Low (< 21)	5	16.12	5	16.12		-	-	-	-	
Normal (21- 35.5)	17	54.85	20	64.52	<	7	22.58	7	22.58	
High (35.6 – 40)	6	19.35	3	9.68	0.001	10	32.26	11	35.48	0.125
Very high (> 40)	3	9.68	3	9.68		14	45.16	13	41.94	
Total	31	100.0	31	100.0		31	100.0	31	100.0	
Fat Mass (FM, kg)										
Low (< 15)	1	3.23	1	3.23		-	-	-	-	
Normal (15- 26.8)	16	51.61	19	61.29	0.001	4	12.90	5	16.13	<
High (> 26.8)	14	45.16	11	35.48		27	87.10	26	83.87	0.001
Total	31	100.0	31	100.0		31	100.0	31	100.0	

According to chi-square analysis, the significance level was accepted at* p≤0.05; ** p≤0.01. F, frequency; R1, before Ramadan; R2, during Ramadan. ()**, reference level.

PRE-M women's dietary intake of cholesterol before fasting was inversely and significantly associated (p≤0.05) with physical activity, and at the end of fasting was inversely and significantly associated (p≤0.05) with age and physical activity. Before fasting, POST-M women's dietary cholesterol intake was inversely and significantly associated with physical activity (p≤0.05), but after fasting, the association was not significant. The dietary intake of vitamin D of PRE-M women before and after fasting was positively and significantly associated (p≤0.05) with educational level and inversely and significantly associated (p≤0.05) with age at the end of fasting. However, POST-M

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women's vitamin D intake was positively and significantly associated (p≤0.05) with physical activity before and after fasting.

Table 4. Frequency distribution of metabolic parameters level of pre-and post-menopausal women before (R1) and the end of Ramadan (R2) fasting month.

Parameter	Premenopausal (n=31)				*p*-value	Post-menopausal (n=31)				*p*-value
	R1		R 2			R 1		R 2		
	F	%	F	%		F	%	F	%	
LDL-C (mmol/L)										
Low (< 3.9)**	30	96.77	31	100.0		23	74.19	21	67.74	< 0.001
Normal (3.9-4.9)	1	3.23	-	-	0.003	8	25.81	9	29.03	
High (> 4.9)	-	-	-	-		-	-	1	3.23	
HDL-C (mmol/L)										
Low (< 0.83)	-	-	1	3.23		1	3.23	-	-	
Normal (0.83-2.49)	31	100.0	30	96.77		30	96.77	30	96.77	<
High (> 2.49)	-	-	-	-	< 0.001	-	-	1	3.23	0.001
Total	**31**	100.0	31	100.0		31	100.0	31	100.0	
Total cholesterol (mmol/L)										
Low (< 2)	25	80.65	-	-		-	-	2	6.45	< 0.001
Normal (2.0-5.2)	-	-	24	77.42	0.017	12	38.71	9	29.03	
High (> 5.2)	6	19.35	7	22.58		19	61.29	20	64.52	
Triglycerides (mmol/L)										
Low (< 0.34)	1	3.23	3	9.67		**-**	**-**	2	6.45	< 0.001
Normal (0.34-2.28)	30	96.77	28	90.33	< 0.001	31	100.0	29	93.55	
High (> 2.28)	-	-	-	-		-	-	-	-	
Fasting blood glucose (mmol/L)										
Low (<3.9)	4	12.90	5	16.13		3	9.68	3	9.67	0.004
Normal (3.9-6.1)	26	83.87	26	83.87	< 0.001	13	41.93	20	64.52	
High (> 6.1)	1	3.23	-	-		15	48.39	8	25.81	
Total	31	100.0	31	100.0		31	100.0	31	100.0	
Blood pressure (Systolic/Diastolic, mm Hg)										
Normal (120/80)	24	77.42	23	74.19		6	19.35	10	32.26	0.021
Elevated (120-129/< 80)	3	9.68	7	22.58		3	9.68	4	12.90	
Hypertension-I (130-139/80-89)	4	12.90	1	3.23	0.049	8	25.81	5	16.13	
Hypertension-II (≥ 140/≥ 90)	-	-	-	-		14	45.16	12	38.71	

According to chi-square analysis, the significance level was accepted at* p≤0.05; ** p≤0.01. F, frequency; R1, before Ramadan; R2, during Ramadan. ()**, reference level.

4. Discussion

A cross-sectional survey was performed in the current study to investigate the socioeconomic characteristics and the influence of fasting during Ramadan on food intake, anthropometric

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indicators, body composition, and associated factors of Saudi PRE-M and POST-M women. According to the study's results, the frequency distribution of PRE-M and POST-M women based on socioeconomic and physical activity revealed that the participants differed in all characteristics, as indicated by the chi-square test. The findings revealed that most PRE-M women aged 31-40 and POST-M women over 50 had a university degree or a medium monthly income and worked in the public or private sectors. These socioeconomic differences could be attributed to differences in living environments and tribes. Most of participants did low physical activity (walking) before and during Ramadan during specific time because they were either at work or busy at home.

In this study, the dietary intakes of PRE-M and POST-M adult women during Ramadan were compared using a student pair *t*-test. For both groups, observing RIF was associated with lower intake of calories, macronutrients, minerals (except Na), and vitamins than before RIF. This dietary pattern provided a more precise estimate of the difference between female intake and what is required to improve understanding of the impact of religious fasting on dietary behaviors and nutrient intakes. The study observed that fasting during Ramadan was associated with significant changes in the intake of many food groups for both groups, implying that Ramadan has its food intake and dietary pattern compared to the rest of the year. Respondents' energy intake before and after fasting was influenced by their protein, carbs, and total fat diet. Additionally, the amount of minerals and vitamins consumed is correlated with the consumption of fruits and vegetables.

Despite an increase in traditional Arabic sweets, cakes, pastries, and sugar-sweetened beverages unique to this month of the year, calorie intake during Ramadan was reduced for both PRE-M and POST-M women. The results of this study also revealed a clear trend toward the decreased intake of carbohydrates as sugar-containing foods by participants during the night hours of Ramadan, which is inconsistent with recent reports [36–38], indicating increased consumption of sugar-sweetened beverages after breaking the fast. Such high consumption of these foods can be linked to the traditions and customs common during this month, during which some sweets are produced, sold, and consumed. Some studies agree with the present study and found decreased energy intake [8,9], but another study by Ibrahim et al. [12].found increased energy consumption during Ramadan. This was mostly due to a higher intake of energy-rich nutrients, especially sweets [7,11] and fats [7,12]. Despite increased sugar consumption during Ramadan, especially among diabetic patients, fasting and associated higher sugar intake had no negative glucometabolic effects in healthy subjects [39]. Still, the effects on diabetic patients remain unknown.

The present study found a decrease in protein intake by Saudi women, which is inconsistent with the reported increase in protein food consumption during Ramadan [11,40]. Whether the reported higher protein intake during Ramadan relates to its satiating effect is debatable. A meta-analysis of the effects of increased protein intake on satiety found that high-protein meals increased satiety rates more than low-protein meals [41]. As a result, this study's total energy and macronutrient intake before and during Ramadan is a hallmark of intermittent fasting [42] and maybe a more practical dietary modification than calorie restriction [43]. In this study, participants' intake of vegetables and fruits was lower after Ramadan, as evidenced by a lower intake of minerals and vitamins after Ramadan.

On the other hand, salads, dates, and dried apricots are important traditional and cultural foods of Ramadan meals [43], and unfortunately, we observed that the intake of such foods was low. In this study, low vegetable and fruit intake and a low intake of fiber-rich foods during Ramadan night could explain the lower dietary fiber, all vitamins, and all minerals during Ramadan. The methodological and cultural differences in the study population can be attributed to discrepancies in the study results regarding the effect of Ramadan on dietary intake [44]. Variation in nutritional assessment tools is a major factor in conflicting results across studies examining food and dietary intake changes. Another major reason for the disparities in studies of Ramadan eating is the unique cultural and traditional food behaviors adopted by different populations of different ethnic and cultural backgrounds, all while adhering to the rules of the halal food system allowed for Muslims [44]. This difference between PRE-M and POST-M women could be attributed to the fact that the

transition to menopause significantly impacts cardiovascular health and response to various changes in diet and lifestyle [45].

In terms of BMI and WHtR, the results showed that for PRE-M, the percentage of overweight decreased significantly while obesity remained unchanged, whereas, for POST-M, the percentage of overweight increased significantly while obesity decreased after RIF. After RIF, both groups' body fat (BF) and fat mass (FM) decreased. The decrease in energy and macronutrient intake during Ramadan indicated that fasting during Ramadan significantly decreased BMI, BF, and FM, which was consistent with the findings of Mazidi et al. [20], who studied changes in cardiometabolic risk factors and anthropometric parameters during Ramadan. Nachvak et al. [46] also reported that fasting during Ramadan positively impacts weight, BMI, body fat, and some biochemical parameters. Furthermore, the negative effect of Ramadan fasting on body fat and BMI is expected to result in a significant reduction in waist circumference, observed in both groups during Ramadan. Although both groups' body fat levels were significantly lower at the end of Ramadan, so was their waist circumference. This may enable women to develop a pattern of body fat redistribution following Ramadan. This result coincided with the BMI, indicating a stronger relationship between BMI and waist circumference. Although BMI, WC, and WHtR are all strongly correlated, WHtR is an independent predictor of early health risk after controlling for age, gender, and BMI [47]. According to this fact, at the end of Ramadan, POST-M women had a higher health risk than PRE-M women because women experienced a variety of health issues during both the PRE-M and POST-M periods [45]. Both groups had low waist-to-hip ratios (WHR), but POST-M women had a higher proportion of normal and high WHR.

The findings supported previous research on reduced waist circumference throughout Ramadhan [48-50]. In addition, a previous study found no significant changes in WHR in fasting women [51]. PRE-M and POST-M women significantly decreased body fat percentage at the end of fasting. Throughout Ramadhan, many studies reported decreased body fat percentage [22,52]. Despite the women's reported decrease in body fat percentage during RIF, there were also conflicting results that showed an increase in body fat percentage during Ramadhan [53]. However, in this study, both respondents had a significant reduction in fat mass, which could be attributed to the fact that eating fat-rich foods as the primary energy source while fasting may play a role in lowering body fat percentage [53]. A systematic review and meta-analysis found that fasting during Ramadan resulted in statistically significant weight and body composition reductions, such as fat mass (kg) and lean mass, in people who were overweight or obese but not in those who were normal weight [53]. In general, Kozakowski et al. [54] reported that compared to PRE-M, Post-M has a higher prevalence of weight gain and a higher risk of many diseases related to obesity, and taking into account the growing frequency of overweight and obesity as a result of metabolic problems that appear in women during menopause should be considered as a socioeconomic factor.

The findings revealed that most responders' HDL-C, FBG, TG, and blood pressure (SBP, DBP) levels were generally maintained at acceptable normal levels before and after RIF but LDL-C levels were significantly lower during RIF than before, particularly for POST-M. HDL-C was found to be normal after fasting in both PRE-M and POST-M women. However, a study has found an increase in HDL-C after fasting during Ramadan [46], while other study has found a decrease [53]. These differences in HDL-C levels between the present study and previous ones could be attributed to the effect of Ramadan fasting on serum lipid levels, which is closely related to dietary habits and other lifestyle changes [53]. The levels of triglycerides (TG), total cholesterol (TC), fasting blood glucose (FBG), and blood pressure (SBP, DBP) were significantly decreased in both respondents after fasting. In agreement with the present study, a previous study found reduced cholesterol and triglyceride levels [55]. Other study found no significant changes in cholesterol or triglyceride levels [52]. There is also evidence of increased cholesterol and triglycerides after RIF [56]. A study found no significant decrease in glucose levels in the blood [57]. Others reported higher [58] or lower [53] fasting blood sugar levels following RIF. Fasting during Ramadan has little impact on blood pressure or blood glucose levels, as reported by Bener et al. [58]. During intermittent fasting, the lower blood pressure could be due to age, weight loss, or inhibition of catecholamine production, resulting in a reduction

in sympathetic tone and, as a result, lower blood pressure, heart rate, and cardiac output [53]. According to the current research, both women's fundamental hematological indicators drastically decreased after fasting. Differences in metabolic biomarkers between this study and previous ones could explain differences in dietary habits, calorie intake, fasting days, daily fasting period, sampling time, genetic propensity, and daily activity.

According to this study and before fasting, the determinant factors associated with the BMI of PRE-M women were occupation and monthly income; women's occupations significantly decreased BMI while income significantly increased it. However, after fasting, physical activity significantly decreased the BMI. Before fasting, women's PBF was significantly lower, and no significant association with socioeconomic characteristics or physical activity was observed after fasting. BMI was significantly increased before and after fasting in POST-M women only with age, whereas PBF increased significantly with age and monthly income but decreased with physical activity. According to Alsaif et al. [59], obese women were likelier than non-obese women to be inactive. Improved interventions are required to encourage the adoption and long-term maintenance of physical activity, which can lead to better weight control, abdominal adiposity, and chronic disease risk [60]. This is primarily due to the fact that physical activity among Saudi women is the primary factor in the high prevalence of obesity. Moreover, the rising monthly income levels lead to increase in overweight which mean that a higher income leads to more disposable income that can be spent on higher-calorie foods, especially given the population's lack of awareness of the health risks associated with obesity.

Before fasting, PRE-M women's calorie intake increased with income. It decreased with education level and physical activity, but after fasting, it decreased with age, education level, and physical activity and increased with income. Caloric intake for POST-M women decreased significantly with education level and physical activity before fasting and increased significantly with income after fasting. Cholesterol levels were significantly lower with physical activity in both groups, but after fasting, they were significantly lower with age and physical activity in PRE-M women. Before fasting, vitamin D levels were significantly higher with education, but after fasting, they increased with education but decreased with age.

According to this study physical activity significantly increased vitamin D levels in POST-M women before and after fasting. According to Fernandes et al. (2017) [61], exercising outside would provide both the benefits of physical activity and sun exposure, namely vitamin D synthesis, and it was discovered that increased plasma concentrations of vitamin D occur with physical activity both indoors and outdoors. The current findings show that low education and occupation can be contributed to dietary habits differences. Women with lower socioeconomic status ate less fish and vegetables and more meat, fried foods, table sugar, pasta, and potatoes [62]. Lower socioeconomic groups consumed less iron, calcium, vitamin A, and vitamin D. Education and occupation explained a dietary pattern that favored lower social class groups. Education and occupation effects were additive or synergistic for some foods and nutrients. Our findings suggest that both indicators should be evaluated to provide a complete picture of social inequalities in dietary habits.

The relatively small sample size was a limitation of this study because it focused on a specific Saudi Arabian region. It wasn't easy to cover the entire country with the study due to its large size. Moreover, all participants were drawn from the same community with an average income to ensure sample homogeneity and avoid disparities and confusion between cultural and socioeconomic factors. Because it is difficult to find the same number of non-fasting Ramadan participants who meet the same criteria as those who fasted, and because different countries have different physiological and dietary habits, the non-fasting control group was excluded. On fasting days, measurements were taken of women exempt from fasting due to menstruation.

5. Conclusion

The socioeconomic backgrounds of the participants varied. Participants consumed low calories, macronutrients, minerals, and vitamins during RIF. Both groups' BMI, waist circumference, waist-to-height ratio, percentage body fat, and fat mass were significantly lower at the end of Ramadan. However, while LDL-C was significantly low, HDL-C levels were normal in PRE-M and POST-M

women. After fasting, respondents' triglycerides, total cholesterol, fasting blood glucose, and blood pressure (SBP, DBP) levels were significantly lower. According to the study, age, occupation, monthly income, and physical activity were the most important factors influencing women's nutritional status and body fat. These findings imply that by encouraging exercise as well as nutritional guidance and support not only during the RIF period but also after it, the positive effects achieved during IRIF can be enhanced, and weight regain before RIF and body composition standards can be avoided.

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References

1. Trepanowski, J.F.; Bloomer, R.J. The Impact of Religious Fasting on Human Health. *Nutr. J* **2010**, 9, 1-9.
2. Obaideen, K.; Abu Shihab, K.H.; Madkour, M.I.; Faris, M.E. Seven Decades of Ramadan Intermittent Fasting Research: Bibliometrics Analysis, Global Trends, and Future Directions. *Diabetes Metab. Syndr.: Clin. Res. Rev.* **2022**, 16, 102566,
3. doi:https://doi.org/10.1016/j.dsx.2022.102566.
4. Kiyani, M.M.; Memon, A.R.; Amjad, M.I.; Ameer, M.R.; Sadiq, M.; Mahmood, T. Study of Human Biochemical Parameters During and After Ramadan. *J. Relig Health* **2017**, 56, 55-62, doi:10.1007/s10943-015-0084-8.
5. Racinais, S.; Périard, J.D.; Li, C.K.; Grantham, J. Activity Patterns, Body Composition and Muscle Function during Ramadan in a Middle-East Muslim Country. *Int. J. Sports Med* **2012**, 33, 641-646, doi:10.1055/s-0032-1304645.
6. Faris, M.e.A.-I.E.; Jahrami, H.A.; Alhayki, F.A.; Alkhawaja, N.A.; Ali, A.M.; Aljeeb, S.H.; Abdulghani, I.H.; BaHammam, A.S. Effect of Diurnal Fasting on Sleep During Ramadan: A Systematic Review and Meta-Analysis. *Sleep Breath,* **2020**, 24, 771-782, doi:10.1007/s11325-019-01986-1.
7. BaHammam, A.S.; Almeneessier, A.S. Recent Evidence on the Impact of Ramadan Diurnal Intermittent Fasting, Mealtime, and Circadian Rhythm on Cardiometabolic Risk: A Review. Front. *Nutr.* **2020**, 7, doi:10.3389/fnut.2020.00028.
8. Shadman, Z.; Poorsoltan, N.; Akhoundan, M.; Larijani, B.; Soleymanzadeh, M.; Akhgar Zhand, C.; Seyed Rohani, Z.A.; Khoshniat Nikoo, M. Ramadan Major Dietary Patterns. Iran. Red. Crescent. *Med. J* **2014**, 16, e16801, doi:10.5812/ircmj.16801.
9. Sadiya, A.; Ahmed, S.; Siddieg, H.H.; Babas, I.J.; Carlsson, M. Effect of Ramadan Fasting on Metabolic Markers, Body Composition, and Dietary Intake in Emiratis of Ajman (Uae) with Metabolic Syndrome. Diabetes Metab. Syndr. *Obes* **2011**, 4, 409-416, doi:10.2147/DMSO.S24221.
10. Daradkeh, G.; Abuzaid, H.; Al-Muhannadi, A.; Abuhmaira, M.; Khalili, A.; Acido, H. Effect of Ramadan fasting on body composition and dietary intake: a prospective study in the State of Qatar. *J Nutr Food Sci* **2021**, 11(4), 1-5.
11. Sajjadi, S.F.; Hassanpour, K.; Assadi, M.; Yousefi, F.; Ostovar, A.; Nabipour, I.; Rahbar, A.; Health. Effect of Ramadan Fasting On Macronutrients & Micronutrients Intake: An Essential Lesson For Healthcare Professionals. *J. Nutr. Fast* **2018**, 6, 205-212.
12. Lamri-Senhadji, M.; El Kebir, B.; Belleville, J.; Bouchenak, M. Assessment of Dietary Consumption and Time-Course of Changes in Serum Lipids and Lipoproteins Before, During and After Ramadan in Young Algerian Adults. *Singapore Med. J* **2009**, 50, 288.

13. Ibrahim, W.H.; Habib, H.M.; Jarrar, A.H.; Al Baz, S.A. Effect of Ramadan Fasting on Markers of Oxidative Stress and Serum Biochemical Markers of Cellular Damage in Healthy Subjects. *Ann. Nutr. Metab.* **2008**, 53, 175-181.
14. Chaouachi, A.; Chamari, K.; Roky, R.; Wong, P.; Mbazaa, A.; Bartagi, Z.; Amri, M. Lipid Profiles of Judo Athletes during Ramadan. Int. J. Sports Med 2008, 29, 282-288, doi:10.1055/s-2007-965338.
15. Nugraha, B.; Ghashang, S.K.; Hamdan, I.; Gutenbrunner, C. Effect of Ramadan Fasting on Fatigue, Mood, Sleepiness, and Health-Related Quality of Life of Healthy Young Men in Summer Time in Germany: A Prospective Controlled Study. *Appetite* **2017**, 111, 38-45, doi:https://doi.org/10.1016/j.appet.2016.12.030.
16. Sezen, Y.; Altiparmak, I.H.; Erkus, M.E.; Kocarslan, A.; Kaya, Z.; Gunebakmaz, O.; Demirbag, R. Effects of Ramadan Fasting on Body Composition and Arterial Stiffness. *J. Pak. Med. Assoc* **2016**, 66, 1522-1527.
17. Harder-Lauridsen, N.M.; Rosenberg, A.; Benatti, F.B.; Damm, J.A.; Thomsen, C.; Mortensen, E.L.; Pedersen, B.K.; Krogh-Madsen, R. Ramadan Model of Intermittent Fasting For 28 d Had No Major Effect on Body Composition, Glucose Metabolism, or Cognitive Functions in Healthy Lean Men. *Nutrition* **2017**, 37, 92-103, doi:https://doi.org/10.1016/j.nut.2016.12.015.
18. Hajek, P.; Myers, K.; Dhanji, A.-R.; West, O.; McRobbie, H. Weight Change During and after Ramadan Fasting. *J. Public Health* **2012**, 34, 377-381, doi:10.1093/pubmed/fdr087.
19. Bakhotmah, B.A. The Puzzle of Self-Reported Weight Gain in A Month of Fasting (Ramadan) Among A Cohort of Saudi Families in Jeddah, Western Saudi Arabia. *Nutr. J* **2011**, 10, 84, doi:10.1186/1475-2891-10-84.
20. Lessan, N.; Saadane, I.; Alkaf, B.; Hambly, C.; Buckley, A.J.; Finer, N.; Speakman, J.R.; Barakat, M.T. The Effects of Ramadan Fasting on Activity and Energy Expenditure. *Am. J. Clin. Nutr* **2018**, 107, 54-61, doi:10.1093/ajcn/nqx016.
21. Mazidi, M.; Rezaie, P.; Chaudhri, O.; Karimi, E.; Nematy, M. The Effect of Ramadan fasting on cardiometabolic Risk Factors and Anthropometrics Parameters: A Systematic Review. *Pak. J. Med Sci* **2015**, 31, 1250.
22. Sadeghirad, B.; Motaghipisheh, S.; Kolahdooz, F.; Zahedi, M.J.; Haghdoost, A.A. Islamic Fasting and Weight Loss: A Systematic Review and Meta-Analysis. *Public Health Nutr.* **2014**, 17, 396-406, doi:10.1017/S1368980012005046.
23. Hosseini, S.R.A.; Sardar, M.A.; Hejazi, K.; Farahati, S. The Effect of Ramadan Fasting and Physical Activity on Body Composition, Serum Osmolarity Levels and Some Parameters of Electrolytes in Females. *Int. J. Endocrinol. Metab* **2013**, 11, 88-94.
24. Jahrami, H.A.; Faris, M.E.; I. Janahi, A.; I. Janahi, M.; Abdelrahim, D.N.; Madkour, M.I.; Sater, M.S.; Hassan, A.B.; Bahammam, A.S. Does Four-Week Consecutive, Dawn-To-Sunset Intermittent Fasting During Ramadan Affect Cardiometabolic Risk Factors in Healthy Adults? A Systematic Review, Meta-Analysis, and Meta-Regression. *Nutr. Metab. Cardiovasc. Dis.* **2021**, 31, 2273-2301, doi:https://doi.org/10.1016/j.numecd.2021.05.002.
25. Rathnayake, N.; Lenora, J.; Alwis, G.; Lekamwasam, S. Prevalence and Severity of Menopausal Symptoms and the Quality of Life in Middle-aged Women: A Study from Sri Lanka. Nurs. Res. Pract. 2019, 2019, 2081507, doi:10.1155/2019/2081507.
26. Choi, Y.-H.; Song, T.-H. Correlation of Anthropometric Data, Nutrient Intakes and Serum Lipids in Premenopausal and Postmenopausal Women. *Korean J. Food Nutr* **2013**, 26, 476-484.
27. Babaei, P.; Mehdizadeh, R.; Ansar, M.M.; Damirchi, A. Effects of ovariectomy and estrogen replacement therapy on visceral adipose tissue and serum adiponectin levels in rats. *Menopause Int*, **2010**, 16(3), 100-104.
28. Turgeon, J.L.; Carr, M.C.; Maki, P.M.; Mendelsohn, M.E.; Wise, P.M. Complex actions of sex steroids in adipose tissue, the cardiovascular system, and brain: Insights from basic science and clinical studies. *Endocrine Rev*, **2006**, 27,575–605.
29. Bhurosy, T.; Jeewon, R. Food Habits, Socioeconomic Status and Body Mass Index Among Premenopausal and Post-Menopausal Women in Mauritius. *J. Hum. Nutr. Diet* **2013**, 26, 114-122, doi:https://doi.org/10.1111/jhn.12100.
30. Nguyen, H.D. Interactions Between Nutrient Intake and Comorbidities for Quality of Life in Premenopausal and Postmenopausal Women. *Menopause* **2022**, 29, 1285-1295.
31. Bashar, M.I.; Ahmed, K.; Uddin, M.S.; Ahmed, F.; Emran, A.-A.; Chakraborty, A. Depression and Quality of Life among Postmenopausal Women in Bangladesh: A Cross-sectional Study. *J. Menopausal Med* **2017**, 23, 172-181, doi:10.6118/jmm.2017.23.3.172.
32. Verhaegen, A.A.; Van Gaal, L.F. Drugs that Affect Body Weight, Body Fat Distribution, and Metabolism. [Updated 2019 Feb 11]. In: Feingold KR, Anawalt B, Blackman MR, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537590/. 2019.
33. Ardawi, M.S.M.; Qari, M.H.; Rouzi, A.A.; Maimani, A.A.; Raddadi, R.M. Vitamin D status in relation to obesity, bone mineral density, bone turnover markers and vitamin D receptor genotypes in healthy Saudi pre-and postmenopausal women. *Osteoporosis Inter*, **2011**, 22, 463-475.

34. Romero-Corral, A.; Somers, V.K.; Sierra-Johnson, J.; et al. Accuracy of body mass index in diagnosing obesity in the adult general population. *Int J Obes* **2008**, 32, 959-66.
35. Ashwell, M.; Gunn, P.; Gibson, S. Waist-to-Height Ratio is A Better Screening Tool Than Waist Circumference and BMI For Adult Cardiometabolic Risk Factors: Systematic Review and Meta-Analysis. Obes. *Rev* **2012**, 13, 275-286.
36. Organization, W.H. Waist Circumference and Waist-Hip Ratio: Report Of A WHO Expert Consultation, Geneva, 8-11 December 2008; 9241501499; 2011.
37. Gupta, S.; Hrishikeshvan, H.; Sehajpal, P.K. Spirulina Protects Against Rosiglitazone Induced Osteoporosis in Insulin Resistance Rats. *Diabetes Res. Clin. Pract* **2010**, 87, 38-43.
38. Madkour, M.I.; El-Serafi, A.T.; Jahrami, H.A.; Sherif, N.M.; Hassan, R.E.; Awadallah, S. Ramadan Diurnal Intermittent Fasting Modulates SOD2, TFAM, NRIF2, and Sirtuins (SIRT1, SIRT3) Gene Expressions in Subjects With Overweight and Obesity. *Diabetes Res. Clin. Pract* **2019**, 155, 107801.
39. Jahrami, H.; BaHammam, A.; Kalaji, Z.; Madkour, M.; Hassanein, M. A Systematic Review, Meta-Analysis, and Meta-Regression of the Impact of Diurnal Intermittent Fasting During Ramadan on Glucometabolic Markers in Healthy Subjects. *Diabetes Res. Clin. Pract* **2020**, 165, 108226.
40. Morilla, R.G.; Rodrigo, J.R.; Caravaca, A.S.; Gutiérrez, C.V.; Villaverde, G.R.; Moreno, B.P. Dietary Modifications, in Young Muslims Engaged in Ramadan Fasting. *Nutr. Hosp*. **2009**, 24, 738-743.
41. Dhillon, J.; Craig, B.A.; Leidy, H.J.; Amankwaah, A.F.; Anguah, K.O.-B.; Jacobs, A.; Jones, B.L.; Jones, J.B.; Keeler, C.L.; Keller, C.E. The Effects of Increased Protein Intake on Fullness: A Meta-Analysis and its Limitations. *J. Acad. Nutr. Diet* **2016**, 116, 968-983.
42. Di Francesco, A.; Di Germanio, C.; Bernier, M.; De Cabo, R. A Time to Fast. *Science* **2018**, 362, 770-775.
43. Wegman, M.P.; Guo, M.H.; Bennion, D.M.; Shankar, M.N.; Chrzanowski, S.M.; Goldberg, L.A.; Xu, J.; Williams, T.A.; Lu, X.; Hsu, S.I. Practicality of intermittent fasting in humans and its effect on oxidative stress and genes related to aging and metabolism. *Rejuvenation Res*. **2015**, 18, 162-172.
44. Shatila, H.; Baroudi, M.; El Sayed Ahmad, R.; Chehab, R.; Forman, M.R.; Abbas, N.; Faris, M.; Naja, F. Impact of Ramadan Fasting on Dietary Intakes Among Healthy Adults: A Year-Round Comparative Study. *Front. Nutr* **2021**, 8, 689788.
45. Osman, F.; Haldar, S.; Henry, C.J. Effects of time-restricted feeding during Ramadan on dietary intake, body composition and metabolic outcomes. *Nutrients*, **2020**, 12(8), 2478.
46. El Khoudary, S.R.; Aggarwal, B.; Beckie, T.M.; Hodis, H.N.; Johnson, A.E.; Langer, R.D.; Limacher, M.C.; Manson, J.E.; Stefanick, M.L.; Allison, M.A. Menopause Transition and Cardiovascular Disease Risk: Implications for Timing of Early Prevention: A Scientific Statement from the American Heart Association. *Circulation* **2020**, 142, e506-e532.
47. Nachvak, S.M.; Pasdar, Y.; Pirsaheb, S.; Darbandi, M.; Niazi, P.; Mostafai, R.; Speakman, J.R. Effects of Ramadan on Food Intake, Glucose Homeostasis, Lipid Profiles and Body Composition Composition. *Eur. J. Clin. Nutr* **2019**, 73, 594-600.
48. Rohin, M.A.K.; Rozano, N.; Abd Hadi, N.; Mat Nor, M.N.; Abdullah, S.; Dandinasivara Venkateshaiah, M. Anthropometry and Body Composition Status During Ramadan Among Higher Institution Learning Centre Staffs with Different Body Weight Status. *Sci. World J* **2013**, 2013.
49. Sadiya, A.; Ahmed, S.; Siddieg, H.H.; Babas, I.J.; Carlsson, M. Effect of Ramadan fasting on metabolic markers, body composition, and dietary intake in Emiratis of Ajman (UAE) with metabolic syndrome. Diabetes, metabolic syndrome and obesity: *Targets and Therapy* **2011**, 4, 409.
50. Saedeghi, H.; Omar-Fauzee, M.S.; Jahromi, M.K.; Abdullah, M.; Rosli, M. The Effects of Ramadan Fasting on the Body Fat Percent among Adults. *Ann. Biol. Res* **2012**, 3, 3958-3961.
51. Suriani, I.; Shamsuddin, K.; Khalib, A.; Hazizi, A.; Fadlan, M. The Effect of Ramadan Weight Loss on Body Composition of Overweight and Obese Muslims in University Putra Malaysia. *Int. J. Public Health Clin. Scie* **2015**, 2, 61-68.
52. Fernando, H.A.; Zibellini, J.; Harris, R.A.; Seimon, R.V.; Sainsbury, A. Effect of Ramadan Fasting on Weight and Body Composition in Healthy Non-Athlete Adults: A Systematic Review and Meta-Analysis. *Nutrients* **2019**, 11, 478.
53. Ziaee, V.; Razaei, M.; Ahmadinejad, Z.; Shaikh, H.; Yousefi, R.; Yarmohammadi, L.; Bozorgi, F.; Behjati, M.J. The Changes of Metabolic Profile and Weight During Ramadan Fasting. *Singapore Med. J* **2006**, 47, 409.
54. Kul, S.; Savaş, E.; Öztürk, Z.A.; Karadağ, G. Does Ramadan Fasting Alter Body Weight and Blood Lipids and Fasting Blood Glucose in A Healthy Population? A Meta-Analysis. *J. Relig. Health* **2014**, 53, 929-942.
55. Kozakowski, J.; Gietka-Czernel, M.; Leszczyńska, D.; Majos, A. Obesity in menopause–our negligence or an unfortunate inevitability?. *Menopause Review/Przegląd Menopauzalny*, **2017**, 16(2), 61-65.
56. Nematy, M.; Alinezhad-Namaghi, M.; Rashed, M. M.; Mozhdehifard, M.; Sajjadi, S. S.; Akhlaghi, S.; Norouzy, A. Effects of Ramadan fasting on cardiovascular risk factors: a prospective observational study. *Nutr J*, **2012**, 11, 1-7.
57. Nordestgaard, B. G.; Varbo, A. Triglycerides and cardiovascular disease. *The Lancet*, **2014**. 384 (9943), 626-635.

58. Bouguerra, R.; Jabrane, J.; Maatki, C.; Salem, B.; Hamzaoui, J.; El Kadhi, A.; Slama, B. Ramadan Fasting in Type 2 Diabetes Mellitus. *In Proceedings of the Annales d'endocrinologie*, **2006**, pp. 54-59.
59. Bener, A.; Al-Hamaq, A.O.; Öztürk, M.; Güllüoglu, S. Does Ramadan Fasting Have Effects on Sleep, Fatigue and Blood Pressure Among Patients with Hypertension? Blood Press. *Monit* **2021**, 26, 108-112.
60. Alsaif, M.A.; Hakim, I.A.; Harris, R.B.; Alduwaihy, M.; Al-Rubeaan, K.; Al-Nuaim, A.R.; Al-Attas, O.S. Prevalence and Risk Factors of Obesity and Overweight in Adult Saudi Population. *Nutr. Res* **2002**, 22, 1243-1252.
61. Jakicic, J. M. The effect of physical activity on body weight. *Obesity*, **2009**, 17(S3), S34-S38.
62. Fernandes, M.R.; Barreto, W.D.R. Association between physical activity and vitamin D: A narrative literature review. *Revista da Associação Médica Brasileira*, **2017**, 63, 550-556.
63. Vlismas, K.; Stavrinos, V.; Panagiotakos, D.B. Socio-economic Status, Dietary Habits and Health-Related Outcomes in Various Parts of The World: A Review. *Cent. Eur. J. Public Health* **2009**, 17, 55-63.