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Effects of Ramadan Fasting, Physical Activity, and Dietary Patterns on Diabetic and Hypertensive Patients

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ABSTRACT

Introduction: The present study aimed to compare the effects of Ramadan fasting and dietary patterns on the blood pressure, fasting glucose level, and body mass index (BMI) of the patients with diabetes mellitus (DM), hypertension (HTN), DM and HTN, and healthy subjects.

Methods: This prospective, cross-sectional study was conducted in Shaban, Ramadan, and Shawwal months in 2020 on 155 subjects who were divided into groups of HTN (G1; n=42), DM (G2; n=32), DM and HTN (G3; n=41), and healthy (G4; n=40). The subjects were interviewed three times during the study period to collect data on demographics, dietary habits, and physical activity. In addition, physical parameters (height and weight) and clinical parameters (systolic and diastolic blood pressure and fasting blood sugar) were measured in each visit. Data were collected three times in the last ten days of each month. Data analysis was performed using the repeated measures ANOVA.

Results: Mean weight and BMI reduced significantly from Shaban (V1) to Ramadan (V2). Systolic and diastolic blood pressure also reduced significantly from V1 to V2. Moreover, the mean sleeping hours significantly decreased from V1 to V2. Considering Tarawih prayer as physical activity, a significant increase was observed in the mean metabolic energy turnover value from V1 to V2. Mean calorie, carbohydrate, and sodium intake also increased significantly from V1 to V2, while they reversed significantly to almost the same values in V3. Protein and cholesterol consumption decreased significantly from V1 to V2, while the value reversed significantly in V3.

Conclusion: The study showed that the Ramadan fasting could effectively control the blood pressure and glucose levels of the patients. Furthermore, physical activity increased significantly due to Tarawih prayers, and carbohydrate, sodium, and calorie intake increased as well. On the other hand, a reduction was denoted in protein and fat consumption. Glucose levels significantly decreased in the diabetic patients, and blood pressure significantly reduced in the hypertensive patients.

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Introduction

Ramadan is the ninth month of the lunar calendar and is considered a prominent period for Muslims across the world due to mandatory religious fasting. Approximately 1.254 billion out of 1.9 billion Muslims aged more than 15 years fasted in the month of Ramadan of 2020 (1). It is obligatory to all adult Muslims to fast in this month, and exceptions are those who are ill or traveling as commanded by the Holy Quran (1:185).

During Ramadan, fasting Muslims abstain from eating, drinking, smoking, and sexual intercourse from dawn to sunset. In the late evening, most of the fasting muslims Tarawih and wake up early before dawn to eat *Sahur* as the first meal of the day. Tarawih is a special voluntary prayer performed in early night in Ramadan. During Ramadan, drastic changes in eating, sleeping, adjustment of medication doses, extra physical activity due to Tarawih, and fasting/re-feeding for 29-30 consecutive days might affect the biochemical markers of diabetic and hypertensive patients. Several studies have investigated the effects of Ramadan fasting on diabetic patients (2-7), hypertensive patients (8-12), and healthy adults (13-18). To the best of our knowledge, no studies have compared the effects of Ramadan fasting on diabetic patients, hypertensive patients, and healthy subjects.

The present study aimed to compare the effects of Ramadan fasting and dietary patterns on the blood pressure, fasting glucose level, and body mass index (BMI) of patients with diabetes mellitus (DM), hypertension (HTN), DM and HTN, and healthy subjects. Dietary habits and physical activity may vary in different countries (especially during Ramadan) depending on the

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geographical location and cultural background (19). Therefore, dietary changes, extra prayers, and lifestyle changes may interfere with the effects of Ramadan fasting on the body mass index (BMI), blood pressure, and glucose levels.

Material and Methods

This prospective, cohort study was conducted during the months of Shaban, Ramadan, and Shawaal of 1441 Hijri (2020 C.E.) on subjects who were selected via convenience sampling among the family members, friends, and neighbors of the researchers. Since this study compared diabetic and hypertensive patients with healthy subjects, three studies conducted by Khan, Samad, and Farag (2, 10, 15) were taken into account to determine the sample size. With a 95% confidence interval and 80% power, the mean maximum sample size was determined to be 32 patients per group. Since diabetes and hypertension complications often begin after the age of 30 years in most of the cases, we had to considered a limited age group in this study.

Initially, 163 patients were enrolled in the study and divided into four groups of diagnosed hypertensive (G1), diagnosed diabetic (G2), diagnosed hypertensive and diabetic (G3), and healthy control (non-diagnosed with HTN or DM) (G4). In total, 155 subjects completed the three visits, including 42 hypertensive patients, 32 diabetic patients, 41 hypertensive and diabetic patients, and 40 healthy controls; the response rate was 95.1% (155/163). The healthy subjects were also examined in terms of previously undiagnosed HTN and DM based on the 2020 ISH Global Hypertension Practice Guidelines for the diagnosis of HTN and the diagnostic criteria for Type 2 DM by the American Diabetes Association (ADA), respectively.

The inclusion criteria of the study were adult patients aged more than 30 years, consent to participate, and confirmed HTN and/or DM diagnosis (except for the healthy controls). The exclusion criteria were as follows: 1) Type 1 DM; 2) pregnant woman; 3) severe diseases; 4) severe hepatic impairment or renal failure; 5) active involvement in weight loss programs and 6) fasting for less than 20 days.

The research objectives were explained to the subjects at the initial visit, along with the benefits of free testing during the study period, and written informed consent was obtained from each subject. The field investigators were trained on the proper and safe use of the calibrated instruments for the measurement of fasting blood sugar, blood pressure, weight, and height before the first visit.

The field investigators visited the subjects on three occasions, which were during the last 10 days of Shaban (1st visit), the last 10 days of Ramadan (2nd visit), and the last 10 days of Shawwal (3rd visit). On all the three visits, physical measurements (height and weight) and clinical measurements (systolic and diastolic blood pressure and fasting blood sugar) were carried out, along with an interview on a pre-designed Performa with each patient. The questionnaire enquired about the subjects' demographics, family history, disease history (duration and treatment), comorbidities, physical activity (type, frequency, duration, and intensity), smoking habits (past/current smoking and quantity), sleeping patterns (hours of nighttime and daytime sleep and longest run of sleep), dietary macronutrients and micronutrients (calories, proteins, fat, carbohydrates, cholesterol, and sodium), and two-day food items consumed for breakfast (Sahur), lunch (Iftar), and diner.

Values of micronutrients were calculated by MyFitnessPal, and blood pressure was measured twice (at least three minutes apart) in a sitting position using calibrated aneroid sphygmomanometers after ensuring that the subjects were calm and had not just had a meal or engaged in strenuous physical activity immediately before the measurement. Fasting blood sugar was quantified after at least 10 hours of fasting using calibrated glucometers. Weight was measured in kilograms without shoes using calibrated weighing machines, and height was measured only on the first visit in centimeters without shoes.

Data were collected in the morning before breakfast in the first and third visits and before *Iftar* in the second visit. Furthermore, details of physical activity and Tarawih (night prayers) were recorded. Physical activities during Ramadan were measured based on the metabolic energy turnover (MET; kcal/kg/hour) as mentioned by Khan (3). Physical activity in Ramadan was calculated with and without Tarawih prayers using the following formula:

Physical activity = MET value x duration of activity (minutes/session) x frequency of the activity/week

The MET value for the Salah (Islamic prayers) was also determined as 1.5* kcal/kg/hour. (Personal communication with Dr. Stephen Herrmann, Stanford Research; Developer of MET values for different activities).

The study protocol was approved by the Institutional Review Committee of Jinnah Sindh Medical University in Karachi, Pakistan (Ref: JSMU/IRB/2020/-329). Data analysis was performed in SPSS version 16 using the repeated measures ANOVA, with the visits considered as the within factor, groups as the between factor, and age as a covariate to clarify the effects of the groups, visits (groups and visits), and age. If the effect of groups and visits was significant with a P-value of less than 0.1, each group was analyzed by the repeated measures ANOVA with visits considered as the within factor. Chi-square and the Friedman nonparametric ANOVA were also utilized to evaluate the associations between the nominal and ordinal scale variables. In addition, the normality of each continuous variable was assessed, and if it was significant, nonparametric ANOVA was used for the categorical variables.

Table 1. Descriptive statistics of weight. BMI, SBP, DBP and FBS in Shaban, Ramadan and Shawwal

Items	Shaban	Ramadan	Shawwal	Mean	p-value[1]
Weight					
Healthy	68.5±15.7	67.9±15.1	69.0±15.5	68.4±15.3	0.212
Hypertensive (HTS)	73.2±11.0	72.2±11.1	72.6±11.8	72.6±11.2	(group)
Diabetes (DM)	67.9±12.7	67.4±12.7	67.5±12.5	66.6±12.6	0.199
HTN + DM	72.0±15.4	71.1±15.2	71.7±14.7	71.6±15.0	(age)
Mean (Effect of visits)[2]	70.5[a]±13.9	69.8[a]±13.7	70.4[a]±13.8	70.3±13.7	
P-value for the combined effect of visits and groups.[3]	0.789(V1xV2)	0.112 (V1xV3)	0.216(V2xV3)		
BMI					
Healthy	25.0[a]±5.2	24.8[a]±5.3	25.2[a]±5.2	25.0±5.2	0.561
Hypertensive (HTS)	26.7[a]±3.9	26.4[b]±4.1	26.5[ab]±4.1	26.6±4.0	(group)
Diabetes (DM)	25.7[a]±4.1	25.5[b]±4.1	25.5[ab]±4.1	25.6±4.1	0.151
HTN + DM	27.5[a]±5.1	27.1[b]±5.0	27.4[a]±4.9	27.3±5.0	(age)
Mean (Effect of visits)[2]	26.2[a]±4.7	26.0[a]±4.7	26.2[a]±4.6	26.2±.7	
P-value for the combined effect of visits and groups.[3]	0.132 (V1 x V2)	0.530 (V2 x V3)	0.102 (V1 x V3)		
Systolic BP					
Healthy	118.5[a]±11.5	115.9[a]±12.6	117.4[a]±9.7	117.3±8.9	< 0.0001
Hypertensive (HTN)	135.2[a]±17.8	129.6[b]±14.3	128.9[b]±12.7	131.2±13.2	(group)
Diabetes (DM)	117.1[a]±8.4	117.4[a]±8.5	119.2[a]±10.5	117.9±7.6	0.001
HTN + DM	134.6[a]±13.1	131.2[a]±15.2	133.2[a]±14.8	132.9±11.4	(age)
Mean (Effect of the visits)[2]	127.0[a]±15.7	124.0[a]±14.7	125.03[a]±13.7	125.3±12.8	
P-value for the combined effect of visits and groups.[3]	0.251 (V1 x V2)	0.824 (V2 x V3)	0.057 (V1 x V3)		
Diastolic BP					
Healthy	77.6±8.1	75.7±8.6	77.4±7.8	76.9±6.7	< 0.0001
Hypertensive (HTN)	85.0±10.1	82.2±8.1	83.3±7.6	83.5±7.0	(group)
Diabetes (DM)	75.8±5.3	75.2±7.8	77.1±6.9	76.03±5.7	0.001
HTN + DM	84.3±10.7	81.6±8.9	83.7±12.0	83.2±8.2	(age)
Mean (Effect of the visits)[2]	81.0[a]±9.1	78.9[a]±8.9	80.6[a]±9.4	80.2±7.8	
P-value for the combined effect of visits and groups.[3]	0.796 (V1 x V2)	0.631 (V1 x V3)	0.965 (V2 x V3)		
Fasting Blood Sugar					
Healthy	97.2[a]±12.4	93.9[a]±11.9	97.4[a]±12.3	96.2±10.05	< 0.0001
Hypertensive (HTN)	109.0[a]±25.9	102.0[b]±21.4	110.1[a]±19.3	107.0±20.5	(group)
Diabetes (DM)	124.2a±34.6	126.3[ab]±36.4	135.0[b]±44.2	128.5±34.4	0.023
HTN + DM	136.4a±46.5	133.9a±44.04	132.6a±34.3	134.3±37.9	(age)
Mean (Effect of the visits)[2]	116.3[a]±35.3	113.4[a]±34.8	117.9[a]±32.9	115.9±31.5	
P-value for the combined effect of visits and groups.[3]	0.356 (V1 x V2)	0.067 (V1 x V3)	0.249 (V2 x V3)		

*Different alphabets indicate statistical significance.

1 This column shows the significance level (p-value) due the effect of group and age as a covariate.

2. This row give the mean value and significant differences due to the visits

3. This row contains the significance level (p-value) due the combined effect of visits and groups.

Results

In total, 155 subjects (healthy and patients) completed the three visits, including 67 (43.2%) males. About 41% of the respondents were aged 51-60 years, and the majority of the participants (78.9%) were migrants from India. The mean age of the healthy subjects, DM patients, HTN patients, and patients with both HTN and DM was 43.3±9.1 (R: 32-72), 54.3±9.0 (R: 34-69), 56.5±9.4 (R: 38-75), and 59.2±8.4 years (R: 46-77), respectively. The mean age of the healthy subjects was significantly lower than the patients with HTN and HTN with DM. However, no significant differences were observed in the mean height, weight, and BMI between the four study groups in the first visit (Figure 1). Moreover, 65% of the participants stated that they performed Tarawih.

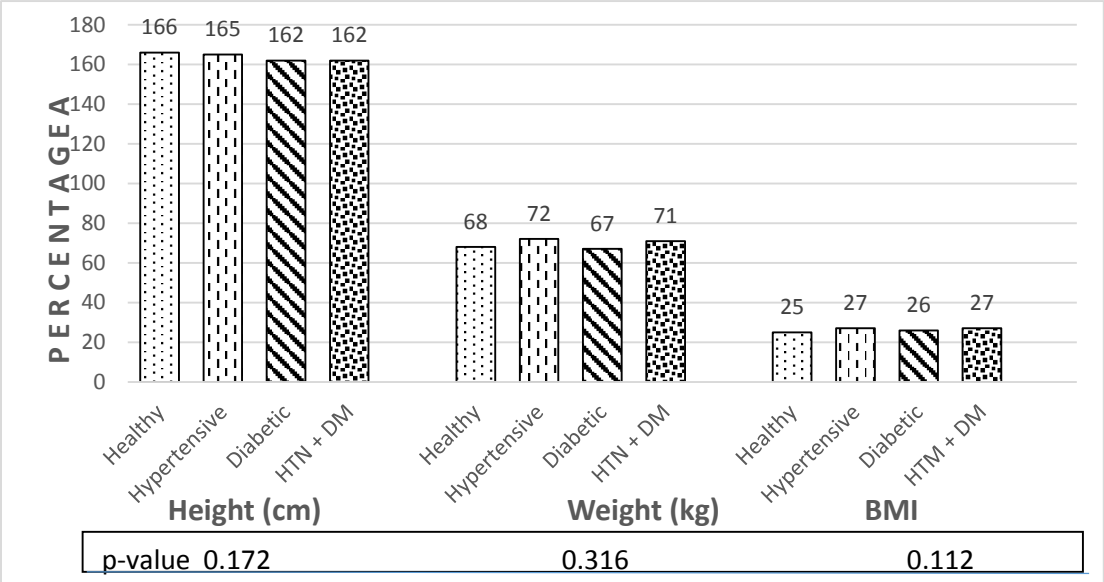

Figure 1. Descriptive statistics of height, weight and BMI

Table 1 shows the descriptive statistics regarding weight, BMI, systolic blood pressure (SBP), diastolic blood pressures (DBP), and fasting blood sugar (FBS), as well as the comparison of the means of Shaban (V1), Ramadan (V2), and Shawwal (V3) between the four groups (visits and groups), with age considered as a covariate. Accordingly, mean weight reduced from V1 to V2 and reversed to almost the same value as V1; however, the difference in this regard was not considered significant. The data showed no significant combined effect of the visits and groups, and the changes in BMI were almost the same as the changes in weight.

According to the findings, SBP reduced from V1 to V2 and increased in V3. The mean values of SBP in the patients with HTN and those with HTN and DM were significantly higher as compared to the healthy subjects and DM patients (P<0.0001). The combined effect of the visits and groups also indicated a significant effect from V1 to V3, and the repeated measures ANOVA showed a significant difference between the visits in the HTN group. In the HTN group, SBP significantly decreased from V1 to V2 and V3. However, the mean DBP decreased in V2, but reversed to almost the same value to V3.

The obtained results demonstrated that the mean FBS increased significantly from V2 to V3 (P<0.05). In addition, the mean FBS values of the healthy subjects and HTN patients were significantly lower compared to the other groups (P<0.0001). A significant difference was also observed in the combined effect of the visits and groups between V1 and V3 (P<0.1). The repeated measures ANOVA also showed a significant reduction in the mean FBS from V1 to V2, as well as an increase in this parameter from V2 to V3 in the patients with HTN (P<0.05). Furthermore, the mean FBS significantly increased from V1 to V3 in the patients with DM.

Table 2. Descriptive statistics of sleeping hours and MET values in Shaban, Ramadan and Shawwal

Items		Shaban	Ramadan	Shawwal	p-value
Total sleeping hours					
	Healthy	7.2a (7.0-8.0)	7.0b(6.0-8.0)	8.0a (7.0-8.0)	0.011
	Hypertensive (HTS)	8.0 (6.0-8.0)	7.0 (6.0-9.0)	8.0 (6.0-8.0)	0.717
	Diabetes (DM)	8.0a (7.0-9.0)	7.5b (6.0-8.8)	8.0a (7.0-9.0)	0.001
	HTN + DM	8.0 (7.0-8.0)	8.0 (6.5-9.0)	8.0 (7.0-8.0)	0.621
Mean (Effect of visits)		8.0a (7.0-8.0)	7.5b (6.0-8.0)	8.0a (7.0-8.0)	0.005
Sleeping hours day time					
	Healthy	0.5 (0.0-1.5)	1.0 (0.0-2.8)	0.5 (0.0-1.9)	0.001
	Hypertensive (HTS)	0.5 (0.0-1.6)	1.2 (0.0-3.0)	1.0 (0.0-2.0)	0.002
	Diabetes (DM)	0.8 (0.0-1.9)	1.2 (0.5-3.0)	0.8 (0.0-2.0)	0.031
	HTN + DM	1.0 (0.0-2.0)	1.5 (0.3-2.0)	1.0 (0.0-2.0)	0.236
Mean (Effect of visits)		1.0a (0.0–2.0)	1.0b(0.0-3.0)	1.0a (0.0-2.0)	<0.0001
MET value without Tarawih kcal/kg/hour					
	Healthy	226.4±559.0	228.0±567.7	201.2±381.2	0.321
	Hypertensive (HTS)	235.0±578.2	168.2±357.9	181.0±338.7	0.181
	Diabetes (DM)	391.1±702.6	231.8±476.1	310.2456.2	0.043
	HTN + DM	273.3±419.5	202.6±416.1	281.4±452.0	0.001
Mean (Effect of the visits)		274.9^{a}±563	206.2^{b}±456	239.2^{a}±406	<0.0001
MET value with Tarawih kcal/kg/hour					
	Healthy	226.4±559.0	610.0±714.4	201.2±381.2	<0.0001
	Hypertensive (HTS)	235.0±578.2	641.8±561.5	181.0±338.7	0.003
	Diabetes (DM)	391.1±702.6	672.1±573.7	310.2±456.2	0.038
	HTN + DM	273.3±419.5	704.1±646.5	281.4±452.0	<0.0001
Mean (Effect of the visits)		274.9^{a}±563	655.8^{b}±635	239.2^{a}±406	<0.0001

*Different alphabets indicate statistical significance.

Table 2 shows the total sleeping hours, daytime sleeping hours, MET values with and without Tarawih prayers in Shaban, Ramadan, and Shawwal, as well as the comparison of the visits. Since sleeping hours were limited in scores and did not fulfill the normality assumption, therefore median and interquartile range were computed. Furthermore, MET values also did not meet the normality assumption, therefore, the nonparametric Friedman test was used for each group to assess the changes in this regard. The obtained results indicated that the sleeping hours of the healthy subjects and DM patients reduced significantly in Ramadan, and total sleeping hours also reduced significantly during Ramadan. In terms of daytime sleeping hours, the healthy subjects and patients with DM and HTN had longer daytime sleeping hours in Ramadan compared to the other groups. The percentage of the participants who had a daytime nap in Shaban, Ramadan, and Shawwal was estimated at 61%, 68%, and 62%, respectively. According to the Friedman two-way nonparametric test, the changes in these percentages were statistically significant (P=0.004).

According to the findings, the mean MET values reduced significantly from V1 to V2 without considering Tarawih prayers. This reduction was attributed to the decreased MET values of the patients with DM and those with HTN and DM. If Tarawih prayers were considered in the calculation of the MET values, a significant increase was observed in the mean values from Shaban to Ramadan (274.9 and 655.8, respectively).

Table 3 shows the summary statistics regarding calorie, protein, carbohydrate, fat, cholesterol, and sodium intake during the months of Shaban, Ramadan, and Shawwal, as well as the comparison of the visits, groups, age, and visits and groups. Accordingly, the mean differences in the calorie intake of the four groups were insignificant (P=0.099), while the age factor showed a significant effect (P=0.019). Notably, the calorie intake of the HTN patients was significantly higher than the other two patient groups. The mean calorie intake increased insignificantly from V1 to V2 (P>0.05) reversed significantly to almost the same value in V3. Furthermore, age had a significant effect on the protein intake of the subjects (P=0.004).

In contrast to calorie intake, the major contributor of the mean protein reduction was observed in the healthy subjects and the patients with HTN and DM together compared to the other groups. The mean carbohydrate intake was also significant among the four groups (P=0.019), and age influenced the effect as a covariate (P=0.002). The mean consumption increased in Ramadan and decreased in Shawwal in the four groups, and the mean intake levels increased by

approximately 40 points in V2 without significance.

Table 3. Descriptive statistics of consumption of calories, protein, carbohydrate, fat, cholesterol and sodium per day in the month pf Shaban, Ramadan and Shawwal

Items	Shaban	Ramadan	Shawwal	Mean	p-value[1]
Calories					
Healthy	1414±517 (21.5)4	1496±610 (23.3)	1408±489 (21.3)	1439±538	0.099
Hypertensive (HTS)	1421±513 (19.7)	1626±702 (23.0)	1497±584 (20.7)	1515±606	(group)
Diabetes (DM)	1276±444 (19.4)	1524±650 (23.4)	1246±445 (19.0)	1349±531	0.019
HTN + DM	1316±476 (18.6)	1417±528 (20.4)	1328±365 (18.9)	1355±460	(age)
Mean (Effect of visits)[2]	1361[a]±490 (19.8)	1516[a]±623 (22.4)	1377[a]±484(20.1)	1418±540	
P-value for the combined effect of visits and groups.[3]	0.659 (V1 x V2)	0.375 (V1 x V3)	0.390 (V2 x V3)		
Protein					
Healthy	72.3[a]±56.6 (1.1)	53.3[b]±25.7 (0.8)	63.6[a]±26.7 (1.0)	63.1±39.5	
Hypertensive (HTS)	57.9[a]±22.7(0.8)	62.9[a]±49.9 (0.9)	65.0[a]±27.4 (0.9)	61.9±35.2	0.204
Diabetes (DM)	59.2[a]±21.1(0.9)	56.4[a]±19.8 (0.9)	58.3[a]±23.9 (0.9)	58.0±21.5	(group)
HTN + DM	71.3[a]±55.2 (1.0)	52.1[b]±24.0 (0.8)	60.3[a]±24.0 (0.9)	61.3±37.9	0.004
Mean (Effect of visits)[2]	65.4[a]±43.3 (0.9)	56.2[a]±32.8 (0.8)	62.0[a]±25.5(0.9)	61.2±34.8	(age)
P-value for the combined effect of visits and groups.[3]	0.061 (V1 x V2)	0.245 (V1 x V3)	0.573 (V2xV3)		
Carbohydrate					
Healthy	201.0±125 (3.0)	224.1±122 (3.5)	193.3±96.1(2.9)	206.2±115.3	
Hypertensive (HTS)	195.4±74.5 (2.7)	259.3±200 (3.7)	191.6±94.7(2.7)	215.4±137.3	0.019
Diabetes (DM)	167.2±75.5 (2.5)	221.4±94.8 (3.4)	160±62.3 (2.4)	182.9±82.6	(group)
HTN + DM	176.5±73.5 (2.5)	194.9±71.4 (2.8)	181.9±75.6(2.6)	184.4±73.3	0.002
Mean (Effect of visits)[2]	186.0[a]±91 (2.7)	225.4[a]±134(3.3)	183[a]±84.6(2.7)	198.1[a]±107.3	(age)
P-value for the combined effect of visits and groups.[3]	0.352 (V1 x V2)	0.944 (V1 x V3)	0.207 (V2 x V3)		
Fat					
Healthy	56.5±57.6 (0.8)	41.8±20.9 (0.7)	71.5±164.9 (0.7)	56.6±101.4	0.209
Hypertensive (HTS)	74.6±126.1(1.0)	61.0±81.7 (0.9)	68.6±78.3 (0.9)	68.1±97.2	(group)
Diabetes (DM)	45.2±17.6 (0.7)	52.1 ±41.5 (0.8)	44.4±17.8 (0.7)	47.2±27.9	0.506
HTN + DM	68.8±167.6 (0.6)	40.5±17.7(o,6)	50.7±24.4 (0.7)	44.7±20	(age)
Mean (Effect of visits)[2]	62.3[a]±112 (9.8)	48.8[a]±48.9 (0.7)	48.9[a]±94.2 (0.8)	54.6±74.4	
P-value for the combined effect of visits and groups.	0.292 (V1 x V2)	0.892 (V1 x V3)	0.275 (V2 x V3)		
Cholesterol					
Healthy	201.5±125 (3.0)	153.7±170 (2.3)	220.6±203 (3.2)	191.9±170.4	0.537
Hypertensive (HTS)	167.6±117 (2.3)	143.3±145 (2.0)	189±111 (2.6)	166.7±126	(group)
Diabetes (DM)	180.5±135 (2.7)	132.1±95 (2.1)	191.7±130 (2.9)	168.1±123.3	0.618
HTN + DM	186.8±121 (2.6)	118.5±113 (1.7)	207.7±124 (3.0)	171±124.9	(age)
Mean (Effect of visits)	184.1[a]±124(2.7)	137.1[b]±135(2.0)	202.7[a]±146(2.9)	174.6±138	
P-value for the combined effect of visits and groups.[3]	0.420 (V1 x V2)	0.984 (V1 x V3)	0.411 (V2 x V3)		
Sodium					
Healthy	2033±760 (30.9)	2265±1234(34.9	1997±585 (30.7)	2098±903.1	0.080
Hypertensive (HTS)	2013±689(27 .9)	2194±878 (31.2)	2177±1025(29.5	2128.3±872.4	(group)
Diabetes (DM)	1881±760 (28,9)	2259±927 (34.7)	1930±722 (29.5)	2023.6±817.9	0.128
HTN + DM	1819±634 (25.9)	1982±705 (28.6)	1942±615 (27.8)	1915±651.1	(age)
Mean (Effect of visits)[2]	1940[a]±708 (28.3)	2170[a]±952 (32.2)	2017[a]±761 (29.3)	2024.6±818.5	
P-value for the combined effect of visits and groups.[3]	0.823 (V1 x V2)	0.917 (V1 x V3)	0.754 (V2 x V3)		

*Different alphabets indicate statistical significance.

1 This column shows the significance level (p-value) due the effect of group and age as a covariate.

2. This row give the mean value and significant differences due to the visits

3. This row contains the significance level (p-value) due the combined effect of visits and groups.

4. Values in the parenthesis are the macronutrient adjust by the weight.

According to the obtained results, fat intake was significantly higher in the HTN patients, while the means of the study groups had no significance in this regard due to the high standard deviations (P=0.209). The mean cholesterol intake of the healthy subjects was significantly higher than the other groups, while it could not reach a significant level due to the high standard deviation. The mean sodium intake was also insignificant in the four groups (P=0.080). Surprisingly, the mean sodium intake was higher in the hypertensive patients compared to the diabetic patients, and the consumption increased significantly by more than 10% in V2 (P<0.05). However, it decreased significantly in the Shawwal visit (V3) (P<0.05). Notably, the visits and groups had no significant effect between any of the visits.

Discussion

As mentioned earlier, no study has been found regarding the simultaneous comparison of the effect of Ramadan fasting on diabetic patients, hypertensive patients, and healthy subjects. Therefore, the present four-arm study was conducted with this objective. The study groups included healthy subjects, only hypertensive patients, only diabetic patients, and both diabetic and hypertensive patients. The patients were selected via convenience sampling for the ease of data collection in 2020, corresponding to 1441 Hijri.

The mean age of the healthy subjects was lowest and significantly different from the patient groups. With increasing age, the risk of diabetes or hypertension also increases (20, 21), therefore, the significantly lower age of the healthy subjects was considered normal. To compensate, age was also added as a covariate to the analysis in the current research. Our findings indicated no significant differences in the mean height, weight, and BMI between the four study groups in V1. Therefore, the initial values weight and BMI had no effects on the changes of the subjects due to other possible co-factors.

Although the difference in the mean BMI from V1 to V2 was only 0.7 kg/m^2 and clinically quite insignificant, the results of the repeated measures ANOVA indicated a statistical significance in this regard. Furthermore, the mean weight and BMI of the subjects decreased in V2. This is consistent with the previous findings regarding the reduction of body weight and BMI from V1 to V2 (2, 5, 6, 10, 11, 14, 16). However, the reduced weight and BMI in Ramadan reversed in Shawwal in our study (V3). This is in line with the results obtained by Jehangir et al. (6). This study demonstrated that BMI decreased significantly in V2 in three patient groups (except the healthy group), while it increased significantly afterwards only in the patients with HTN and DM in the present study. Therefore, it could be concluded that the patients with both HTN and DM were more careful in controlling their diet and experienced more weight loss and BMI reduction compared to the other groups.

As expected, the hypertensive patients (with or without DM) had a higher mean SBP and DBP compared to the other two groups. With the exception of the DM patients, the mean SBP of the other groups reduced in V2, and statistical significance was only observed in the HTN patients in this regard. The significant reduction of SBP and DBP in the HTN patients in V2 is consistent with previous studies (5, 9, 10), and the insignificant change in V3 is in line with the study by Aslan et al. (11).

As expected, the mean FBS was significantly higher in the DM patients (with and without HTN). In contrast to the SBP and DBP, FBS reduced from V1 to V2 in all the groups, except the DM patients, and only the HTN patients showed a significant reduction in this regard. These findings are consistent with the results obtained by Khan (2), Khan (3), Tiboura (4), Khan (8), and Darzabi (16).

In the current research, a significant difference was denoted in the total sleeping hours of the subjects from V1 to V2. However, an individual group analysis indicated that only the sleeping hours of the healthy subjects and DM patients decreased significantly due to Ramadan activities. In a similar study, BaHammam (23) and Roky (24) also reported that the sleeping hours of healthy fasting subjects reduced in Ramadan. Furthermore, Alghamdi (25) stated that the total sleeping hours reduced during Ramadan in DM patients. In the present study, daytime nap significantly increased during Ramadan to compensate for reduced night's sleep, which is in line with the findings of Alghamdi (25).

In the present study, physical activity assessment based on the MET value showed that physical exercise and other strenuous physical activities

significantly decreased in the fasting subjects to avoid hunger or thirst while fasting. The least significant reduction in this regard was observed in the healthy subjects since ill individuals are often more careful and believe that physical exercise will make it difficult to complete the number of their fasting days. This is consistent with the studies conducted by Khan (3), Khan (8), and Prastya (14). On the other hand, Harder-Lauridsen (18) and Alghamdi (25) reported no significant reduction in physical exercises, while strenuous physical activities showed a downward trend in the mentioned studies.

To the best of our knowledge, Tarawih as a physical activity in numerical terms has not been discussed in the literature. In addition, the MET value of the Islamic congregation prayers has not been listed in the "2011 Compendium of Physical Activities: a second update of codes and MET values". This institution assigned the MET value of more than 800 physical activities. After discussing with the institution, we decided that the MET value of Tarawih prayers should be 1.5. According to our findings, physical activities would increase significantly in Ramadan if Tarawih prayers were included in the calculations. In the Muslim community, it is rather customary for individuals to attend Tarawih prayers even if they do not adhere to obligatory prayers regularly. Tarawih prayers takes more than one hour and is often performed with enthusiasm. As a result, it significantly increases the mean MET value of physical activity in Ramadan. The MET value has been reported to reach more than 600 points, which is the cutoff point for an active individual (8).

According to the results of the present study, calorie intake increased during Ramadan and reversed to almost the same level in Shawwal. Although the frequency of meals decreases for most fasting individuals during Ramadan, high-calorie diets are also common for *Sahur* and *Iftar* meals most of the time, which increase the total consumed calories in Ramadan. This trend of changes is in line with the findings of Zaroouk et al. (22) and inconsistent with the results obtained by Prasetya and Sapwarobol (14). However, most of the studies in this regard have not shown any significant change in calorie intake (5, 18, 22). In the current research, the trend of calorie intake during the three-month period was the same in all the groups. Therefore, it could be inferred that although diabetic patients avoid sweets and hypertensive patients avoid salts, energy intake in the form of calories followed the same trend in all the three months. Due to the significant age effect, the increase of approximately 150 points in calorie intake had no significant difference.

According to the current research, the mean protein intake reduced by more than nine points in Ramadan and reversed to almost the same amount as that of Shaban in Shawwal. The healthy subjects and the patients with both HTN and DM consumed significantly less quantities of protein in Ramadan compared to Shaban. In the study by Sadiya (7), the participants had metabolic syndrome, and a significant reduction was reported in protein intake from Shaban to Ramadan. Furthermore, studies on healthy subjects have shown the reduction of protein intake during Ramadan.

According to the results of the present study, carbohydrate intake reduced significantly in Ramadan and reversed to almost the same amount as Shaban in Shawwal in the four groups. This is inconsistent with the earlier findings in this regard (5, 7, 14, 17, 22). Similarly, fat intake was observed to decrease insignificantly in Ramadan. However, the mean value in Shawwal remained almost the same as that of Ramadan. Most of the studies in this regard (22) have reported no significant change in fat intake during the study period. However, Sadiya et al. (7) observed a significant increase in fat intake in the last week of Ramadan compared to the first week of the month in patients with metabolic syndrome. In the present study, the mean cholesterol intake in Ramadan was significantly lower compared to that of Shaban.

Dietary habits are diverse in different cultures and countries (9). Therefore, the similar trend of decrease or increase in any particular dietary component is not necessarily comparable. Since dietary habits were self-reported only for the last two days of the visits in our study, they may have differed from the regular food items consumed by the participants. Furthermore, recall bias might have affected the results. In addition, each community of Pakistan prepares its *Iftar* and *Sahur* meals according to their ethical customs and ancestral traditions. As mentioned earlier, most of our participants were immigrants and follow their traditional and familial dietary habits for *Sehur* and *Iftar* meals. Therefore, our findings should be generalized with caution.

Conclusion

According to the results, Ramadan fasting could be able to control blood pressure and blood glucose levels. Furthermore, physical activity increased significantly due to Tarawih prayers. Carbohydrate, sodium, and calorie intake showed increasing trend, while protein and fat intake showed decreasing trend, FBS levels significantly decreased in the diabetic patients, while blood pressure significantly reduced in the hypertensive patients.

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