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ORIGINAL ARTICLE

Combined Effect of Ramadan Intermittent Fasting and COVID-19 Lockdown on Weight, Dietary and Lifestyle Patterns

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ABSTRACT

Background: Ramadan fasting as a pivotal Islamic practice can profoundly affect dietary habits, physical activity, and overall lifestyle. This study investigated the impact of Ramadan fasting during the COVID-19 lockdown on perceived weight changes and lifestyle modifications among Muslims globally. This study was undertaken to assess the influence of Ramadan fasting and lockdown restrictions on weight perception and lifestyle changes, including dietary patterns and physical activity levels, across a diverse multinational sample.

Methods: A cross-sectional multicenter observational study was conducted involving 21,657 adult Muslims from 20 countries during Ramadan 2020. Data were collected via a comprehensive electronic questionnaire covering dietary intake, physical activity, sleep patterns, and self-reported weight changes.

Results: The analysis indicated significant lifestyle and dietary adjustments during Ramadan under lockdown. Participants reported shifts towards healthier eating, with increased fruit, vegetable, and home-cooked meal consumption. However, challenges such as reduced physical activity and increased intake of fried and sugary foods were noted. Marital status, age, and a family history of obesity were significant determinants of weight changes.

Conclusion: Despite the pandemic's constraints, individuals adapted their lifestyles during Ramadan fasting, reflecting the resilience of dietary and physical activity behaviors. The study highlights the complex relationship between religious fasting, health, and pandemic-related lifestyle disruptions, emphasizing the need for context-specific nutritional and health guidance.

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Introduction

The observance of Ramadan, the ninth month of the Islamic calendar, entails fasting from dawn to sunset, a practice engaged in by about 1.5 billion Muslims worldwide. This religious mandate, one of the five pillars of Islam, necessitates complete abstinence from food, drink, and other physical needs during daylight hours (1). The significance of Ramadan extends beyond spiritual purification, influencing various aspects of daily life, including dietary habits and nutritional composition, physical activity, and lifestyle behaviors including sleep habits (2-4). As the Islamic calendar is lunar based, the timing of Ramadan shifts annually and thereby the fasting duration varies across different geographical locations and seasons. This variability presents a unique opportunity to study the impact of Ramadan intermittent fasting on human health and behavior in a naturalistic setting.

An emerging research underscored the multifaceted effects of Ramadan intermittent fasting (RIF) on health parameters, including metabolic changes, weight regulation, and psychological well-being (5). Notably, RIF has been associated with improvements in cardiovascular health, insulin sensitivity, liver functions, and lipid profiles, alongside modifications in body weight and composition (1, 6-10). However, the literature reveals a complex picture, with factors such as dietary quality, sleep patterns, and physical activity levels during Ramadan that significantly influence the outcomes (11).

The COVID-19 pandemic has led to unprecedented global health responses, including stringent social distancing measures, lockdowns, and quarantines. These interventions, aimed at curtailing the spread of the virus, could significantly influence the public health, alter the access to healthcare, modify the physical activity levels, and impact the dietary habits across populations. The variability in these impacts highlights the need to explore how such global health crises affect weight and lifestyle behaviors, especially during periods of restrictive living conditions (12-15). The intersection of these pandemic-related restrictions with the observance of Ramadan, a period of intermittent fasting practiced by Muslims worldwide, presents a unique opportunity to examine lifestyle and weight changes. Ramadan fasting traditionally encourages healthier eating habits, enhanced self-discipline, and a focus on spiritual growth, which could counteract the negative lifestyle changes that lockdowns induce. However, the comprehensive effects of combined pandemic restrictions and fasting during Ramadan on weight and lifestyle remain underexplored globally (16).

This multicentric study was undertaken to address this gap by investigating the influence of Ramadan fasting alongside pandemic-induced lockdowns on perceived weight and lifestyle changes. It aimed to provide a global perspective by analyzing data from multiple countries, offering insights into how these dual factors influence health behaviors and weight management. The research identified the preventive and contributory factors to weight change and informing public health strategies for managing health and lifestyle during concurrent religious observance and global health crises.

Materials and Methods

In a cross-sectional observational framework investigation scrutinized the effects of RIF on lifestyle and dietary modifications among adults Muslims during the COVID-19 outbreak. A detailed methodological description was discussed before (17), and the data collection period spanned from May 10, 2021 (27th Ramadan, 1442 Hijri) to June 10, 2021 (29th Shawwal, 1442 Hijri). Eligible participants were adult Muslims (≥18 years) practicing RIF in twenty countries. Exclusion criteria included a history of mental health issues and adherence to specific diets. A UAE-based research team initiated this study, employing snowball sampling for participant recruitment. Collaborators in various other regions disseminated the survey through digital platforms like email, WhatsApp, and Facebook. This strategy facilitated extensive questionnaire distribution, even amidst pandemic-related restrictions. Utilizing G*Power for one-tailed Student's t-tests and bivariate correlation, the study determined a sample size of 207 from each country based on an anticipated effect size of 0.2, alpha error of 0.05, and a power of 0.90 (18).

Conforming to the Declaration of Helsinki's ethical standards (19), ethical clearance was obtained from the Social Sciences Research Ethics Committee of the United Arab Emirates University, UAE (Approval number ERS 2021-7308) and Tehran University of Medical Sciences, Tehran, Iran (Approval number IR.TUMS.FNM.REC.1400.022). Participants gave informed consent, with no financial or non-financial incentives for participation. A comprehensive electronic questionnaire in eleven languages assessed demographics, dietary intake, eating habits, sleep, physical activity, computer use, and smoking during RIF. The translation adhered to established guidelines for accuracy and cultural relevance, including forward and backward translations and pilot testing with 30 participants (20).

Standardization of similar responses, exclusion of incomplete or non-fasting responses, and body mass index (BMI) calculation using World Health Organization (WHO) norms were part of data quality assurance. Abnormal or underage responses were also excluded. The questionnaire captured sociodemographic data, eating behavior, dietary diversity, weight changes, and health status before and during Ramadan. The collected sociodemographic information encompassed gender and age (in years), country of residence, nationality, region, marital status (single, married, divorced, or widow), residence area (city, town, or village), household income, living conditions (alone, with friends, or with family), educational level, the number of fasting days experienced, occupational status (employed or unemployed), work sector (private or government), father's and mother's level of education, total household income, classification of household income, living status before and during the month of Ramadan (alone or with family), personal and family history of obesity, diabetes, hypertension, cardiovascular diseases, and number of days of fasting during Ramadan.

Information regarding participants' dietary habits and modified eating practices since fasting, including quality, quantity, types of products, and mealtime schedules, was obtained through questionnaires. The section on dietary diversity specifically probed adjustments made to common food groups, encompassing vegetables, fruits, cereals and grains, oils and fats, milk and milk products, pulses, dates, fish and seafood, low-fat meat (chicken and turkey), sugar, salty snacks, fried foods, carbonated or sugary drinks, energy drinks, hot beverages, pastries, homemade foods, traditional foods, and fast foods (21, 22). The frequency of ordering fast food and eating out before and during Ramadan was captured through a modified short food frequency questionnaire, tailored to align with prevalent dietary patterns in the country (22). Similarly, eating behaviors before and during the fasting month of Ramadan were assessed by asking participants about the daily quantity of water consumed, snacking habits, intake of large food quantities, and eating despite a lack of hunger (23).

Participants were requested to provide self-reported data on their current body weights (in kilograms) and heights (in centimeters), which were subsequently utilized to calculate their BMI (kg/m^2) during the analysis. The BMI values were then categorized into four groups of underweight (<18.5),

Table 1: Demographic characteristics of the study population.

Variable	Male	Female	Total
Sex	8175	13482	21657
Age (Years)			
18-32	6,266	11,013	17,279
33-47	1,333	1,903	3,236
48-62	486	521	1,007
63 or older	90	45	135
Marital status			
Single	5,802	9,639	15,441
Married	2,264	3,547	5,811
Divorced/widow	109	296	405
Education			
Illiterate	2	3	5
less than primary	52	30	82
Primary	98	125	223
High school or secondary	1407	2373	3780
BSc undergraduate	5226	8988	14214
MSc	1091	1516	2607
PhD	297	444	741
Occupation			
Unemployed, do not work	266	1732	1,998
Student	4,585	8,115	12,700
Employed	3,169	3,493	6,662
Retired	155	142	297
Residence area			
City	5,397	9,558	14,955
Town	1,168	1,711	2,879
Village	1,610	2,213	3,823

normal (18.5-24.9), overweight (25.0-29.9), and obese (>30). Additionally, respondents were inquired about their perceived weight status during Ramadan, categorizing it as lost, maintained, or gained. They were also asked to self-perceive their current weight status as normal, underweight, overweight, or obese. Furthermore, participants indicated the amount of weight perceived to have been lost (-1 to -4.5 or more), maintained (0), or gained (+1 to +4.5 or more) during Ramadan. The respondents were also prompted to evaluate their health status before and during Ramadan using a Likert scale (Poor, Fair, Good, Very good, and Excellent). This Likert scale was later condensed into poor or sound during the analysis.

Results

In this research, there were a total of 21,657 participants from twenty countries. Of the total participants, 62.2% (n=13,482) were females and 3.78% (n=8,175) were males. The age range of the participants was 18 years and older. Based on marital status, 71.3% (n=15,441) of participants were single. The participants were from the countries of Afghanistan (8.2%), Algeria (2.68%), Bahrain (2.93%), Bangladesh (4.33%), Egypt (9.55%), Indonesia (3.65%), Iran (13%), Iraq (4.93%), Jordan (2.71%), Kuwait (0.05%), Libya (3.42%), Morocco (6.05%), Pakistan (8.33%), Palestine (7.57%), Qatar (1.74%), Saudi Arabia (1.71%), Syria (5.38%), Tunisia (2.28%), UAE (14.67%), and Yemen (3.73%) (Table 1).

Table 2 shows the prevalence of underweight, overweight, and obesity in the studied twenty countries of this research. The prevalence of underweight, overweight, and obesity in twenty countries was equal to 9%, 25%, and 13%, respectively. Among the studied countries, the lowest prevalence of underweight was related to Afghanistan (2%), and the highest was associated with Yemen (15%). The lowest prevalence of overweight was linked to Iran (2%) and Algeria (2%), and the highest prevalence of overweight was related to Egypt (35%). The lowest prevalence of obesity was associated with Iran, Algeria, Palestine, Tunisia, and Yemen, with 8% prevalence, and the highest prevalence of obesity was related to the country of Bahrain, with 29% prevalence. Figure 1 and Figure 2 show the prevalence of normal weight, underweight, overweight, and obesity among associated demographic factors studied in this research.

Our results depicted that people with a family history of obesity had a higher prevalence of obesity and were overweight. People who did not have any physical activity during Ramadan, the prevalence of underweight, overweight, and obese was higher among such people when compared to those who did some physical activity. Underweight prevalence was higher among females (10.80%) than males (5.30%). At the same time, the prevalence of overweight and obesity was higher in males. People who were married or divorced/widow had more prevalence of overweight and obese than singles.

Table 2: Prevalence of underweight, overweight, and obesity in various countries.

Variable	Underweight% (CI%)	Overweight% (CI%)	Obesity% (CI%)
Total (20 countries)	09 (08-09)	25 (24-25)	13 (13-14)
Afghanistan	02 (01-06)	20 (15-27)	11 (07-16)
Algeria	11 (09-14)	19 (16-23)	08 (06-10)
Bahrain	07 (05-10)	24 (20-27)	29 (25-33)
Bangladesh	10 (08-12)	21 (19-24)	15 (13-18)
Egypt	03 (02-04)	35 (33-37)	15 (14-17)
Indonesia	05 (04-07)	31 (28-34)	15 (12-17)
Iran	13 (12-14)	19 (18-21)	08 (07-09)
Iraq	08 (07-10)	28 (25-30)	11 (09-13)
Jordan	05 (04-07)	30 (26-34)	16 (13-19)
Kuwait	05 (02-10)	28 (20-37)	23 (16-31)
Libya	07 (06-09)	26 (23-29)	16 (14-19)
Morocco	09 (08-11)	23 (21-26)	10 (09-12)
Pakistan	12 (11-14)	25 (23-27)	18 (17-20)
Palestine	08 (07-10)	21 (19-23)	08 (07-10)
Qatar	04 (02-06)	34 (30-39)	22 (18-26)
Saudi Arabia	10 (08-14)	23 (19-28)	18 (15-23)
Syria	10 (09-12)	22 (19-24)	15 (13-17)
Tunisia	05 (04-08)	23 (20-27)	08 (06-11)
United Arab Emirates	07 (07-08)	26 (25-28)	13 (12-14)
Yemen	15 (13-17)	22 (19-25)	08 (06-10)

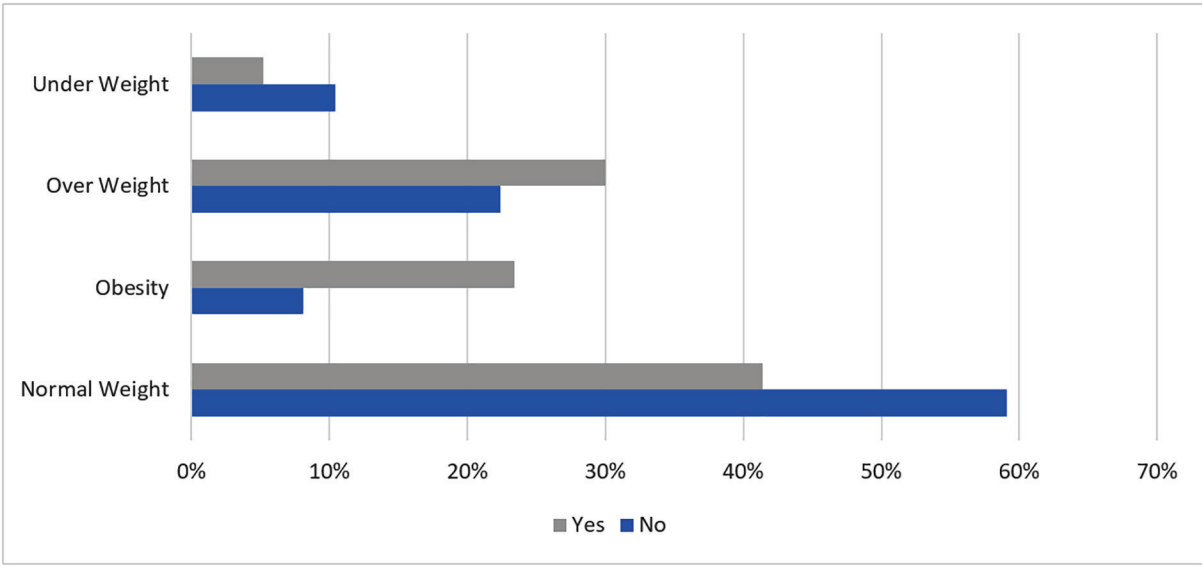

Figure 1: Family history of obesity and weight changes.

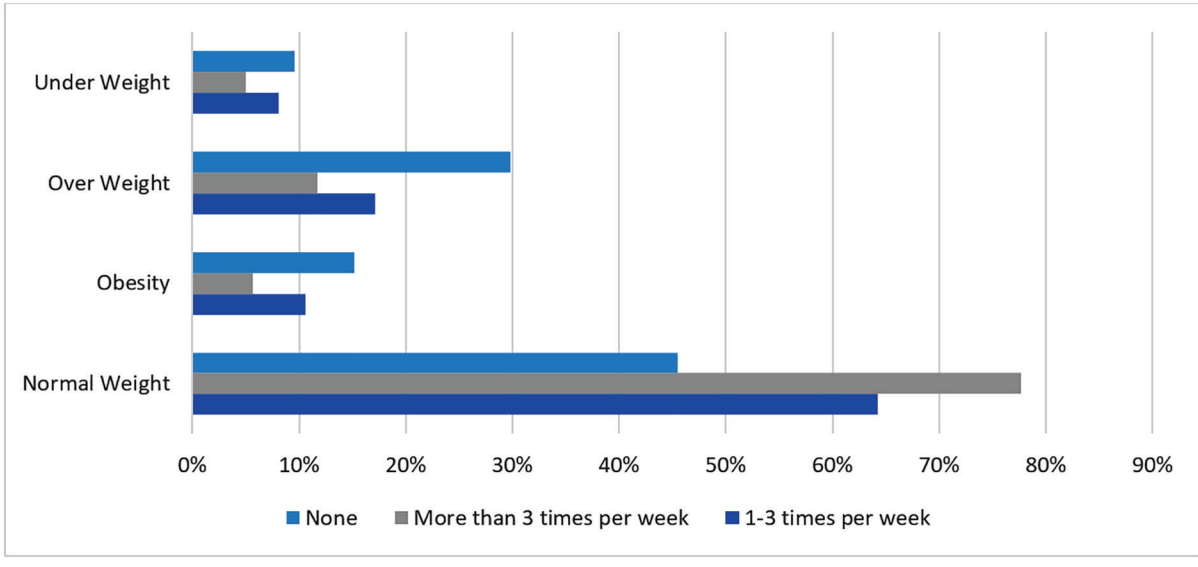

Figure 2: Physical activity and weight changes.

The ratio of overweight and obese was higher in illiterate and individuals with less than a high school education. People who reported excellent, good, or very good health status had a more normal prevalence than other weight groups. At the same time, the prevalence of underweight was high with poor health.

This study aimed to analyze the effect of food consumption behavior, family history of diseases, physical activity, and dietary patterns on BMI during Ramadan.

Table 3 shows the role of demographic variables, family and personal history of diseases, and lifestyle components, including nutrition quality, smoking, and physical activity in underweight, overweight, and obese subjects. Multinomial logit model results indicated that the most significant variables for increasing risk of being underweight were being male, having a personal history of hypertension, having poor health status, and having physical activity. The most influencing variables for increasing risk of overweight/obesity were marital status, personal history of tension, and poor diet quality.

Females had more relative risk of being underweight by 0.56 (p<0.01) than males. Age was also positively and significantly related to underwear. Still, this relationship was more robust, while obese people in the upper age bracket had more risk of being obese by 7.9 (p<0.05) than those who aged 18-32 years. A family history of obesity, diabetes, and high blood pressure was negatively related to weight level. Similarly, the personal history of obese was strongly and negatively associated with underweight as it lowered the relative risk of underweight by 0.43 (p<0.01); but the risk of being overweight and obese decreased by only 0.07 and 0.02, respectively, and then those who had no personal history of obesity.

Table 3: Analysis of factors associated with underweight, overweight and obesity cases.

Variable	Relative risk ratio	Standard error	Z value	95% Confidence interval	
Normal weight	Base outcome				
Sex					
Male	Reference group				
Female	0.5430	0.0340	0.0000	0.4800	0.6140
Age (Years)					
18-32	Reference group				
33-47	4.0030	0.7360	0.0000	2.7910	5.7400
48-62	4.1310	1.5210	0.0000	2.0080	8.5000
63 or older	4.8390	4.9130	0.1210	0.6610	35.4060
Marital status					
Single	Reference group				
Married	1.9540	0.1850	0.0000	1.6230	2.3530
Divorced	3.9820	1.8400	0.0030	1.6100	9.8470
Obesity family history					
Yes	Reference group				
No	0.7950	0.0540	0.0010	0.6950	0.9080
High blood pressure family history					
Yes	Reference group				
No	0.8960	0.0510	0.0550	0.8010	1.0030
Diabetes mellitus family history					
Yes	Reference group				
No	0.8620	0.0490	0.0090	0.7710	0.9630
Obesity personal history					
Yes	Reference group				
No	0.4240	0.0510	0.0000	0.3350	0.5360
Diabetes mellitus personal history					
Yes	Reference group				
No	0.9070	0.1180	0.4520	0.7030	1.1700
High blood pressure personal history					
Yes	Reference group				
No	1.3090	0.1430	0.0140	1.0570	1.6220
Health status					
Excellent	Reference group				
Very good	0.9680	0.0670	0.6340	0.8460	1.1080
Good	0.8890	0.0650	0.1080	0.7690	1.0260
Fair	0.6320	0.0600	0.0000	0.5250	0.7600
Poor	0.5220	0.0860	0.0000	0.3770	0.7220
Smoking habits					
Non-smoker	Reference group				
Smoker	0.8930	0.1000	0.3120	0.7160	1.1130
Self-described diet quality during Ramadan					
Excellent	Reference group				
Very good	1.2050	0.1080	0.0370	1.0110	1.4380
Good	1.0470	0.0930	0.6020	0.8810	1.2450
Fair	0.8610	0.0830	0.1190	0.7130	1.0390
Poor	0.8370	0.1100	0.1780	0.6460	1.0840
Physical activity					
None	Reference group				
1-3 times per week	1.1790	0.0710	0.0060	1.0470	1.3260
More than three times a week	1.5680	0.1710	0.0000	1.2660	1.9410
Constant	20.7280	3.8980	0.0000	14.3370	29.9660
Overweight					
Sex					
Male	Reference group				

Female	0.2920	0.0200	0.0000	0.2550	0.3350
Age (Years)					
18-32	Reference group				
33-47	8.1660	1.5250	0.0000	5.6620	11.7760
48-62	9.4210	3.4860	0.0000	4.5610	19.4570
63 or more	7.9400	8.0980	0.0420	1.0760	58.6000
Marital status					
Single	Reference group				
Married	3.5680	0.3590	0.0000	2.9290	4.3470
Divorced	5.8170	2.7290	0.0000	2.3190	14.5910
Obesity family history					
Yes	Reference group				
No	0.6740	0.0510	0.0000	0.5820	0.7810
High blood pressure family history					
Yes	Reference group				
No	0.8670	0.0560	0.0280	0.7640	0.9850
Diabetes mellitus family history					
Yes	Reference group				
No	0.8160	0.0530	0.0020	0.7190	0.9260
Obesity personal history					
Yes	Reference group				
No	0.0760	0.0090	0.0000	0.0600	0.0960
Diabetes mellitus personal history					
Yes	Reference group				
No	1.1170	0.1580	0.4340	0.8470	1.4740
High blood pressure personal history					
Yes	Reference group				
No	1.3870	0.1660	0.0060	1.0980	1.7530
Health status					
Excellent	Reference group				
Very good	0.8640	0.0670	0.0590	0.7430	1.0050
Good	0.7910	0.0650	0.0050	0.6730	0.9300
Fair	0.5540	0.0600	0.0000	0.4480	0.6860
Poor	0.3250	0.0670	0.0000	0.2170	0.4860
Smoking					
Non-smoker	Reference group				
Smoker	0.8260	0.1000	0.1130	0.6520	1.0470
Self-described diet quality during Ramadan					
Excellent	Reference group				
Very good	1.0580	0.1060	0.5700	0.8700	1.2870
Good	0.9480	0.0940	0.5910	0.7810	1.1510
Fair	1.0130	0.1090	0.9080	0.8190	1.2510
Poor	1.1370	0.1690	0.3880	0.8490	1.5230
Physical activity					
None	Reference group				
1-3 times per week	1.1640	0.0790	0.0250	1.0190	1.3300
More than three times a week	1.9240	0.2260	0.0000	1.5280	2.4230
Constant	39.0200	7.7420	0.0000	26.4490	57.5680
Obesity					
Sex					
Male	Reference group				
Female	0.2680	0.0210	0.0000	0.2300	0.3130
Age (Years)					
18-32	Reference group				
33-47	10.2970	1.9920	0.0000	7.0470	15.0450
48-62	13.6130	5.1160	0.0000	6.5170	28.4360

63 or older	7.7080	7.9810	0.0490	1.0130	58.6500
Marital status					
Single	Reference group				
Married	4.4880	0.4990	0.0000	3.6090	5.5810
Divorced	6.1180	2.9470	0.0000	2.3800	15.7250
Obesity family history					
Yes	Reference group				
No	0.5220	0.0440	0.0000	0.4420	0.6160
High blood pressure family history					
Yes	Reference group				
No	0.9750	0.0740	0.7350	0.8410	1.1300
Diabetes mellitus family history					
Yes	Reference group				
No	0.6930	0.0520	0.0000	0.5980	0.8030
Obesity personal history					
Yes	Reference group				
No	0.0250	0.0030	0.0000	0.0190	0.0320
Diabetes mellitus personal history					
Yes	Reference group				
No	1.3360	0.2030	0.0560	0.9920	1.7990
High blood pressure personal history					
Yes	Reference group				
No	1.2070	0.1560	0.1440	0.9380	1.5550
Health status					
Excellent	Reference group				
very good	0.7920	0.0710	0.0090	0.6650	0.9430
Good	0.7580	0.0730	0.0040	0.6280	0.9150
Fair	0.5700	0.0720	0.0000	0.4460	0.7300
Poor	0.3220	0.0760	0.0000	0.2030	0.5130
Smoking status					
Non-smoker	Reference group				
Smoker	0.9290	0.1240	0.5820	0.7160	1.2060
Self-described diet quality during Ramadan					
Excellent	Reference group				
Very good	0.8820	0.1000	0.2680	0.7060	1.1020
Good	0.7510	0.0850	0.0110	0.6010	0.9370
Fair	0.8870	0.1100	0.3320	0.6960	1.1300
Poor	1.1290	0.1890	0.4710	0.8120	1.5680
Physical activity					
None	Reference group				
1-3 times per week	1.0360	0.0820	0.6570	0.8870	1.2090
More than three times a week	1.3280	0.1790	0.0350	1.0200	1.7290
Constant	43.7410	9.1490	0.0000	29.0290	65.9070
Pseudo R-squared	0.1500	Number of obs	21657	-	-
Chi-square	7515.32	Prob>Chi^2	0	-	-

Personal history of hypertension was positively associated with the risk of being underweight by 1.30 (p<0.05) and overweight by 1.41 (p<0.01), but its relationship with obesity was not statistically significant. Good health status significantly reduced the relative risk of being overweight and obese by 0.86 (p<0.05) and 0.78 (p<0.01) when compared to those with excellent health status. Similarly, physical activity was negatively and significantly related to overweight and obesity. For people who continued physical activity during Ramadan, their risk of being overweight decreased by 0.60-0.65 (p<0.01) than those who did not perform any physical activity; while the risk of being obese decreased by 0.60-0.80 (p<0.01). Finally, smoking and personal history of diabetes were not significantly related to weight.

Table 4 presents factors like modified consumption of fruits, vegetables, fried food, oil fats, milk and tea, pulses, meat, snacks, dates, etc.

Table 4: Analysis of diet factors in relation to underweight, overweight, and obese cases during Ramadan.

Variable	Relative risk ratio	Standard error	*P* value	95% Confidence interval	
Normal weight: Base outcome					
Underweight					
Fruits modified					
Do not consume	Reference group				
Remain as usual	1.6860	0.1560	0.0000	1.4060	2.0210
Decreased	0.8810	0.0590	0.0570	0.7730	1.0040
Increased	1.1070	0.0680	0.0960	0.9820	1.2490
Fried food modified					
Do not consume	Reference group				
Remain as usual	0.7590	0.0740	0.0050	0.6270	0.9180
Decreased	2.0830	0.1400	0.0000	1.8270	2.3760
Increased	1.2390	0.0790	0.0010	1.0940	1.4030
Vegetables modified					
Do not consume	Reference group				
Remain as usual	0.4290	0.0500	0.0000	0.3410	0.5390
Decreased	0.8700	0.0560	0.0300	0.7660	0.9870
Increased	0.5010	0.0300	0.0000	0.4460	0.5640
Cereal food modified					
Do not consume	Reference group				
Remain as usual	1.0090	0.1060	0.9350	0.8200	1.2400
Decreased	0.7050	0.0500	0.0000	0.6130	0.8100
Increased	0.6730	0.0370	0.0000	0.6040	0.7490
Oil fat modified					
Do not consume	Reference group				
Remain as usual	0.8550	0.1090	0.2200	0.6670	1.0980
Decreased	0.8800	0.0650	0.0810	0.7620	1.0160
Increased	1.1010	0.0660	0.1050	0.9800	1.2380
Milk modified					
Do not consume	Reference group				
Remain as usual	1.3550	0.1090	0.0000	1.1580	1.5850
Decreased	1.2860	0.0860	0.0000	1.1280	1.4660
Increased	1.0530	0.0630	0.3830	0.9370	1.1830
Pulses modified					
Do not consume	Reference group				
Remain as usual	0.7520	0.0600	0.0000	0.6440	0.8790
Decreased	0.6900	0.0590	0.0000	0.5840	0.8160
Increased	0.9390	0.0520	0.2570	0.8410	1.0470
Dates modified					
Do not consume	Reference group				
Remain as usual	0.7790	0.0800	0.0150	0.6370	0.9530
Decreased	0.7130	0.0560	0.0000	0.6120	0.8310
Increased	1.2690	0.1050	0.0040	1.0790	1.4940
Chicken modified					
Do not consume	Reference group				
Remain as usual	0.8940	0.0570	0.0770	0.7900	1.0120
Decreased	0.7750	0.0640	0.0020	0.6590	0.9120
Increased	0.8660	0.0510	0.0140	0.7720	0.9710
Sugar modified					
Do not consume	Reference group				
Remain as usual	1.0600	0.0900	0.4910	0.8980	1.2510
Decreased	0.7630	0.0540	0.0000	0.6650	0.8760
Increased	0.7320	0.0430	0.0000	0.6520	0.8220
Meat modified					
Do not consume	Reference group				
Remain as usual	1.0170	0.0870	0.8440	0.8600	1.2020

Decreased	1.4080	0.1030	0.0000	1.2200	1.6240
Increased	1.1640	0.0760	0.0200	1.0250	1.3210
Salty snacks modified					
Do not consume	Reference group				
Remain as usual	1.1090	0.0700	0.0980	0.9810	1.2540
Decreased	1.0310	0.0770	0.6860	0.8910	1.1920
Increased	0.7970	0.0480	0.0000	0.7090	0.8970
Tea-coffee modified					
Do not consume	Reference group				
Remain as usual	1.4430	0.1050	0.0000	1.2510	1.6640
Decreased	1.1340	0.0870	0.0990	0.9770	1.3170
Increased	1.3760	0.1150	0.0000	1.1680	1.6210
Homemade food modified					
Do not consume	Reference group				
Remain as usual	0.6320	0.0910	0.0010	0.4760	0.8380
Decreased	1.1050	0.0870	0.2030	0.9470	1.2900
Increased	0.7520	0.0580	0.0000	0.6470	0.8760
Delivery items modified					
Never or rare	Reference group				
1-2 times per week	1.1820	0.0980	0.0440	1.0050	1.3910
2-3 times per week	1.1070	0.0650	0.0820	0.9870	1.2410
3-4 times per week	1.2060	0.1550	0.1460	0.9370	1.5510
everyday	1.4670	0.2170	0.0100	1.0980	1.9620
Constant	0.3860	0.0460	0.0000	0.3060	0.4880
Overweight					
Fruits modified					
Do not consume	Reference group				
Remain as usual	1.3670	0.1090	0.0000	1.1690	1.5990
Decreased	0.7330	0.0390	0.0000	0.6600	0.8140
Increased	0.8790	0.0430	0.0080	0.7990	0.9670
Fried food modified					
Do not consume	Reference group				
Remain as usual	0.8700	0.0650	0.0610	0.7520	1.0060
Decreased	1.7880	0.0970	0.0000	1.6060	1.9890
Increased	1.2870	0.0640	0.0000	1.1670	1.4190
Vegetables modified					
Do not consume	Reference group				
Remain as usual	0.7950	0.0840	0.0300	0.6470	0.9780
Decreased	2.2500	0.1380	0.0000	1.9960	2.5370
Increased	1.9240	0.1080	0.0000	1.7230	2.1490
Cereal food modified					
Do not consume	Reference group				
Remain as usual	0.7140	0.0630	0.0000	0.6000	0.8490
Decreased	0.3910	0.0230	0.0000	0.3480	0.4390
Increased	0.4870	0.0210	0.0000	0.4470	0.5300
Oil fat modified					
Do not consume	Reference group				
Remain as usual	1.2910	0.1260	0.0090	1.0660	1.5640
Decreased	1.5220	0.0890	0.0000	1.3580	1.7050
Increased	1.0710	0.0520	0.1560	0.9740	1.1790
Milk modified					
Do not consume	Reference group				
Remain as usual	1.4500	0.0980	0.0000	1.2700	1.6550
Decreased	1.3800	0.0770	0.0000	1.2370	1.5390
Increased	1.4770	0.0710	0.0000	1.3440	1.6220
Pulses modified					
Do not consume	Reference group				

Remain as usual	0.7670	0.0510	0.0000	0.6740	0.8740
Decreased	0.7470	0.0510	0.0000	0.6540	0.8540
Increased	1.0150	0.0460	0.7490	0.9280	1.1090
Dates modified					
Do not consume	Reference group				
Remain as usual	1.0710	0.0940	0.4330	0.9020	1.2730
Decreased	1.3400	0.0910	0.0000	1.1720	1.5310
Increased	1.0810	0.0800	0.2920	0.9350	1.2510
Chicken modified					
Do not consume	Reference group				
Remain as usual	0.8840	0.0460	0.0180	0.7970	0.9790
Decreased	0.8040	0.0530	0.0010	0.7060	0.9160
Increased	0.9780	0.0450	0.6260	0.8930	1.0710
Sugar modified					
Do not consume	Reference group				
Remain as usual	1.0340	0.0720	0.6300	0.9020	1.1850
Decreased	0.7420	0.0430	0.0000	0.6620	0.8310
Increased	0.8180	0.0390	0.0000	0.7450	0.8970
Meat modified					
Do not consume	Reference group				
Remain as usual	0.7830	0.0560	0.0010	0.6810	0.9000
Decreased	1.4060	0.0820	0.0000	1.2540	1.5770
Increased	1.0210	0.0530	0.6870	0.9220	1.1300
Salty snacks modified					
Do not consume	Reference group				
Remain as usual	1.0380	0.0530	0.4670	0.9390	1.1470
Decreased	1.1290	0.0690	0.0470	1.0020	1.2720
Increased	0.8610	0.0410	0.0020	0.7850	0.9450
Tea-coffee modified					
Do not consume	Reference group				
Remain as usual	1.4010	0.0820	0.0000	1.2490	1.5720
Decreased	1.1440	0.0700	0.0280	1.0150	1.2890
Increased	1.4050	0.0950	0.0000	1.2300	1.6050
Homemade food modified					
Do not consume	Reference group				
Remain as usual	0.5040	0.0530	0.0000	0.4100	0.6200
Decreased	0.3510	0.0200	0.0000	0.3130	0.3930
Increased	0.3850	0.0210	0.0000	0.3460	0.4290
Delivery items modified					
Never or rare	Reference group				
1-2 times per week	1.1880	0.0790	0.0100	1.0430	1.3530
2-3 times per week	1.1170	0.0520	0.0170	1.0200	1.2230
3-4 times per week	0.9690	0.1070	0.7790	0.7810	1.2040
everyday	1.0500	0.1410	0.7130	0.8080	1.3660
Constant	0.4740	0.0480	0.0000	0.3890	0.5770
Obesity					
Fruits modified					
Do not consume	Reference group				
Remain as usual	1.1580	0.1610	0.2930	0.8810	1.5200
Decreased	2.3050	0.2020	0.0000	1.9410	2.7380
Increased	2.5120	0.2050	0.0000	2.1410	2.9490
Fried food modified					
Do not consume	Reference group				
Remain as usual	1.3090	0.1330	0.0080	1.0730	1.5970
Decreased	0.8660	0.0750	0.0970	0.7320	1.0260
Increased	1.4460	0.1040	0.0000	1.2550	1.6640
Vegetables modified					

Do not consume	Reference group				
Remain as usual	1.2170	0.1490	0.1090	0.9570	1.5470
Decreased	0.7270	0.0620	0.0000	0.6140	0.8600
Increased	0.7820	0.0590	0.0010	0.6740	0.9060
Cereal food modified					
Do not consume	Reference group				
Remain as usual	0.8460	0.1140	0.2160	0.6490	1.1030
Decreased	1.2810	0.1040	0.0020	1.0930	1.5020
Increased	0.7780	0.0530	0.0000	0.6820	0.8880
Oil fat modified					
Do not consume	Reference group				
Remain as usual	0.7450	0.1020	0.0310	0.5700	0.9730
Decreased	0.5550	0.0470	0.0000	0.4710	0.6540
Increased	0.4520	0.0310	0.0000	0.3950	0.5160
Milk modified					
Do not consume	Reference group				
Remain as usual	0.7280	0.0700	0.0010	0.6030	0.8780
Decreased	0.5760	0.0460	0.0000	0.4920	0.6750
Increased	0.6220	0.0420	0.0000	0.5450	0.7090
Pulses modified					
Do not consume	Reference group				
Remain as usual	1.1630	0.1070	0.1010	0.9710	1.3940
Decreased	0.6950	0.0750	0.0010	0.5620	0.8590
Increased	1.2440	0.0840	0.0010	1.0890	1.4200
Dates modified					
Do not consume	Reference group				
Remain as usual	1.4130	0.1770	0.0060	1.1060	1.8060
Decreased	1.2890	0.1290	0.0110	1.0590	1.5680
Increased	1.3180	0.1420	0.0110	1.0660	1.6280
Chicken modified					
Do not consume	Reference group				
Remain as usual	0.6020	0.0460	0.0000	0.5190	0.6990
Decreased	0.7650	0.0710	0.0040	0.6370	0.9170
Increased	0.5960	0.0400	0.0000	0.5220	0.6810
Sugar modified					
Do not consume	Reference group				
Remain as usual	1.2400	0.1440	0.0650	0.9870	1.5580
Decreased	2.6240	0.2370	0.0000	2.1980	3.1340
Increased	2.2190	0.1740	0.0000	1.9030	2.5860
Meat modified					
Do not consume	Reference group				
Remain as usual	1.5030	0.1410	0.0000	1.2500	1.8070
Decreased	1.0620	0.0960	0.5030	0.8900	1.2680
Increased	1.1090	0.0850	0.1780	0.9540	1.2890
Salty snacks modified					
Do not consume	Reference group				
Remain as usual	0.9630	0.0780	0.6430	0.8210	1.1290
Decreased	1.3680	0.1260	0.0010	1.1430	1.6380
Increased	1.4050	0.0960	0.0000	1.2290	1.6070
Tea-coffee modified					
Do not consume	Reference group				
Remain as usual	0.8230	0.0660	0.0150	0.7030	0.9620
Decreased	0.9130	0.0750	0.2650	0.7770	1.0720
Increased	0.7030	0.0690	0.0000	0.5790	0.8520
Homemade food modified					
Do not consume	Reference group				
Remain as usual	0.3660	0.0610	0.0000	0.2630	0.5090

Decreased	0.4910	0.0410	0.0000	0.4170	0.5780
Increased	0.3560	0.0290	0.0000	0.3040	0.4180
Delivery items modified					
Never or rare	Reference group				
1-2 times per week	0.7980	0.0860	0.0370	0.6460	0.9860
2-3 times per week	0.8880	0.0640	0.0960	0.7710	1.0220
3-4 times per week	0.6920	0.1260	0.0440	0.4850	0.9890
everyday	0.6800	0.1560	0.0920	0.4340	1.0650
Constant	0.2240	0.0320	0.0000	0.1690	0.2960
Pseudo r-squared	0.070	Number of obs	21657.000		
Chi-square	3505.280	Prob>Chi^2	0.000		

Moreover, a weight comparison was also performed among homemade and delivery food consumers. Table 4 reveals the relative risk ratio for the model of underweight, overweight, and obese, while normal weight was a base category. The results in Table 4 show that the relative risk of being obese increased by 2.31 (p<0.01) with the decrease in fruits during the study period in comparison to those who did not consume fruits during Ramadan; but the risk of being overweight decreased by 0.88 (p<0.01) with the increase in consumption of fruits. The relative risk of being overweight and obese also increased by 1.29 (p<0.01) and 1.45 (p<0.01), respectively, among those who improved the consumption of fried foods. Consumption of more vegetables decreased the relative risk of obesity as our findings demonstrated that an increase in consumption of vegetables significantly reduced the relative risk of obesity by 0.78 (p<0.01) and underweight by 0.50 (p<0.01) than the base group. Similarly, cereal food items also declined the risk of overweight and obesity by 0.48 (p<0.01) and 0.78 (p<0.01), respectively, as the consumption of cereal food items maintained the body mass and lowered the chances of obesity and weight gain.

Consumption of oil and fat could also significantly affect weight. A decrease in the consumption of oil fats during the month of Ramadan could reduce the relative risk of obesity by 0.56 (p<0.01), but it was inversely related to being overweight. The consumption of pulses was positively and significantly associated with weight. The relative risk of overweight decreased by 0.74 (p<0.01) in those who reduced the consumption of pulses during Ramadan. In contrast, the risk of obesity increased by 1.24 (p<0.01) in those with improved pulse consumption. Dates were also high-calorie food, which was commonly consumed during Ramadan. So, it has an inconclusive relationship with the weight of people. However, the relative risk of obesity increased among those who consumed more dates or maintain consumption according to everyday routine life. Chicken consumption was also not harmful to body weight, and the decrease or increase in its consumption did not create any obesity or underweight condition. An increase in consumption of chicken could decrease the relative risk of obesity by 0.60, and a decrease in its consumption lowered the risk of obesity by 0.76 (p<0.01) and underweight by 0.78 (p<0.01).

Excessive sugar was harmful to health as it increased the risk of obesity by 2.22 and lowered the risk of being underweight by 0.73 (p<0.01). People who consumed sugar in Ramadan either decreased its consumption, while the relative risk of being malnourished and overweight decreased between 0.76 and 0.78 (p<0.01); but increased the ratio of obesity by 2.51 (p<0.01). An increase in the consumption of salty snacks could lower the relative risk of being underweight by 0.80 (p<0.01) and increased the risk of obese by 1.41 (p<0.01). Tea and coffee illustrated irregular patterns with weight gain and loss. For people who drank more tea in Ramadan after intake of food (Aftar) or remained in their usual routine, the risk of being overweight increased by 1.40 (p<0.01). However, it lowered the risk of obesity as it was consumed after food to control the appetite. During Ramadan, people made various items at home to consume during Aftar, but it did not affect their weight too much. Results of our study also revealed that consumption of homemade food items declined the risk of being overweight, underweight, and obese. Still, delivery items increased the risk of being overweight; either these increase or decrease.

Discussion

This study was conducted on more than 21,500 adults from around the globe to analyze the observed nutritional patterns on BMI during Ramadan. The study highlighted the heterogeneous patterns in food consumption behavior during Ramadan. Our results showed that the most significant factors preventing underweight were consuming vegetables, fruits, cereal foods, chicken and turkey meats, and homemade food items. The

most important risk factors for being overweight were consumption of meat, fried foods, oil fats, milk, delivery foods and frequently drinking of carbonated beverages, tea and coffee. In contrast, obesity risk factors were consumption of carbonated drinks, tea, coffee, meat, sugar, dates, pulses, fried foods, and fruits. In the month of Ramadan and lockdown, some people consumed unhealthy food items, which were responsible for obesity and were negatively associated with being underweight (24). Vegetables and fruits are considered as essential and low-calorie items to maintain body weight through regular physical activity. An increase in the intake of fruits and vegetables helps control blood pressure and helps control being overweight. But, if physical activity is not managed with the increased consumption of such items, it can lead to obesity (25).

Cereal food items can also lower the risk of overweight and obesity as these items contain balanced nutrients like fiber and minerals. However, excessive consumption of cereals such as sugar can result in an imbalance of weight and can cause obesity or unhealthy weight loss when associated with other diseases like diabetes. People who consume excessive amounts of fried food items in the Ramdan were reported to be overweight and obese as it contains excessive oil fats, while during the month of Ramdan, the physical activities become much lower. Therefore, successive use of fried foods affects the metabolism, increases empty calories and thus results in weight gain and obesity (26). The relationship between weight and salty snacks is complex. Some people consume high-caloric snacks in Ramadan, including crackers, potatoes, and pretzels, which increases the risk of obesity and overweight. However, some snacks with lower calories do not contain nutrients like fiber and vitamins, which can be used to control diet and weight balance. One of the significant findings of our study included homemade food items that helped prevent underweight, overweight, and obesity conditions. Diversified food patterns cooked at home were shown to lower the risk of overweight and obesity (27).

Our results also showed that married people had a high risk of being overweight and obese. This might be why married people change their life patterns by sharing meals, frequently sitting together for a meal outside, or social gatherings. However, a healthier lifestyle and physical activities can reduce the risk of weight gain and weight loss. Moreover, age is positively related to BMI classification among the demographic characteristics (28). Age doesn't always have to be related to weight gain or loss. It is indirectly associated with other factors like physician activity, nutrient intake, consumption pattern of food items, and health status. Good health status lowers the risk of being underweight, overweight, and obese in all ages (29, 30). Previous studies also highlighted the importance of physical activities in weight loss and controlling obesity. Aerobic or any physical activity of 5-120 mins a week helps maintain good health and weight loss in the prevalence of overweight and obesity (31).

Conclusion

People who take care of their dietary patterns were shown to have a low risk of being underweight, overweight, or obese. Maintaining food patterns by Muslims during Ramadan requires cautious nutritional habits and choices. This research provided practical implications for supporting healthy food patterns during Ramadan to avoid health consequences. Muslim communities can encourage and start group walks, physical activities, and a few fitness classes to help burn excessive calories. A social media campaign about nutritional guidelines that guide calorie intake after sunset and sunrise time can also be launched. Religious scholars can also be involved in this matter on a platform through social media to encourage healthy food intake and adopt healthy practices.

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Authors' Contribution

The study was conceptualized by SA and MAK. Formal analysis was conducted by HD. The original draft of the manuscript was prepared by RAF, AA, HD, MF, SA, and MAK. Review and editing of the manuscript were carried out by SA, MAK, and HD. Project administration and supervision were performed by MAK, SA, and HD.

Conflict of Interest

None declared.

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