

Multidimensional evaluation of the effects of Ramadan intermittent fasting on the health of female students at the University of Bahrain

Layla Alsowaid, Simone Perna, Gabriella Peroni, Clara Gasparri, Tariq A. Alalwan & Mariangela Rondanelli

To cite this article: Layla Alsowaid, Simone Perna, Gabriella Peroni, Clara Gasparri, Tariq A. Alalwan & Mariangela Rondanelli (2021) Multidimensional evaluation of the effects of Ramadan intermittent fasting on the health of female students at the University of Bahrain, Arab Journal of Basic and Applied Sciences, 28:1, 360-369, DOI: [10.1080/25765299.2021.1975403](https://doi.org/10.1080/25765299.2021.1975403)

To link to this article: <https://doi.org/10.1080/25765299.2021.1975403>



© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group on behalf of the University of Bahrain.



Published online: 13 Sep 2021.



Submit your article to this journal [↗](#)



Article views: 771



View related articles [↗](#)



View Crossmark data [↗](#)



Multidimensional evaluation of the effects of Ramadan intermittent fasting on the health of female students at the University of Bahrain

Layla Alsowaid^a, Simone Perna^a , Gabriella Peroni^b , Clara Gasparri^b, Tariq A. Alalwan^a and Mariangela Rondanelli^{c,d}

^aDepartment of Biology, College of Science, University of Bahrain, Zallaq, Bahrain; ^bEndocrinology and Nutrition Unit, Azienda di Servizi alla Persona "Istituto Santa Margherita," University of Pavia, Pavia, Italy; ^cDepartment of Public Health, Experimental and Forensic Medicine, University of Pavia, Pavia, Italy; ^dIRCCS Mondino Foundation, Pavia, Italy

ABSTRACT

This research aimed to assess the effects of Ramadan intermittent fasting (RIF) on different dimensions, namely calorie intake, fullness and hunger sensations, mental health, body weight, waist circumference (WC), quality of sleep, body composition, hydration and nutritional status among female students at the University of Bahrain. A prospective single cohort study was conducted on 20 female students. The measurements were taken before Ramadan as well as the end of each week of Ramadan. From baseline to the end of Ramadan, there was a significant decrease in body weight (−0.779 kg, CI95% −1.287, −0.271), fat mass (FM) (−1.735 kg, CI95% −2.349, −1.122) and WC (−2.158 cm, CI95% −3.902, −0.414). In addition, the Hydragram[®] showed an increase at week 4 (0.288% CI95% 0.72, 0.504) and nutritional status with Nutrigran[®] increased during the time ($P_{\text{trend}} < 0.001$). No changes were detected for anxiety status, hunger and fullness sensations and quality of sleep. The decrease in weight positively affected the loss of FM ($r = 0.597$), and the increase in the Pittsburgh sleep quality index affected the reduction of FM ($r = -0.460$). The $P_{\text{trend}} < 0.01$ for visual analogue scales and WC showed a clear effect of time on these outcomes. The findings of this study suggest potential benefits of RIF on cardiovascular and metabolic health.

ARTICLE HISTORY

Received 11 January 2021
Revised 16 June 2021
Accepted 28 August 2021

KEYWORDS

Body composition; body fat; intermittent fasting; Ramadan fasting; satiety

Introduction

Annually, more than 1.5 billion Muslims worldwide observe the holy month of Ramadan in which adults refrain from food and fluid intake from dawn to sunset (Norouzy et al., 2013; Salti et al., 2004). The duration of fasting varies from around 12 to 18 hours per day depending on the geographical location of the country and the season in which Ramadan occurs (Sadiya, Ahmed, Siddieg, Joy, & Carlsson, 2011).

There are profound changes in lifestyle and dietary habits during Ramadan. For instance, two meals instead of three are consumed daily, one before sunrise (*sahour*) and one after sunset (*iftar*). In addition, the consumption of various traditional festive foods in the Arabian Gulf region, which are usually high in fat and sugar energy such as *harees* and *legaimaat* increases during Ramadan compared to regular months (Alalwan, Mandeel, & Al-Sarhani, 2017).

Furthermore, sleep duration in Ramadan was reported to be delayed by 2 to 4 hours due to the increase in nocturnal body temperature, which were attributed to late meal consumption and reduced

physical activity (Roky, Chapotot, Hakkou, Benchekroun, & Buguet, 2001). Other studies, on the other hand, assessing sleeping patterns during fasting have reported conflicting results (BaHammam, Alaseem, Alzakri, & Sharif, 2013; Qasrawi, Pandi-Perumal, & BaHammam, 2017).

There has been an increase in interest in the effects of Ramadan intermittent fasting (RIF) on various physiological and cognitive functions (Cherif, Roelands, Meeusen, & Chamari, 2016; Vasconcelos et al., 2014). In addition to avoiding solid foods, the absence of fluid intake during the day might have a greater impact on different health outcomes. There are various results about the effects of RIF on body water status. Trabelsi et al. (2011) found that there was no deference in total body water (TBW) before and after Ramadan among physically active men while other studies reported a slight reduction in TBW after Ramadan among healthy men (Nachvak et al., 2019) and healthy overweight women (Attarzadeh Hosseini, Sardar, Hejazi, & Farahati, 2013).

The effect of intermittent fasting (IF) on plasma lipid profile including triglycerides, total cholesterol, low-density lipoprotein (LDL) and high-density lipoprotein (HDL) are demonstrated by several recent studies (Ahmed, Farooq, & Siddiqi, 2021; Mirmiran, Bahadoran, Gaeini, Moslehi, & Azizi, 2019). Likewise, Akanji, Mojiminiyi, and Abdella (2000) reported that IF improves lipid parameters and reduces the risks of coronary heart disease in hyperlipidemic subjects, while Rahbar et al. (2019) reported significant decreases in triglycerides, cholesterol, and LDL levels in healthy adult males at the end of Ramadan. Moreover, Ara, Jahan, Sultana, Choudhury, and Yeasmin (2016) noticed a significant increase in HDL levels in subjects after Ramadan compared to before Ramadan.

Although the impact of IF on body weight has been studied, previous studies have shown conflicting outcomes and its effects on body composition are still unclear. Several studies reported that IF results in weight loss (A-Hh & Am, 2007; Freire, 2020; Hajek, Myers, Dhanji, West, & McRobbie, 2012) while others showed no significant change in body weight (Lamri-Senhadjji, El Kebir, Belleville, & Bouchenak, 2009; McNeil et al., 2014). Furthermore, Rohin et al. (2013) reported a significant decrease in waist circumference (WC) in normal subjects after fasting in Ramadan. Interestingly, there are a few studies that have reported weight regain within a few weeks after fasting Ramadan (Hajek et al., 2012; McNeil et al., 2014). Studies concerning the effect of RIF on body composition have attributed the change in body weight to numerous causes including reduction in TBW, significant fat loss without triggering gluconeogenesis or the decrease in visceral fat compartment (Nachvak et al., 2019; Syam, Sobur, Abdullah, & Makmun, 2016; Yucel, Degirmenci, Acar, Albayrak, & Haktanir, 2004).

Health outcomes related to RIF are controlled by many factors, including differences in daily temperature, length of fasting, differences in dietary consumption and fluid intake, physical activity levels, working hours, sleep duration, social behaviours, and age (Faris, Jahrami, Obaideen, & Madkour, 2019). Therefore, the present study aimed to determine the effects of RIF on calorie intakes, fullness or hunger sensation, mental health related to anxiety status, body weight, WC, quality of sleep, body composition, hydration and nutritional status among female students at the University of Bahrain.

Materials and methods

Study design

This prospective single-cohort study was conducted one week before and during Ramadan from 30th

April 2019 to 30th May 2019. Data was collected during the five follow-up periods; one week before Ramadan (baseline) and each week of Ramadan. The study was approved by the Ethics Committee of the Department of Biology, College of Science, University of Bahrain (AURS/590/2019) and informed consent was obtained from all study participants.

Inclusion and exclusion criteria

Subjects with the following criteria were included: female students, aged between 18 to 25 years, and had undergone fasting during Ramadan. Potential subjects with the following criteria were excluded from the study: subjects having acute or chronic diseases, taking medication, being under a specific therapeutic diet protocol, pregnant or lactating, using contraceptive, having started fasting one week or more before Ramadan and subjects fasting less than 20 consecutive days during Ramadan.

Procedure

All the subjects underwent fasting in Ramadan, but without any dietary regime before and during Ramadan and without changing their daily activities and lifestyle. In addition, subjects were monitored in regards to their sleep and food intake during the study period.

Outcomes

The primary outcome was the differences in the means of the change in body weight from baseline to the end of the Ramadan. The secondary outcomes were the differences in the means of the change in anxiety status, quality of sleep, hunger sensation, WC, body composition including fat mass, fat free mass, hydration and nutrition.

Experimental design

The study was preformed one week before Ramadan and lasted until the end of Ramadan with a follow-up of five weeks. During the study protocol, subjects were asked to maintain their physical and dietary habits. In addition, the study assessed their sleep quality, food intake and portion size, as well as the duration of their menstrual period.

Study follow-up

Subjects were invited for follow-up assessments five times; one follow-up during each of the five weeks. The measurements and data were collected either

Table 1. General baseline characteristics of the subjects.

Variable	Mean, SD	Test for normality Shapiro W. P value
Age (years)	22.25 (1.21)	.175
STAI (points)	13.84 (3.92)	.767
VAS (points)	1.21 (2.20)	.694
Weight (Kg)	66.91 (15.13)	.943
BMI (kg/m ²)	25.65 (5.55)	.968
WC (cm)	85.32 (14.17)	.915
PSQI (points)	13.32 (7.10)	.419
BCMI (units)	8.12 (1.13)	.61
BMR (kcal)	1364.77 (85.01)	.575
FFM (kg)	41.48 (4.75)	.789
FM (kg)	24.02 (10.68)	.536
TBW (L)	30.48 (3.65)	.704
ECW (L)	14.79 (1.81)	.839
ICW (L)	15.68 (2.19)	.534
Nutrigran® (mg 24 h/htm)	630.32 (84.63)	.563
Hydragram®(%(TBW/FFM))	72.79 (82)	.264
Calories(kcal)	1153.69 (411.83)	.384

STAI, State Trait Anxiety Inventory; VAS, Visual Analogous Scale; BMI; Basal Metabolic Rate; WC, Waist Circumference; PSQI, Sleep Quality Assessment; BCMI, Body Cell Mass Index; BMR, Basal Metabolic Rate; FFM, Fat Free Mass, FM, Fat Mass; TBW, Total Body Water; ECW, Extra Cellular Water; ICW, Intra Cellular Water.

*In bold *p* value <.05.

on Wednesday or Thursday each week between 11:00 am and 3:30 pm.

Body composition and hydration measurement with bioelectrical impedance analysis (BIA)

During each visit, the body composition of the subjects was assessed using AKERN bioelectrical impedance analysis (BIA) device, via the tetra-polar electrode method using four-touch electrodes (Khalil, Mohktar, & Ibrahim, 2014). Measurements taken included the following: basal metabolic rate (BMR), body cell mass index (BCMI), fat mass (FM), fat free mass (FFM), TBW, extracellular water (ECW), and the new parameters Nutrigran® and Hydragram®, which interpret the subjects' nutrition and hydration state, respectively on the basis of creatinine excretion rate and hydration factor in percent (water content of FFM), respectively.

Other measurements

The height of the subjects was measured at baseline with a stadiometer to the nearest 0.5 cm. Subjects were asked to record the dates of the beginning and the end of their menstrual cycles and the number of days they went without fasting as Islamic law exempt menstruating women from fasting.

Each week subjects were weighed to the nearest 0.1 kg using a precision scale in light clothing and without shoes using standardized techniques. The body mass index (BMI) was calculated using the following formula: $BMI = \text{body weight (kg)} / \text{height}^2 \text{ (m)}$. WC, which indicates health risks associated with central adiposity, was measured using a measuring tape to the nearest 0.1 cm. State Trait Anxiety Inventory

(STAI) was used to measure anxiety (Marteau & Bekker, 1992). Sleep quality assessments were made using Pittsburgh Sleep Quality Index (PSQI) for the evaluation of sleep disorders (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Subjective sensations of hunger and fullness were assessed using visual analogue scales (VAS) (Solah et al., 2015). Prior to each follow-up visit, data on food and beverage intake were collected from the 24-hour dietary recall (Castell, Serra-Majem, & Ribas-Barba, 2015) and all the information was entered into the Diet Organizer software to calculate the calorie intake.

Sample size was determined based on the previous study done by Hallak et al. (Hallak & Nomani, 1988). The Twenty subjects were considered adequate for this purpose based on several considerations; from the moment this was intended as a pilot study. With a sample size of 20 subjects per arm, the study would have 80 power to obtain a significant difference on a two-sided, alpha equal to 0.05, using a two-sided two-sample t-test at 0.05 level of significance.

Statistical analysis

All the statistical analyses were performed using Statistical Package for Social Sciences (SPSS) Version 21 (IBM Corp, USA). The mean and standard deviation (SD) for each variable was calculated. According to the Shapiro-Wilks normality tests, all variables had a normal distribution so parametric tests including T-test, GLM: repeated measure were run to compare these variables.

The mean of the change differences of the variables from the baseline to each follow-up period were calculated repeated measure analysis (General Linear Models).

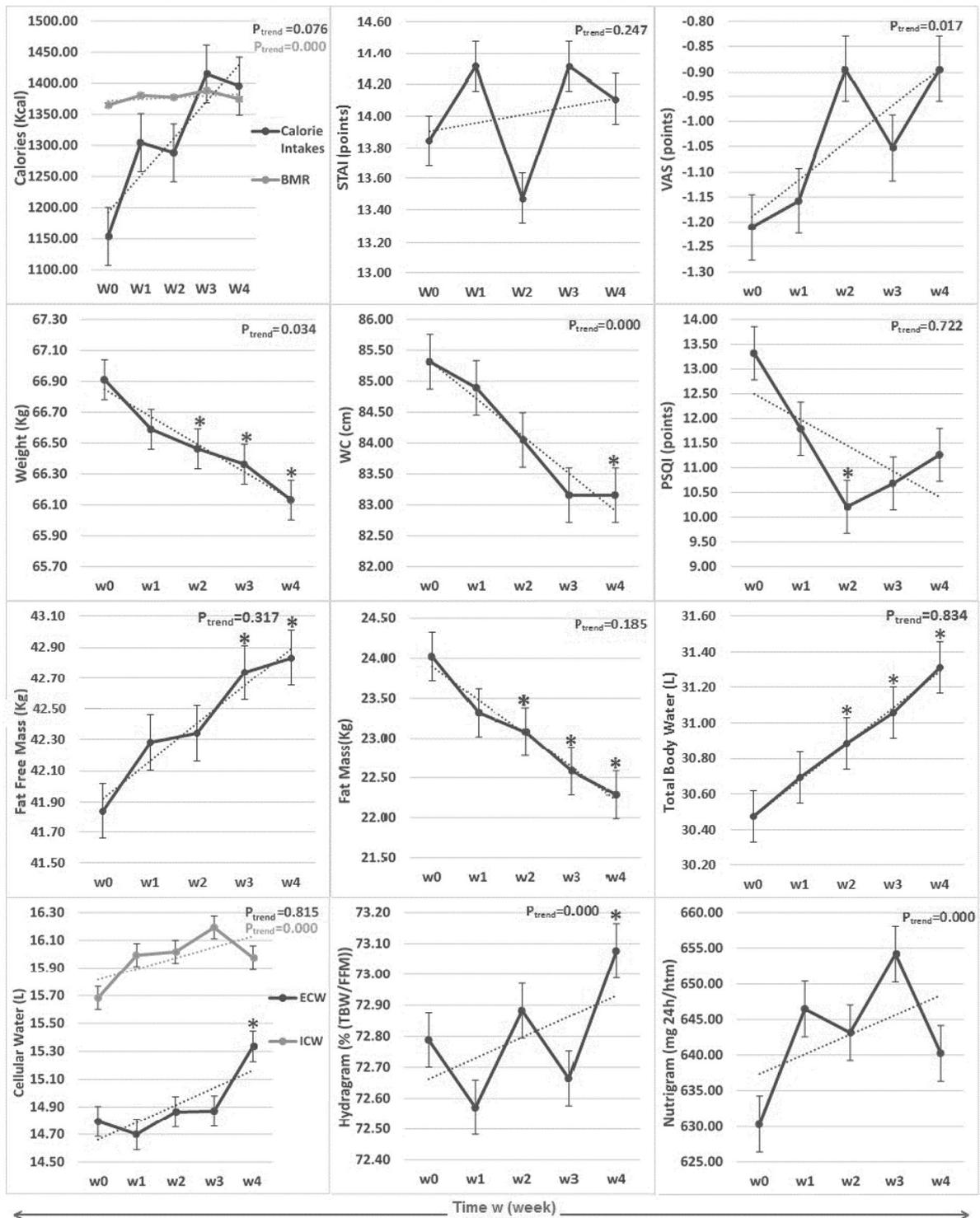


Figure 1. The mean change of the main outcomes at Week 1, 2, 3 and 4 (from baseline). STAI, State Trait Anxiety Inventory; VAS, Visual Analogus Scale; WC, Waist Circumference; PSQI, Sleep Quality Assessment; BMR, Basal Metabolic Rate; ECW, Extra Cellular Water; ICW, Intra Cellular Water; (*), statistically significant compared to the baseline at the level $p < .05$.

In addition, a paired t-test was performed to compare each outcome from baseline to Weeks 1, 2, 3 and 4.

The relationships between mean change differences among the variables were investigated using Pearson correlation coefficient (r). The correlation coefficient through the linear regression analysis [R^2] was assessed to describe the strengths of the associations. The P_{trend} was calculated to assess the effect of time on the interest outcomes.

Results

Twenty female students were eligible and enrolled following the protocol criteria and all of them completed the study successfully. The baseline parameters of the subjects are shown in Table 1. All of the variables were normally distributed on the baseline. The mean age of the subjects was 22.25 years with a standard deviation of 1.21 years. The mean BMI of

Table 2. The mean change differences from the baseline within the four weeks for each variable.

Variable	Week	Mean difference	Upper limit	Lower limit	Variable	Week	Mean difference	Upper limit	Lower limit
STAI	1	0.474	2.315	-1.368	FFM (kg)	1	0.441	-0.233	1.115
	2	0.368	1.882	-2.618		2	0.5	-0.003	1.003
	3	0.474	2.862	-1.915		3	0.894	0.013	1.775
	4	0.263	2.515	-1.989		4	0.988	0.4	-1.578
VAS	1	0.053	-1.177	1.283	FM (kg)	1	-0.7	-1.435	0.035
	2	0.316	-0.584	1.216		2	-0.941	-1.61	-0.273
	3	0.158	-1.273	1.588		3	-1.435	-2.228	-0.642
	4	0.316	-0.945	1.577		4	-1.735	-2.349	-1.122
Weight (Kg)	1	-0.321	-0.672	0.03	TBW (L)	1	0.218	-0.359	0.794
	2	-0.447	-0.817	-0.078		2	0.406	0.024	0.788
	3	-0.547	-1.014	-0.08		3	0.582	0.067	1.098
	4	-0.779	-1.287	-0.271		4	0.835	0.385	1.286
BMI (kg/m ²)	1	-0.123	-0.254	0.009	ECW (L)	1	-0.094	-0.537	0.349
	2	-0.17	-0.311	-0.029		2	0.07	-0.364	0.505
	3	-0.212	-0.39	-0.033		3	0.076	-0.417	0.57
	4	-0.303	-0.495	-0.11		4	0.541	0.13	0.953
WC (cm)	1	-0.421	-1.682	0.84	ICW (L)	1	0.312	-0.151	0.775
	2	-1.263	-3.564	1.038		2	0.335	-0.054	0.725
	3	-2.158	-4.647	0.331		3	0.511	-0.248	1.272
	4	-2.158	-3.902	-0.414		4	0.294	-0.075	0.663
PSQI	1	-1.526	-3.882	0.83	Nutrigran® (mg 24h/htm)	1	16.171	-3.205	35.546
	2	-3.105	-5.647	-0.563		2	12.841	-3.842	29.524
	3	-2.632	-5.483	0.219		3	23.876	-12.602	60.355
	4	-2.053	-4.707	0.602		4	9.947	-6.172	26.066
BMR (kcal)	1	15.882	-3.196	-34.961	Hydragram® (%(TBW/FFM))	1	-0.218	-0.681	0.246
	2	12.647	-3.906	-29.2		2	0.094	-0.055	0.243
	3	23.412	-12.514	-59.337		3	-0.124	-0.518	0.271
	4	9.706	-5.98	-25.391		4	0.288	0.072	0.504
BCMI	1	0.206	-0.033	0.445	Calories (kcal)	1	150.805	-99.553	401.163
	2	0.159	-0.062	0.38		2	134.511	-137.990	407.011
	3	0.1	-0.579	0.779		3	261.437	-13.360	536.234
	4	0.124	-0.087	0.334		4	241.821	-37.443	521.086

STAI, State Trait Anxiety Inventory; VAS, Visual Analogus Scale; WC, Waist Circumference; PSQI, Sleep Quality Assessment; BCMI, Body Cell Mass Index; BMR, Basal Metabolic Rate; FFM, Fat Free Mass, FM, Fat Mass; TBW, Total Body Water; ECW, Extra Cellular Water; ICW, Intra Cellular Water.
*In bolt p value <.001.

the subjects at the baseline was 25.65 ± 5.55 kg/m² (Table 1).

Overall, the subjects' weight ranged between normal weight and overweight, with only two subjects being underweight and five being obese at the baseline.

The differences in the means of the change in the variables in each weekly follow-up are presented in Figure 1. During Ramadan (time X effect), there were a statistically decrease during the time on WC ($P_{\text{trend}} < 0.001$), and an increase (during the time) in Nutrigran® ($P_{\text{trend}} < 0.001$) and hydragram® ($P_{\text{trend}} < 0.001$) as well as intracellular water (ICW) ($P_{\text{trend}} < 0.001$). Also, there was a decrease in body weight with time ($P_{\text{trend}} < 0.001$).

Table 2 compares the changes of all variables from the baseline though Weeks 1, 2, 3 and 4. Statistically significant decreases of weight were observed at Week 2 (-0.447 kg, CI95% -0.817, -0.078), Week 3 (-0.547 kg, CI95% -1.014, -0.08) and at Week 4 (-0.779 kg, CI95% -1.287, -0.271).

Regarding the WC, a statistically significant decrease was detected only at Week 4 of (-2.158 cm, CI 95% -3.902, -0.414). Moreover, there were statistically significant decreases in FM at Week 2 (-0.941 kg, CI95% -1.610, -1.273), Week 3 (-1.435, CI95% -2.228, -0.642) and Week 4 (-1.735 kg, CI95% -2.349, -1.122). In addition, there was a statistically significant increase in ECW at Week 4 (0.541 L, CI95% 0.13, 0.953), and significant

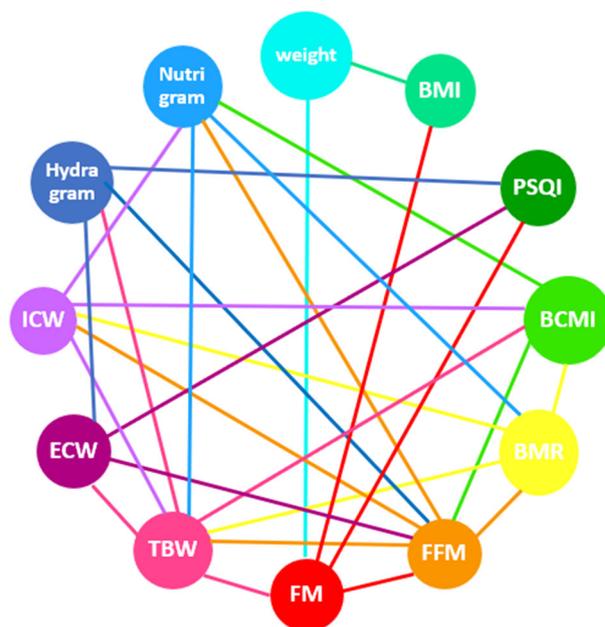


Figure 2. Graphical representation of the statistically significant correlations among the variables. STAI, State Trait Anxiety Inventory; VAS, Visual Analogus Scale; WC, Waist Circumference; PSQI, Sleep Quality Assessment; BCMI, Body Cell Mass Index; BMR, Basal Metabolic Rate; FFM, Fat Free Mass, FM, Fat Mass; TBW, Total Body Water; ECW, Extra Cellular Water; ICW, Intra Cellular Water.

increase in hydration at Week 4 (+0.288% CI95% 0.072, 0.504). Furthermore, the sleep disorders decreased significantly only at Week 2 (-3.105, CI95% -5.647, -0.563).

Table 3. The significance of Pearson's correlations of each variable with the other variables.

Variables	Correlation coefficient	sig. (2tailed)	Variables	Correlation coefficient	Sig. (2tailed)
Δ Weight (kg)	Δ BMI	0.964	Δ TBW (L)	Δ BMR	0.541
	Δ FM	0.597		Δ BCMI	-0.535
BMI (kg/m ²)	Δ Weight	0.964	Δ FFM	0.981	
	Δ FM	0.607	Δ FM	-0.51	
Δ PSQI	Δ FM	-0.46	Δ ECW	0.581	
	Δ ECW	0.508	Δ ICW	0.579	
	Δ Hydragram®	0.483	Δ Hydragram®	0.624	
Δ BMR (kcal)	Δ BCMI	0.993	Δ Nutrigram®	0.536	
	Δ FFM	0.629	Δ PSQI	0.508	
	Δ TBW	0.541	Δ FFM	0.474	
	Δ ICW	0.991	Δ TBW	0.581	
	Δ Nutrigram®	0.999	Δ Hydragram®	0.875	
Δ BCMI	Δ BMR	0.993	Δ BMR	0.991	
	Δ FFM	0.623	Δ BCMI	0.981	
	Δ TBW	0.535	Δ FFM	0.651	
	Δ ICW	0.981	Δ TBW	0.579	
	Δ Nutrigram®	0.992	Δ Nutrigram®	0.991	
Δ FFM (kg)	Δ BMR	0.629	Δ Hydragram® (%(TBW/FFM))	Δ PSQI	0.483
	Δ BCMI	0.607	Δ FFM	0.478	
	Δ FM	-0.466	Δ TBW	-0.624	
	Δ TBW	0.981	Δ ECW	0.875	
	Δ ECW	0.474	Δ BMR	0.999	
	Δ ICW	0.651	Δ BCMI	0.992	
	Δ Hydragram®	0.478	Δ FFM	0.625	
	Δ Nutrigram®	0.625	Δ TBW	0.536	
Δ FM (kg)	Δ weight	0.597	Δ ICW	0.991	
	Δ BMI	0.607			
	Δ PSQI	-0.46			
	Δ FFM	-0.466			
	Δ TBW	-0.51			

With the correlation coefficient and *p*-values.

BMI, Body Mass Index; PSQI, Sleep Quality Assessment; BMR, Basal Metabolic Rate; BCMI, Body Cell Mass Index; FFM, Fat Free Mass; FM, Fat Mass; TBW, Total Body Water; ECW, Extra Cellular Water; ICW, Intra Cellular Water

The Pearson's correlations among the variables are shown in Figure 2. Table 3 illustrates the correlation coefficient (*r*) and the *p*-value of each variable in association with the other variables, the changes in BMR, BCMI, FM, TBW, ECW, ICW, hydration and nutrition effect FFM. All the following factors effected the hydration, as well as quality of sleep, FFM, TBW and ECW.

Figure 3 shows the linear regression models among the variables with the values of the correlation of determination. The greatest correlation among the data was between hunger and fullness sensation and anxiety with a confidence of determination (*R*²) of 0.239. There were positive relationships between sensation of hunger and fullness with nutrition and with weight; *R*² = 101 and *R*² = 0.029, respectively.

The decrease in weight and sleep disorders was associated with a decrease of hydration. In addition, there were negative effects of anxiety on hydration and weight with *R*² = 0.054 and *R*² = 0.032, respectively. However, there were no significant effects of hydration on nutrition or hunger and fullness sensation. Sleep disorders were not affected by anxiety.

Discussion

This study is the first study in literature that evaluates in a multidimensional level different areas of

health, such as anxiety, hunger and fullness sensation, body weight, WC, quality of sleep, body composition, nutrition and hydration before and within the weeks of Ramadan. Moreover, it is the first of its kind to use Nutrigram® and Hydragram® to determine the effects of RIF on nutritional status and hydration.

The findings of this study confirm that RIF had a significant reductive effect on body weight. This reduction correlated significantly with a decrement of FM, which is in agreement with a recent meta-analysis reporting that weight lost during Ramadan fasting results in loss of FM due to changes in overall metabolism, including lipid metabolism (Fernando, Zibellini, Harris, Seimon, & Sainsbury, 2019).

Moreover, our data showed that RIF had significantly decreased WC. Similar findings were reported by Fakhrazadeh, Larijani, Sanjari, Baradar-Jalili, and Amini (2003) in Iran, Saleh, Elsharouni, Cherian, & Mourou (2005) in Kuwait, and Sayedda, Kamal, and Ahmed (2013) in India. On the contrary, Ongsara, Boonpol, Prompalad, and Jeenduang (2017) reported that no significant difference was found in WC in healthy Thai subjects following RIF. Nonetheless, WC is a better predictor of central obesity with a RIF-induced decrease in WC being associated with a reduction in the risks of coronary artery diseases and cardiovascular diseases, hypertension, and insulin-

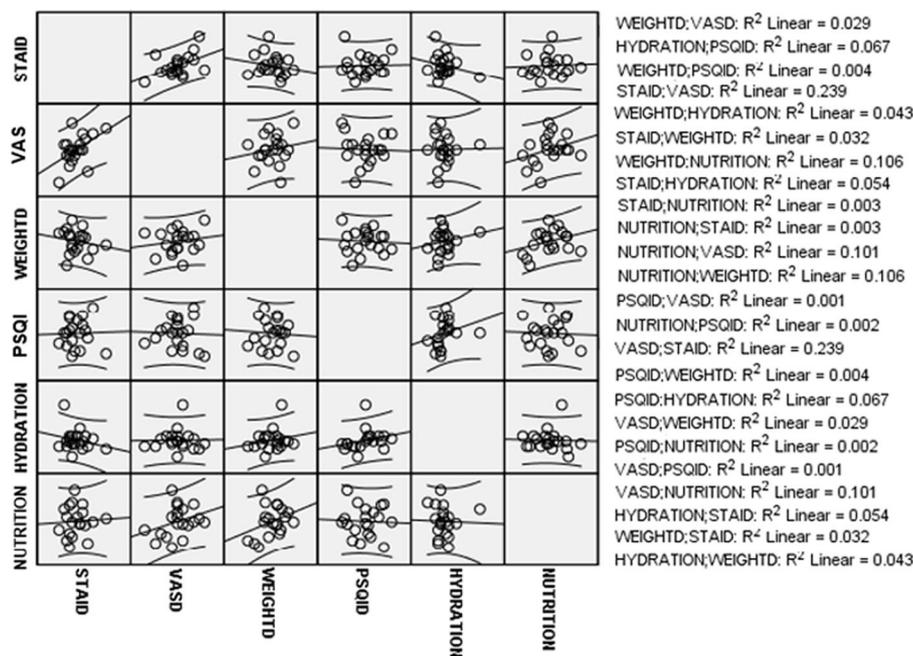


Figure 3. The linear regression models among the variables with the values of correlation of determination. *STAI, State Trait Anxiety Inventory; VAS, Visual Analogus Scale; PSQI, Sleep Quality Assessment.

resistant type 2 diabetes (Celik et al., 2014; Shehab, Abdulle, El Issa, Al Suwaidi, & Nagelkerke, 2012).

In this study weight reduction was not correlated with the reduction of FFM. On the contrary, the data revealed an increment of FFM during the last weeks of Ramadan compared to pre-Ramadan, and thus RIF did not trigger gluconeogenesis. This finding is in line with those of past research (Syam et al., 2016).

Some studies have attributed the loss of body weight during RIF to the reduction in energy intake (Rahbar et al., 2019). In contrast, data from our study showed a slight non-significant increment. This is possibly due to the Ramadan diet pattern observed in the Arabian Gulf states, which includes consuming more sweetened traditional foods (Alalwan et al., 2017). In fact, dietary habit is well-established as the main factor affecting gut microbiota structure and function (David et al., 2014). In terms of the effects of fasting behavior on gut microbiota, Ozkul, Yalinay, and Karakan (2020) reported that fasting can lead to shifts in gut microbial community composition. More recently, Ali et al. (2021) concluded that RIF and ethnicity, which are strongly mediated by dietary changes, can alter the gut microbiota of humans.

In addition, data from the present study extended the previous findings and indicated that low energy intake was not correlated with body weight loss (Nachvak et al., 2019). In agreement with other studies (Maughan & Shirreffs, 2012; Singh et al., 2011), data revealed an increase in TBW from the second week of fasting. This is likely due to the fact that the body tends to balance the amount of water through water retention mechanism by adaptation of the

kidneys. Similarly, Karli et al. 47 reported a balance of body water in Ramadan among athletes through this mechanism. More importantly, these findings support that the weight loss during Ramadan was not due to dehydration.

Interestingly, there was no significant effect of RIF on hunger and fullness sensation over time. This result coincides with that of McNeil et al. (2014) and Alharbi et al. (2017). Previous studies suggested that consuming low glycemic index foods during the pre-dawn *suhour* meal maintained blood glucose during fasting by decreasing the release of glucose from muscle to the blood, which in turn encourages the body to use fat as its primary form of energy (Png, Bhaskaran, Sinclair, & Aziz, 2014). Furthermore, the breakdown of fat results in the production of ketones, which suppress appetite, and thus sparing glucose and prolonging the feeling of satiety (Maher & Clegg, 2019).

In this study, the current data showed no effects of RIF on quality of sleep. Similar outcomes were documented by Herrera (2012) on a cohort of athletes. Nevertheless, the changing of sleep patterns during Ramadan fasting was attributed to changes in the circadian rhythm of body temperature, which are related to changes in the circadian rhythm of melatonin secretion (Al-Rawi et al., 2020). When it comes to anxiety, our study showed no effect of RIF on levels of anxiety and depression, which is similar to the findings of the study by Mohammadi, Larjani, Sanjari, and Jalili (2001). It is suggested that fasting during Ramadan decreases anxiety levels in people due to the religious and spiritual component such as

reciting the Quran, and participating in repetitive rituals like prayers that increase the peace of mind (Koushali, Hajiamini, Ebadi, Bayat, & Khamseh, 2013).

Nevertheless, it was difficult to assess the effect on anxiety in our study because the student subjects had submission deadlines and examinations on several occasions during the follow-up visits, which may have affected their level of anxiety.

The main limitations of this study included the small number of subjects, the variety of diet and differences in individual adaptation responses to fasting. Another major limitation included the days of menstrual period, during which some subjects were exempted from fasting, were analyzed and considered as possible confounding factors. Further research is needed to assess the effect of RIF on macro- and micro-nutrients and on biochemical markers. In addition, it would be useful to conduct future research that will assess microbiota composition changes and the impact on different metabolic and hormones markers.

Conclusions

This study has examined the effect of IF on health. Ramadan fasting practitioners will benefit from a decrease in body weight. This is not because of lower calorie intakes or reduction in FM that could be a factor in the reduction of the risks of several chronic diseases. RIF has been proven to be safe because it does not affect hydration and nutritional status since the body adapts to the loss in water and nutrients and does not impact negatively on anxiety status, sleep disorders, and hunger and fullness sensation.

Disclosure statement

The authors declare that there is no conflict of interest.

ORCID

Simone Perna  <http://orcid.org/0000-0002-2720-1473>
 Gabriella Peroni  <http://orcid.org/0000-0002-1632-1787>
 Tariq A. Alalwan  <http://orcid.org/0000-0002-7693-4542>
 Mariangela Rondanelli  <http://orcid.org/0000-0001-8336-4851>

Data availability statement

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

References

A-Hh, M., & Am, F. (2007). Body composition, nutrient intake and physical activity patterns in young women during Ramadan. *Singapore Medical Journal*, 48(10), 906.

- Ahmed, N., Farooq, J., & Siddiqi, H. S. (2021). Impact of intermittent fasting on lipid profile – A quasi-randomized clinical trial. *Frontiers in Nutrition*, 7, 596787. doi:10.3389/fnut.2020.596787
- Akanji, A. O., Mojiminiyi, O. A., & Abdella, N. (2000). Beneficial changes in serum apo A-1 and its ratio to apo B and HDL in stable hyperlipidaemic subjects after Ramadan fasting in Kuwait. *European Journal of Clinical Nutrition*, 54(6), 508–513. doi:10.1038/sj.ejcn.1601047
- Alalwan, T. A., Mandeel, Q. A., & Al-Sarhani, L. (2017). Traditional plant-based foods and beverages in Bahrain. *Journal of Ethnic Foods*, 4(4), 274–283. doi:10.1016/j.jef.2017.10.003
- Alharbi, T. J., Wong, J., Markovic, T., Yue, D., Wu, T., Brooks, B., ... Little, T. J. (2017). Brief report: Ramadan as a model of intermittent fasting: Effects on body composition, metabolic parameters, gut hormones and appetite in adults with and without type 2 diabetes mellitus. *Obesity Medicine*, 6, 15–17. doi:10.1016/j.obmed.2017.03.002
- Ali, I., Liu, K., Long, D., Faisal, S., Hilal, M. G., Ali, I., ... Long, R. (2021). Ramadan fasting leads to shifts in human gut microbiota structured by dietary composition. *Frontiers in Microbiology*, 12, 642999. doi:10.3389/fmicb.2021.642999
- Al-Rawi, N., Madkour, M., Jahrami, H., Salahat, D., Alhasan, F., BaHammam, A., & Al-Islam Faris, M. (2020). Effect of diurnal intermittent fasting during Ramadan on ghrelin, leptin, melatonin, and cortisol levels among overweight and obese subjects: A prospective observational study. *PLoS One*, 15(8), e0237922. doi:10.1371/journal.pone.0237922
- Ara, T., Jahan, N., Sultana, N., Choudhury, R., & Yeasmin, T. (2016). Effect of Ramadan fasting on total cholesterol (TC) low density lipoprotein cholesterol (LDL-C) and high density lipoprotein cholesterol (HDL-C) in healthy adult male. *Journal of Bangladesh Society of Physiologist*, 10(2), 46–50. doi:10.3329/jbsp.v10i2.27163
- Attarzadeh Hosseini, S. R., Sardar, M. A., Hejazi, K., & Farahati, S. (2013). The effect of Ramadan fasting and physical activity on body composition, serum osmolarity levels and some parameters of electrolytes in females. *International Journal of Endocrinology and Metabolism*, 11(2), 88–94. doi:10.5812/ijem.9602
- BaHammam, A. S., Alaseem, A. M., Alzakri, A. A., & Sharif, M. M. (2013). The effects of Ramadan fasting on sleep patterns and daytime sleepiness: An objective assessment. *Journal of Research in Medical Sciences*, 18(2), 127–131.
- Buyse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. doi:10.1016/0165-1781(89)90047-4
- Castell, G. S., Serra-Majem, L., & Ribas-Barba, L. (2015). What and how much do we eat? 24-hour dietary recall method. *Nutricion Hospitalaria*, 31(Suppl 3), 46–48. doi:10.3305/nh.2015.31.sup3.8750
- Celik, A., Saricicek, E., Saricicek, V., Sahin, E., Ozdemir, G., Bozkurt, S., ... Kilinc, M. (2014). Effect of Ramadan fasting on serum concentration of apelin-13 and new obesity indices in healthy adult men. *Medical Science Monitor*, 20, 337–342. doi:10.12659/MSM.890139
- Cherif, A., Roelands, B., Meeusen, R., & Chamari, K. (2016). Effects of intermittent fasting, caloric restriction, and Ramadan intermittent fasting on cognitive performance

- at rest and during exercise in adults. *Sports Medicine (Auckland, NZ)*, 46(1), 35–47. doi:10.1007/s40279-015-0408-6
- David, L. A., Maurice, C. F., Carmody, R. N., Gootenberg, D. B., Button, J. E., Wolfe, B. E., ... Turnbaugh, P. J. (2014). Diet rapidly and reproducibly alters the human gut microbiome. *Nature*, 505(7484), 559–563. doi:10.1038/nature12820
- Fakhrzadeh, H., Larijani, B., Sanjari, M., Baradar-Jalili, R., & Amini, M. R. (2003). Effect of Ramadan fasting on clinical and biochemical parameters in healthy adults. *Annals of Saudi Medicine*, 23(3–4), 223–226. doi:10.5144/0256-4947.2003.223
- Faris, M. A. I. E., Jahrami, H. A., Obaideen, A. A., & Madkour, M. I. (2019). Impact of diurnal intermittent fasting during Ramadan on inflammatory and oxidative stress markers in healthy people: Systematic review and meta-analysis. *Journal of Nutrition & Intermediary Metabolism*, 15, 18–26. doi:10.1016/j.jnim.2018.11.005
- Fernando, H. A., Zibellini, J., Harris, R. A., Seimon, R. V., & Sainsbury, A. (2019). Effect of Ramadan fasting on weight and body composition in healthy non-athlete adults: A systematic review and meta-analysis. *Nutrients*, 11(2). doi:10.3390/nu11020478
- Freire, R. (2020). Scientific evidence of diets for weight loss: Different macronutrient composition, intermittent fasting, and popular diets. *Nutrition (Burbank, Los Angeles County, CA)*, 69, 110549. doi:10.1016/j.nut.2019.07.001
- Hajek, P., Myers, K., Dhanji, A. R., West, O., & McRobbie, H. (2012). Weight change during and after Ramadan fasting. *Journal of Public Health*, 34(3), 377–381. doi:10.1093/pubmed/fdr087
- Hallak, M. H., & Nomani, M. Z. A. (1988). Body weight loss and changes in blood lipid levels in normal men on hypocaloric diets during Ramadan fasting. *The American Journal of Clinical Nutrition*, 48(5), 1197–1210. doi:10.1093/ajcn/48.5.1197
- Herrera, C. P. (2012). Total sleep time in Muslim football players is reduced during Ramadan: A pilot study on the standardized assessment of subjective sleep-wake patterns in athletes. *Journal of Sports Sciences*, 30(Suppl 1). doi:10.1080/02640414.2012.676666
- Khalil, S. F., Mohktar, M. S., & Ibrahim, F. (2014). The theory and fundamentals of bioimpedance analysis in clinical status monitoring and diagnosis of diseases. *Sensors (Basel, Switzerland)*, 14(6), 10895–10928. doi:10.3390/s140610895
- Koushali, A. N., Hajiamini, Z., Ebadi, A., Bayat, N., & Khamseh, F. (2013). Effect of Ramadan fasting on emotional reactions in nurses. *Iranian Journal of Nursing and Midwifery Research*, 18(3), 232–236. <http://www.ncbi.nlm.nih.gov/pubmed/23983761>.
- Lamri-Senhadj, M. Y., El Kebir, B., Belleville, J., & Bouchenak, M. (2009). Correspondence to: Assessment of dietary consumption and time-course of changes in serum lipids and lipoproteins before, during and after Ramadan in young Algerian adults. *Singapore Medical Journal*, 50(3), 288.
- Maher, T., & Clegg, M. E. (2019). Dietary lipids with potential to affect satiety: Mechanisms and evidence. *Critical Reviews in Food Science and Nutrition*, 59(10), 1619–1644. doi:10.1080/10408398.2017.1423277
- Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *The British Journal of Clinical Psychology*, 31(3), 301–306. doi:10.1111/j.2044-8260.1992.tb00997.x
- Maughan, R. J., & Shirreffs, S. M. (2012). Hydration and performance during Ramadan. *Journal of Sports Sciences*, 30(Suppl 1), S33–S41. doi:10.1080/02640414.2012.688140
- McNeil, J., Mamlouk, M. M., Duval, K., Schwartz, A., Nardo Junior, N., & Doucet, É. (2014). Alterations in metabolic profile occur in normal-weight and obese men during the Ramadan fast despite no changes in anthropometry. *Journal of Obesity*, 2014, 482547. doi:10.1155/2014/482547
- Mirmiran, P., Bahadoran, Z., Gaeini, Z., Moslehi, N., & Azizi, F. (2019). Effects of Ramadan intermittent fasting on lipid and lipoprotein parameters: An updated meta-analysis. *Nutrition, Metabolism, and Cardiovascular Diseases: NMCD*, 29(9), 906–915. doi:10.1016/j.numecd.2019.05.056
- Mohammadi, M. R., Larijani, M., Sanjari, M., & Jalili, R. (2001). Effects of Ramadan of anxiety & depression. *Iranian Journal of Endocrinology and Metabolism*, 3, 27–27. <https://www.sid.ir/en/journal/ViewPaper.aspx?id=498471>.
- Nachvak, S. M., Pasdar, Y., Pirsaeheb, S., Darbandi, M., Niazi, P., Mostafai, R., & Speakman, J. R. (2019). Effects of Ramadan on food intake, glucose homeostasis, lipid profiles and body composition. *European Journal of Clinical Nutrition*, 73(4), 594–600. doi:10.1038/s41430-018-0189-8
- Norouzy, A., Salehi, M., Philippou, E., Arabi, H., Shiva, F., Mehrnoosh, S., ... Nematy, M. (2013). Effect of fasting in Ramadan on body composition and nutritional intake: A prospective study. *Journal of Human Nutrition and Dietetics*, 26(Suppl 1), 97–104. doi:10.1111/jhn.12042
- Ongsara, S., Boonpol, S., Prompalad, N., & Jeenduang, N. (2017). The effect of Ramadan fasting on biochemical parameters in healthy Thai subjects. *Journal of Clinical and Diagnostic Research: JCDR*, 11(9), BC14–BC18. doi:10.7860/JCDR/2017/27294.10634
- Ozkul, C., Yalinay, M., & Karakan, T. (2020). Structural changes in gut microbiome after Ramadan fasting: A pilot study. *Beneficial Microbes*, 11(3), 227–233. doi:10.3920/BM2019.0039
- Png, W., Bhaskaran, K., Sinclair, A. J., & Aziz, A. R. (2014). Effects of ingesting low glycemic index carbohydrate food for the sahur meal on subjective, metabolic and physiological responses, and endurance performance in Ramadan fasted men. *International Journal of Food Sciences and Nutrition*, 65(5), 629–636. doi:10.3109/09637486.2014.886187
- Qasrawi, S. O., Pandi-Perumal, S. R., & BaHammam, A. S. (2017). The effect of intermittent fasting during Ramadan on sleep, sleepiness, cognitive function, and circadian rhythm. *Sleep & Breathing = Schlaf & Atmung*, 21(3), 577–586. doi:10.1007/s11325-017-1473-x
- Rahbar, A. R., Safavi, E., Rooholamini, M., Jaafari, F., Darvishi, S., & Rahbar, A. (2019). Effects of intermittent fasting during Ramadan on insulin-like growth factor-1, interleukin 2, and lipid profile in healthy Muslims. *International Journal of Preventive Medicine*, 10(1), 7. doi:10.4103/ijpvm.IJPVM_252_17
- Rohin, M. A. K., Rozano, N., Hadi, N. A., Nor, M. N. M., Abdullah, S., & Venkateshaiah, M. D. (2013). Anthropometry and body composition status during Ramadan among higher institution learning centre staffs with different body weight status. *Scientific World Journal*, 2013, 1–7. doi:10.1155/2013/308041
- Roky, R., Chapotot, F., Hakkou, F., Benchekroun, M. T., & Buguet, A. (2001). Sleep during Ramadan intermittent

- fasting. *Journal of Sleep Research*, 10(4), 319–327. doi:10.1046/j.1365-2869.2001.00269.x
- Sadiya, A., Ahmed, S., Siddieg, H. H., Joy, I. J., & Carlsson, M. (2011). 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*, 4, 409–416. doi:10.2147/dmso.s24221
- Saleh, S. A., Elsharouni, S. A., Cherian, B., & Mourou, M. (2005). Effects of Ramadan fasting on waist circumference, blood pressure, lipid profile, and blood sugar on a sample of healthy Kuwaiti men and women. *Malaysian Journal of Nutrition*, 11(2), 143–150.
- Salti, I., Benard, E., Detournay, B., Bianchi-Biscay, M., Le Brigand, C., Voinet, C., & Jabbar, A. (2004). A population-based study of diabetes and its characteristics during the fasting month of Ramadan in 13 countries: Results of the epidemiology of diabetes and Ramadan 1422/2001 (EPIDIAR) study. *Diabetes Care*, 27(10), 2306–2311. doi:10.2337/diacare.27.10.2306
- Sayedda, K., Kamal, S., & Ahmed, Q. (2013). Effect of Ramadan fasting in healthy students. *National Journal of Physiology, Pharmacy and Pharmacology*, 3(1), 48–52. doi:10.5455/njppp.2013.3.48-52
- Shehab, A., Abdulle, A., El Issa, A., Al Suwaidi, J., & Nagelkerke, N. (2012). Favorable changes in lipid profile: The effects of fasting after Ramadan. *PLoS One*, 7(10), e47615. doi:10.1371/journal.pone.0047615
- Singh, R., Hwa, O. C., Roy, J., Jin, C. W., Ismail, S. M., Lan, M. F., ... Aziz, A.-R. (2011). Subjective perception of sports performance, training, sleep and dietary patterns of Malaysian junior Muslim athletes during Ramadan intermittent fasting. *Asian Journal of Sports Medicine*, 2(3), 167–168. doi:10.5812/asjasm.34750
- Solah, V. A., Meng, X., Wood, S., Gahler, R. J., Kerr, D. A., James, A. P., ... Johnson, S. K. (2015). Effect of training on the reliability of satiety evaluation and use of trained panellists to determine the satiety effect of dietary fibre: A randomised controlled trial. *PLoS One*, 10(5), e0126202. doi:10.1371/journal.pone.0126202
- Syam, A. F., Sobur, C. S., Abdullah, M., & Makmun, D. (2016). Ramadan fasting decreases body fat but not protein mass. *International Journal of Endocrinology and Metabolism*, 14(1). doi:10.5812/ijem.29687
- Trabelsi, K., el Abed, K., Trepanowski, J. F., Stannard, S. R., Ghilissi, Z., Ghozzi, H., ... Hakim, A. (2011). Effects of Ramadan fasting on biochemical and anthropometric parameters in physically active men. *Asian Journal of Sports Medicine*, 2(3), 134–144. doi:10.5812/asjasm.34775
- Vasconcelos, A. R., Yshii, L. M., Viel, T. A., Buck, H. S., Mattson, M. P., Scavone, C., & Kawamoto, E. M. (2014). Intermittent fasting attenuates lipopolysaccharide-induced neuroinflammation and memory impairment. *Journal of Neuroinflammation*, 11, 85. doi:10.1186/1742-2094-11-85
- Yucel, A., Degirmenci, B., Acar, M., Albayrak, R., & Haktanir, A. (2004). The effect of fasting month of Ramadan on the abdominal fat distribution: Assessment by computed tomography. *The Tohoku Journal of Experimental Medicine*, 204(3), 179–187. doi:10.1620/tjem.204.179