

Review Article

Islamic fasting and weight loss: a systematic review and meta-analysis

Behnam Sadeghirad¹, Shahrzad Motaghipisheh², Fariba Kolaheidoost³,
Mohammad J Zahedi⁴ and Ali A Haghdoost^{2,5,*}

¹Kerman Neuroscience Research Center, University of Medical Sciences, Kerman, Islamic Republic of Iran: ²Research Center for Modeling in Health, University of Medical Sciences, Avicenna Ave., Jihad Blvd, Postal Code 7619813159, Kerman, Islamic Republic of Iran: ³Aboriginal & Global Health Research Group, Department of Medicine, University of Alberta, Edmonton, Canada: ⁴Physiology Research Center, Internal Medicine Department, University of Medical Sciences, Kerman, Islamic Republic of Iran: ⁵Department of Infectious Disease Epidemiology, London School of Hygiene and Tropical Medicine, London, UK

Submitted 17 April 2012: Final revision received 20 June 2012: Accepted 30 July 2012: First published online 27 November 2012

Abstract

Objective: Studies on the effects of Ramadan fasting on weight changes have been contradictory. We brought together all published data to comprehensively examine the effects in a systematic review and meta-analysis.

Design: Relevant studies were obtained through searches of PubMed and CINAHL and by independent screening of reference lists and citations without any time restriction. All searches were completed between October and November 2011.

Setting: Changes in body weight during and after Ramadan were extracted from thirty-five English-language studies and were meta-analysed. Most of the studies were conducted in West Asia (*n* 19); the remainder were conducted in Africa (*n* 7), East Asia (*n* 3) and North America/Europe (*n* 4).

Subjects: Healthy adults.

Results: Fasting during Ramadan resulted in significant weight loss (−1.24 kg; 95 % CI −1.60, −0.88 kg). However, most of the weight lost was regained within a few weeks and only a slight decrease in body weight was observed in the following weeks after Ramadan compared with that at the beginning of Ramadan. Weight loss at the end of Ramadan was significant in both genders (−1.51 kg for men and −0.92 kg for women); but again the weight loss lasted no longer than 2 weeks after Ramadan. Weight loss during Ramadan was greater among Asian populations compared with Africans and Europeans.

Conclusions: Weight changes during Ramadan were relatively small and mostly reversed after Ramadan, gradually returning to pre-Ramadan status. Ramadan provides an opportunity to lose weight, but structured and consistent lifestyle modifications are necessary to achieve lasting weight loss.

Keywords
Body weight
Ramadan fasting
Energy intake
Weight loss
Systematic review

Many religions recommend fasting and adherents find it spiritually and physically helpful. Ramadan, the ninth lunar month of the Islamic Hijri calendar, is a period during which healthy adult Muslims are expected to refrain from eating, drinking, smoking, sexual activity and indulging in anything that is excessive or ill natured from dawn to dusk⁽¹⁾. Islamic fasting during Ramadan does not require energy restriction; however, as intake of food and fluid becomes less frequent and is exclusively nocturnal – between sunset and sunrise – changes in body mass and weight might be expected^(1,2). Since the Islamic calendar is based on a lunar cycle, every year Ramadan moves 11 d

back and makes the fasting period vary from 11 to 18 h depending on geographical location of the country and the fasting season⁽¹⁾.

Several nutritional changes occur and the quality of ingested nutrients differs during Ramadan compared with the rest of the year⁽³⁾; moreover, changes in meal frequency, food composition, energy intake and sleep duration have been reported^(1,4). Therefore, different effects of Ramadan fasting on lifestyle and metabolic indices have been reported in both the normal population and specific groups^(1,5,6).

Within the last 30 years, results describing the effects of Ramadan fasting on body weight have been inconclusive.

There are studies that reported a definite loss of body weight or body fat during Ramadan^(7–13), while there are as many studies that showed either no significant loss of body weight^(14–17) or a slight increase in body weight during or after Ramadan^(3,18–20).

We performed a meta-analysis based on a systematic review to clarify the results of published literature designed to investigate the effects of Ramadan fasting on body weight. In addition, we extracted data on energy intake, diet composition, fasting time and participant age to examine the effects of these variables on weight changes due to Ramadan fasting.

Methods

Search strategy

All literature published in peer-reviewed journals addressing the effects of Ramadan fasting on body weight and composition were potential contributors to the database. We searched MEDLINE through PubMed and CINAHL (Cumulative Index to Nursing and Allied Health Literature) through EBSCO (Elton B Stephens Company) host.

Due to the religious nature of Ramadan fasting, the data available in the literature rely on weight changes before and after Ramadan, and no randomized controlled trial has been done. Therefore, a search strategy that combined a highly sensitive filter for observational studies along with subject-specific terms was used. The MeSH (Medical Subject Headings) terms and text words (and their combinations and truncated synonyms) were adapted as appropriate to search each database. The combination of keywords in searches of both databases was as follows: ('Ramadan' OR 'fast*' OR 'Muslim fast*' OR 'Islam fast*' OR 'Islamic fast*') AND ('body weight' OR 'weight reduction' OR 'weight loss' OR 'weight gain' OR 'body fat distribution' OR 'waist circumference' OR 'BMI' OR 'BMI' OR 'body composition'). Attempts to contact authors to access missing data were also extensively performed. All searching procedures were completed between October and November 2011.

Additional studies were identified by searching the reference lists of identified papers and by searching the Science Citation Index for eligible papers that were commonly cited to identify subsequent studies that had cited them. The search was confined to full papers published in the English language with no limit on the date of publication.

Selection criteria

We read the abstracts of all identified studies to exclude those that were clearly not relevant. The full texts of the remaining articles were read to determine if they met the inclusion criteria. The extracted data were checked independently by two reviewers (S.M. and B.S.) and any discrepancies were resolved by consensus. Primary and quantitative studies were included if a baseline estimation of body weight either before Ramadan fasting or within the final week of the month of Ramadan and body weight after

Ramadan were provided. Since any lifestyle change needs a minimum period of time to induce physiological change and weight change in particular, we excluded studies that reported body weight changes in a short time period (e.g. <2 weeks). We also excluded studies that were not representative of the general population. Studies conducted on specific subgroups, such as medically ill patients (e.g. diabetic, hyperlipidaemic or transplant patients), pregnant or breast-feeding women, athletes, refugees and prisoners, were excluded as well. There was 100% agreement on inclusion and exclusion of studies.

Quality assessment and data extraction

To assess the quality of included studies, a simple checklist based on the Newcastle–Ottawa Scale and the Agency for Health Care Research and Quality was generated⁽²¹⁾. Studies were evaluated for methodological considerations of observational studies such as the representativeness of the sample, comparison, exposure ascertainment, outcome assessment, adequacy of follow-up, consideration of confounders and type of analysis.

Two investigators independently extracted data, reconciling differences by consensus. Information related to body weight, BMI, average daily nutrient consumption (i.e. intakes of carbohydrate, protein and fat) and total daily energy intake of participants before, during and after Ramadan, average fasting time during Ramadan, publication and study date, study population, sample size, age and gender of participants was extracted. There was 94% agreement between data collectors across all items.

Statistical analysis

To compare the effects of Ramadan fasting on body weight, the difference between baseline body weight (weight in the first day of Ramadan or before that) and follow-up weight (either in the final week of Ramadan (Δ weight1) or >2 weeks after Ramadan (Δ weight2)) was computed for each study and used as the study end point. Additionally, the difference in body weight between the final week of Ramadan and >2 weeks after Ramadan (Δ weight3) was computed.

For meta-analysis of the weight change between pre- and post-Ramadan, other than final and baseline measurements, the standard deviations of the weight change are also necessary; however, the availability of the latter in publications of interest is a challenging issue^(22,23). In the current review, only four studies reported data on variances of Δ weight1 and only two studies reported data on variances of Δ weight2 and Δ weight3. Since a large proportion of the primary articles did not provide information on variances of the Δ weights, the imputation method based on reported *P* values for Δ weights was used to calculate standard deviations of the weight changes. A detailed description of this method and its validity is reported elsewhere^(22,24).

The analysis and reporting of the current review conformed as much as practicable to the MOOSE

(Meta-analyses Of Observational Studies in Epidemiology) guideline⁽²⁵⁾. We chose a fixed- or random-effects model to estimate the combined effects according to the results of the heterogeneity test (Cochrane Q). In addition, in order to minimize the random variation among point estimations, we adjusted findings of the studies using Bayesian analysis in forest plots. This technique uses the combined estimation as the prior probability and re-estimates the effect of each study accordingly⁽²⁶⁾.

We estimated τ^2 as the indicator of heterogeneity using the restricted likelihood method. A significance level of $P < 0.10$ and $I^2 > 50\%$ were considered as heterogeneity. In the case of significant heterogeneity, the random-effects model was used and the relevant factors were explored in subgroup analysis where data were available. We also used the meta-regression model to examine the effects of energy intake, diet composition, age and average fasting time on the weight changes during and after Ramadan fasting. Publication bias was examined visually with a funnel plot

of study precision *v.* effect size and by using Begg and Mazumdar's adjusted rank correlation test. A sensitivity analyses was conducted to assess the contribution of each study to the overall effect. The analyses were performed using the Stata statistical software package version 11.

Results

Description of studies

Out of 698 retrieved studies, thirty-five studies on the effects of fasting during Ramadan on body weight met the inclusion criteria and were subjected to meta-analysis; the stages of evaluation and exclusion of the identified studies are presented in Fig. 1.

The methodological quality of the included studies was moderate, with a median score (stars) of 7 out of a possible 9 (interquartile range: 6–8). No study was omitted due to poor quality.

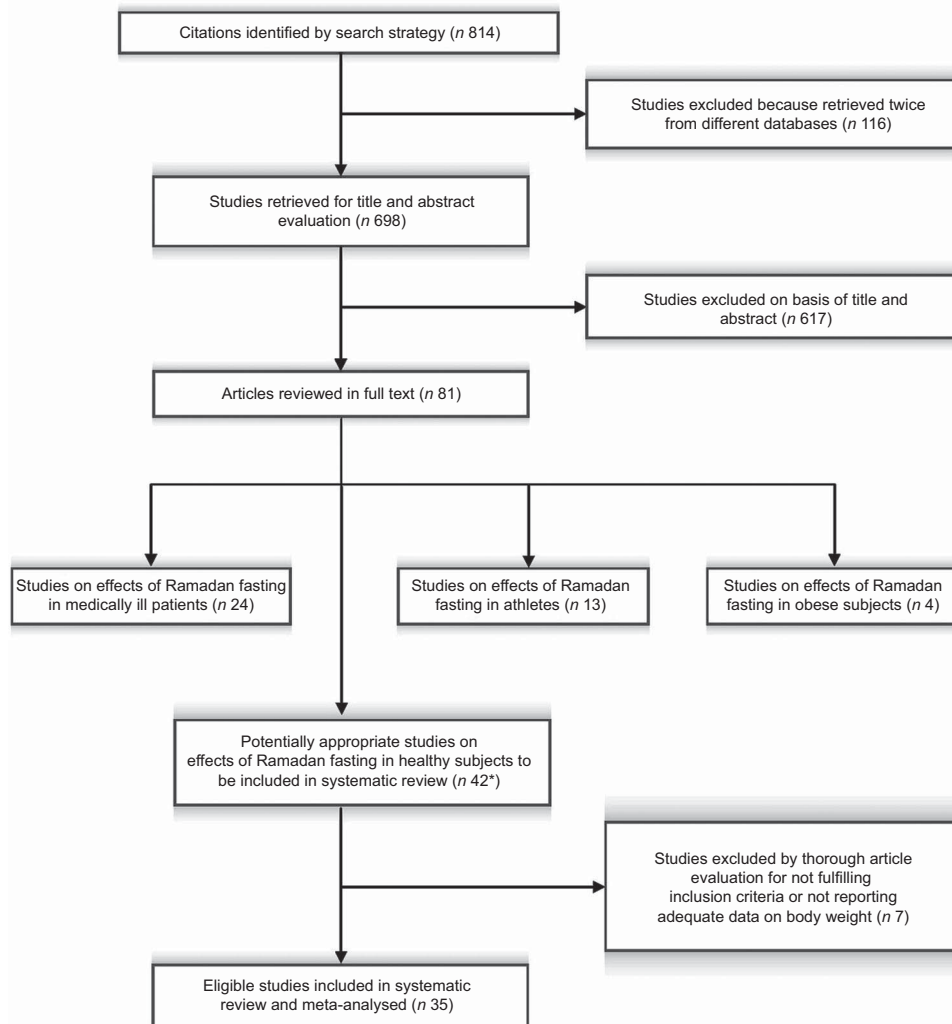


Fig. 1 Flowchart showing the selection of studies included in the present systematic review of Ramadan fasting effects on body weight (*two studies reported the effects of Ramadan fasting in healthy and obese subjects, and in healthy and diabetic subjects)

Table 1 provides detailed information on the studies used in the meta-analysis^(3,8–20,27–47) and descriptive statistics of their characteristics. The average number of subjects per study was 35.8 (SD 27.9) and the subjects' average age was 29.4 (SD 6.4) years old. The average time for fasting during the month of Ramadan in the included studies was 13.3 (SD 1.6) h/d (Table 2). Most of the included studies (54%) provided findings for men and women combined; however, of studies reporting data only for one gender, twelve findings were recorded for men and four for women. Included studies were undertaken in different geographical locations. The studied populations included West Asian (n 19; more than 60% of eligible studies), African (n 7), East Asian (n 3) and North American/European (n 4).

Weight variation and Ramadan fasting

One study did not report the body weight of participants before Ramadan, whereas all of the included studies reported body weight at the end of Ramadan. A total of sixteen studies reported participants' body weight after Ramadan. The mean initial weight for all 1234 subjects was 68.5 (SD 6.5) kg and the average baseline BMI was 23.5 (SD 1.9) kg/m² (Table 2). When findings were pooled together, the results of the meta-analysis showed a 1.24 kg weight reduction during Ramadan (95% CI -1.60, -0.88 kg; $P < 0.001$). Figure 2 shows the forest plot of thirty-four studies which pertain to the effects of fasting on body weight during Ramadan. The findings showed substantial heterogeneity in this category ($I^2 = 79.1\%$). The weight reduction during Ramadan was followed by a significant increase in weight after Ramadan (0.72 kg, 95% CI 0.32, 1.13 kg; $P < 0.001$; Fig. 3). These findings also had substantial heterogeneity ($I^2 = 81.7\%$). When the reported body weight after Ramadan was compared with baseline values, the results of the meta-analysis showed a weight loss of 0.27 kg (95% CI -0.51, -0.04 kg; $P = 0.023$; $I^2 = 4.1\%$). Figure 4 shows the forest plot with mean differences and 95% confidence intervals, and the pooled estimate for the weight change after Ramadan compared with baseline values using a fixed-effects model. We did not find any sign of publication bias for studies in any of these categories (Table 3).

When findings for weight variation were meta-analysed separately for men and women, weight loss in both genders at the end of Ramadan was statistically significant (-1.51 kg for men and -0.92 kg for women); however, this weight loss did not last for >2 weeks after Ramadan. In both men and women, body weight after Ramadan compared with the baseline value showed a small non-significant decrease (-0.10 kg, $P = 0.83$ and -0.55 kg, $P = 0.37$, respectively). During post-Ramadan weeks, compared with the end of Ramadan, men gained 1.02 kg in weight (95% CI 0.42, 1.63 kg; $P < 0.001$), whereas women's weight remained unchanged (Table 3).

In East Asian populations, there was a significant weight loss (-1.56 kg, 95% CI -2.10, -1.04; $P < 0.001$)

between baseline and the end of Ramadan. Weight reduction during Ramadan was also statistically significant in West Asian and African populations (-1.24 kg, $P < 0.001$ and -1.13 kg, $P = 0.001$, respectively). Although weight loss in Europeans was less than that in other populations, it was statistically significant (-0.64 kg, $P < 0.001$). Meta-analysis of studies undertaken in Africa and West Asia showed that the weight lost during Ramadan was regained after Ramadan; however, studies of East Asian populations showed a reduction in participants' body weight after Ramadan compared with baseline values (Table 3).

Diet composition and energy consumption during fasting periods were recorded in fourteen studies and thirteen studies recorded baseline values before Ramadan. In three studies, the total daily energy intake did not change. During Ramadan, the number of studies with increased total daily energy intake was equal to the number of studies with decreased total daily energy intake during Ramadan. Before Ramadan, the total average daily energy intake was 8027 (SD 2110) kJ, which increased to 8219 (SD 2527) kJ during Ramadan month. The total energy intake continued to increase even after Ramadan (9923 (SD 1818) kJ/d). Overall, carbohydrate was the food group with the largest consumption (>55% of total energy intake) before, during and after Ramadan.

Meal frequency during Ramadan, compared with the periods before and after Ramadan, was reduced to essentially two per day in almost all studies. The increase in total daily energy intake during Ramadan was not due to an increase in carbohydrate consumption (56.9 (SD 10.1) *v.* 57.4 (SD 5.5) % of total energy intake). The percentage of energy intake from protein and fat during Ramadan did not change considerably compared with before or after the month of Ramadan (Table 2).

The total energy intake was not similar in all geographical locations. The baseline daily energy intake was considerably lower in West Asian populations. During the month of Ramadan, West and East Asian populations reduced their daily energy intake by 600–900 kJ/d, whereas the daily energy intake of African populations increased by about 1100 kJ/d (Table 4). The increase in energy intake in African populations during Ramadan was mainly due to an 84 g/d increase in carbohydrate consumption (from 775.3 (SD 626.0) to 859.3 (SD 713.8) g/d) and a 45 g/d increase in fat consumption (286.1 (SD 268.4) to 331.3 (SD 296.5) g/d), while protein consumption increased only by 27 g/d (174.3 (SD 124.0) to 201.0 (SD 141.0) g/d). In both West and East Asian populations a decline in carbohydrate consumption during Ramadan was the main reason for the reduction in daily energy intake.

In meta-regression model, the effects of baseline BMI, age, fasting time and energy intake on Δ weights were investigated; however, none of these variables had a considerable effect on the weight reduction during and after Ramadan.

Table 1 Description of studies included in the present systematic review of Ramadan fasting effects on body weight, and body weight, energy intake and diet composition before, during and after Ramadan fasting

Author & date	Country	SS*	Age (years)	Gender	Fasting duration† (h)	At the beginning or before Ramadan				End of Ramadan				After Ramadan			
						Wt‡	Energy§	CARB	Fat¶	Wt‡	Energy§	CARB	Fat¶	Wt‡	Energy§	CARB	Fat¶
Fedail <i>et al.</i> (1982) ⁽⁸⁾	UK & Sudan	18	30.0	Both		69.5				67.7							
Shoukry (1986) ⁽²⁷⁾		30		Both		66.6				65.3							
Husain <i>et al.</i> (1987) ⁽²⁸⁾	Malaysia	21	20–45	Both	14.5	57.3	9213			55.7	7679			56.9			
Hallak and Nomani (1988) ⁽⁹⁾	Syria	16	18–30	M	16.0	66.2				63.7							
Takruri (1989) ⁽²⁹⁾		137		Both		67.6				65.5							
Nomani <i>et al.</i> (1990) ⁽¹⁰⁾	Syria	16	18–30	M	15.0	66.2				63.8							
Sweileh <i>et al.</i> (1992) ⁽¹¹⁾		7	22–35	Both		72.1	4409	651.1	193.0	70.2	5087	755.4	222.7				
Maislos <i>et al.</i> (1993) ⁽³⁰⁾	Israel	24	27.0	Both	13.5					68.0				68.2			
El Ati <i>et al.</i> (1995) ⁽¹⁴⁾	Tunisia	16	25–39	F	13.0	59.3	10 216	297.6	100.5	58.9	10 203	243.1	119.6	58.6	11 011	318.2	109.2
Adlouni <i>et al.</i> (1998) ⁽³¹⁾	Morocco	32	25–50	M	12.0	69.6	11 237	347.2	100.4	67.8	13 443	412.3	118.1	69.1	11 942	341.1	104.6
Bigard <i>et al.</i> (1998) ⁽³²⁾	France	17	38.0	Both	18.0	73.1				71.1							
Finch <i>et al.</i> (1998) ⁽¹⁵⁾	UK	41	35.3	Both	11.0	71.0				70.7				70.8			
Maislos <i>et al.</i> (1998) ⁽¹⁸⁾	Israel	22	24.0	Both	12.5	68.0				67.0				68.0			
Ramadan <i>et al.</i> (1999) ⁽³³⁾	Kuwait	13	36.5	M	14.5	73.6				72.7							
Roky <i>et al.</i> (2001) ⁽³⁴⁾	Morocco	8	20–28	M	12.0	67.0				65.0				67.0			
Ramadan (2002) ⁽³⁵⁾	Kuwait	16	35.0	M	12.0	80.2				79.1							
Fakhrzadeh <i>et al.</i> (2003) ⁽³⁶⁾	Iran	91	20.8	Both	12.0	63.0	6337			62.2	4959						
Kassab <i>et al.</i> (2003) ⁽³⁷⁾	Bahrain	26	18–45	F	12.5	72.5	6975			71.7	6954			72.3			
Kassab <i>et al.</i> (2004) ⁽³⁸⁾	Bahrain	46	22.0	F	12.5	80.8	6950			80.1	6996			80.5			
Rahman <i>et al.</i> (2004) ⁽¹²⁾	Bangladesh	20	38.3	M	12.0	64.1				62.1	8850	408.9	24.7	63.0	8935	433.3	17.9
Yucel <i>et al.</i> (2004) ⁽¹⁶⁾	Turkey	34	32.5	Both	13.0	68.7				68.6							
Aksungar <i>et al.</i> (2005) ⁽³⁹⁾	Turkey	24	30.0	Both	15.0	72.7				72.6				72.3			
Al-Numair (2006) ⁽⁴⁰⁾	Saudi Arabia	45	30–45	M	12.0	85.5	9002	350.0	55.0	83.2	7997	310.0	51.0				
Dewanti <i>et al.</i> (2006) ⁽⁴¹⁾	Indonesia	37	39.0	M	14.0	64.5				63.0							
Lamine <i>et al.</i> (2006) ⁽¹⁹⁾	Tunisia	30	23.7	Both	12.0	61.3	6959	244.0	50.9	61.7	8357	251.0	82.6	62.1	7323	259.1	53.5
Ziaee <i>et al.</i> (2006) ⁽⁴²⁾	Iran	81	22.7	Both	11.0	62.4				61.2							
Al-Hourani and Atoum (2007) ⁽⁴³⁾	Jordan	47	21.6	F	12.0	57.5	5242	174.2	45.7	56.9	4902	164.3	13.9				
Furuncuoglu <i>et al.</i> (2007) ⁽⁴⁴⁾	Turkey	39	28.0	Both	14.0	64.2				62.8							
Mansi (2007) ⁽¹³⁾	Jordan	70	21.3	Both	12.5	76.6				72.7				73.6			
Haouari <i>et al.</i> (2008) ⁽¹⁷⁾	Tunisia	36	24.0	M	12.0	70.9	9684			70.5	9600						
Ibrahim <i>et al.</i> (2008) ⁽⁴⁵⁾	United Arab Emirates	14	25–58	Both	16.0	70.5	7707	269.5	57.7	69.1	8056	268.0	65.5				
Haghdoost and Poorranjbar (2009) ⁽²⁰⁾	Iran	41	20.4	M	14.0	71.6				71.1				72.3			
Lamri-Senhadj <i>et al.</i> (2009) ⁽³⁾	Algeria	46	24.0	Both	12.0	61.1	10 493			60.6	12 051			61.7	10 420		
Hajek <i>et al.</i> (2011) ⁽⁴⁶⁾	UK	87	34.3	Both	15.5	71.2				70.6				71.1			
Unalacac <i>et al.</i> (2011) ⁽⁴⁷⁾	Turkey	10	27.4	M	13.5	71.9				71.1							

M, males; F, females.

*SS, study sample size.

†Fasting duration, average fasting hours per day during Ramadan.

‡Wt, body weight (kg).

§Energy, energy intake (kJ/d).

||CARB, carbohydrate intake (g/d).

¶Fat, fat intake (g/d).

Table 2 Description of variables based on studies included in the present systematic review of Ramadan fasting effects on body weight

Variable	Men				Women				Total			
	Mean*	SD	Range	<i>nt</i>	Mean*	SD	Range	<i>nt</i>	Mean*	SD	Range	<i>nt</i>
Sample size	24.3	13.4	8–50	19	27.6	14.5	9–47	10	35.8	27.9	7–137	35
Fasting duration (h/d)	13.4	1.8	11–18	19	12.8	1.2	11–15	10	13.3	1.6	11–18	31
Age (years)	29.3	7.3	20.4–39.0	19	25.0	4.8	20.8–33.5	10	28.1	6.5	20.4–42.0	33
Baseline BMI (kg/m ²)‡	24.1	2.2	21.8–28.6	12	23.1	1.4	21.0–25.3	8	23.5	1.9	21.2–28.6	22
Body weight (kg)												
Before Ramadan	70.8	6.6	62.9–85.5	18	63.0	9.5	49.9–80.8	10	68.5	6.5	57.3–85.5	34
End of Ramadan	69.7	6.6	61.3–83.2	18	62.2	9.6	48.3–80.1	10	67.2	6.2	55.7–83.2	35
After Ramadan	69.7	5.1	62.6–82.4	7	67.7	11.5	49.2–80.5	6	69.5	5.8	56.9–80.5	16
Energy intake (kJ/d)												
Before Ramadan	9062	1949	6021–11 237	6	7137	1594	5242–10 216	7	7931	1923	4409–11 237	13
End of Ramadan	8940	2822	5078–13 443	7	6870	2297	4814–11 716	7	7914	2640	4903–13 443	14
After Ramadan	10 913	1250	8935–11 942	3	10 233	644	9713–11 011	2	9977	1636	7327–11 942	5
% of daily energy intake from carbohydrate												
Before Ramadan	58.9	6.0	50.5–63.9	3	56.5	4.8	48.8–63.0	3	58.0	5.0	48.8–63.9	8
End of Ramadan	59.8	8.7	51.4–77.1	4	54.3	7.0	39.9–60.0	3	56.7	8.0	39.9–77.1	9
After Ramadan	62.0	12.5	50.8–81.1	3	56.0	6.3	48.4–61.0	2	59.7	9.8	48.4–81.1	5
% of daily energy intake from fat												
Before Ramadan	26.7	4.9	23.0–33.7	3	31.7	3.9	26.0–37.1	3	28.5	4.9	18.3–37.1	8
End of Ramadan	23.5	7.5	10.6–33.0	4	33.0	6.5	24.0–43.2	3	28.7	8.4	10.6–43.2	9
After Ramadan	24.2	10.9	7.6–34.1	3	30.6	5.7	26.0–37.4	2	26.7	8.8	7.6–37.4	5
% of daily energy intake from protein												
Before Ramadan	13.7	1.0	13.0–15.1	3	12.8	0.7	12.2–14.1	3	13.5	1.4	12.2–20.0	8
End of Ramadan	13.0	1.8	11.2–15.5	4	13.7	1.5	12.9–16.9	3	13.5	1.9	11.2–20.3	9
After Ramadan	13.7	1.5	11.3–15.0	3	13.5	0.6	13.0–14.2	2	13.5	1.1	11.3–15.0	5

*Frequency-weighted mean for all variables except sample size and fasting duration.

†Number of studies included in each analysis.

‡BMI before or at the beginning of Ramadan.

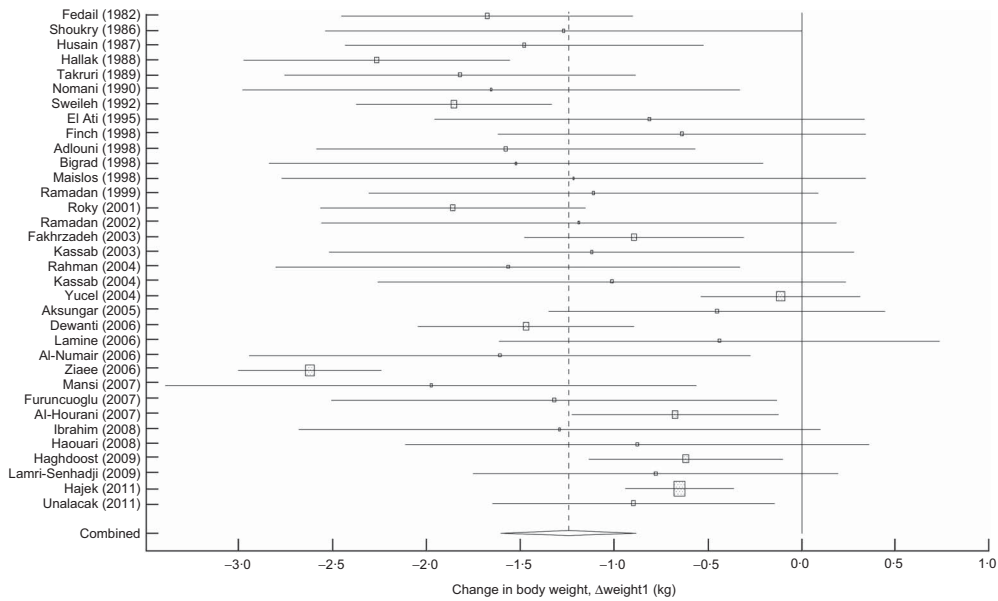


Fig. 2 Forest plot showing the change in body weight during Ramadan ($\Delta\text{weight1}$; difference between baseline body weight (weight in the first day of Ramadan or before that) and follow-up weight (weight in the final week of Ramadan)); values are means with 95% confidence intervals shown by horizontal bars. Studies are ordered alphabetically by name of first author and publication date. The pooled or 'combined' mean difference was calculated by a random-effects model. Studies are represented as squares centred on the point estimate of the result of each study. The area of the square represents the weight given to the study in the meta-analysis. The meta-analysed effect measure (centre line of diamond, dashed line) and its confidence interval are represented as a diamond. The solid vertical line is the line of no effect

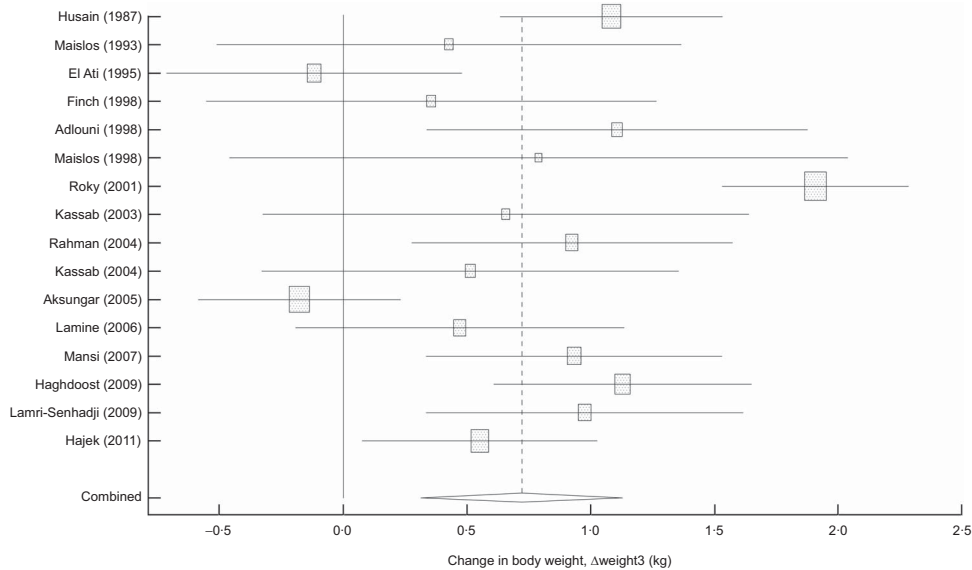


Fig. 3 Forest plot showing the change in body weight from the final week of Ramadan to >2 weeks after Ramadan ($\Delta\text{weight3}$); values are means with 95% confidence intervals shown by horizontal bars. Studies are ordered alphabetically by name of first author and publication date. The pooled or 'combined' mean difference was calculated by a random-effects model. Studies are represented as squares centred on the point estimate of the result of each study. The area of the square represents the weight given to the study in the meta-analysis. The meta-analysed effect measure (centre line of diamond, dashed line) and its confidence interval are represented as a diamond. The solid vertical line is the line of no effect

Discussion

Religious fasting, including Islamic fasting, provides a unique and interesting vantage point for evaluating the effects of food restriction/modification⁽⁶⁾. Ramadan

fasting is a natural experiment that occurs annually for 1 month and requires specific practices, such as nocturnal consumption of food and changes in meal frequency, food quality, energy intake and sleep cycle. Different studies have reported both positive and negative effects

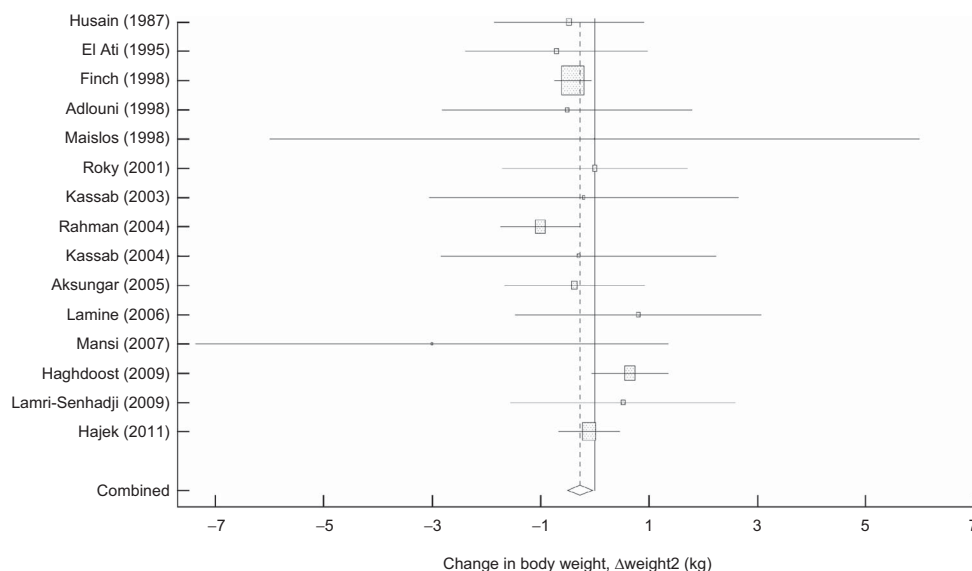


Fig. 4 Forest plot showing the change in body weight due to Ramadan (Δ weight2; difference between baseline body weight (weight in the first day of Ramadan or before that) and follow-up weight >2 weeks after Ramadan); values are means with 95 % confidence intervals shown by horizontal bars. Studies are ordered alphabetically by name of first author and publication date. The pooled or ‘combined’ mean difference was calculated by a fixed-effects model. Studies are represented as squares centred on the point estimate of the result of each study. The area of the square represents the weight given to the study in the meta-analysis. The meta-analysed effect measure (centre line of diamond, dashed line) and its confidence interval are represented as a diamond. The solid vertical line is the line of no effect

Table 3 Results of the meta-analysis of the studies investigating the effect of fasting on weight changes before and after Ramadan

	<i>n</i> *	Difference (kg)	95 % CI		<i>P</i> value for difference	<i>I</i> ² (%)	<i>P</i> value for publication bias†
			Lower	Upper			
Δweight1							
Men	19	-1.51	-2.04	-0.98	<0.001	75.0	0.22
Women	10	-0.92	-1.37	-0.48	<0.001	10.1	0.65
African	7	-1.13	-1.81	-0.46	0.001	52.5	0.10
West Asian	18	-1.24	-1.85	-0.62	<0.001	85.4	0.07
East Asian	3	-1.56	-2.10	-1.04	<0.001	<1	0.12
Europe	3	-0.64	-0.92	-0.35	<0.001	<1	0.60
Total	34	-1.24	-1.60	-0.88	<0.001	79.1	0.33
Δweight2							
Men	5	-0.10	-1.02	0.82	0.83	53.5	0.62
Women	4	-0.55	-1.76	0.65	0.37	<1	0.90
African	5	-0.05	-0.92	0.82	0.90	<1	0.32
West Asian	6	-0.29	-0.29	0.87	0.33	<1	0.85
East Asian	2	-0.88	-1.53	-0.23	0.008	–	–
Europe	2	-0.32	-0.61	-0.02	0.035	–	–
Total	15	-0.27	-0.51	-0.04	0.023	4.1	0.73
Δweight3							
Men	5	1.02	0.42	1.63	0.001	56.9	0.62
Women	4	-0.04	-0.52	0.44	0.87	<1	0.50
African	5	0.89	-0.03	1.82	0.058	90.2	0.92
West Asian	7	0.55	-0.04	1.14	0.069	70.7	0.88
East Asian	2	1.08	0.69	1.48	<0.001	–	–
Europe	2	0.46	0.01	0.92	0.049	–	–
Total	16	0.72	0.32	1.13	<0.001	81.7	0.47

Δweight1, difference between body weight at the end of Ramadan and baseline body weight before Ramadan; Δweight2, difference between body weight after Ramadan (>2 weeks) and baseline body weight; Δweight3, difference between body weight after Ramadan and body weight at the end of Ramadan (when the number of findings was <3, only pooled analysis was performed).

*Number of studies included in each analysis.

†Based on Begg’s test to estimate the chance of publication bias.

of Ramadan fasting on overall health. The present review summarizes the best available evidence on the effects of Ramadan fasting on weight loss in a healthy population.

Weight loss may reduce cardiovascular morbidity and mortality and may lead to prevention of type 2 diabetes and improved control of hypertension^(48–50). At any given

Table 4 Frequency-weighted mean diet composition in different geographical locations

Variable	Time	Africa			West Asia			East Asia		
		Mean	SD	n*	Mean	SD	n*	Mean	SD	n*
Energy intake (kJ/d)	Before Ramadan	9769	1448	160	6829	1167	269	9213	2757	21
	End of Ramadan	10 899	1827	160	6160	1307	269	8251	592	41
	After Ramadan	10 145	1705	124	–	–	–	8935	560	20
Carbohydrate intake (g/d)	Before Ramadan	775.3	626.0	124	261.4	82.3	106	–	–	–
	End of Ramadan	859.3	713.8	124	239.9	69.1	106	408.9	49.9	20
	After Ramadan	753.5	587.3	124	–	–	–	433.3	42.6	20
Fat intake (g/d)	Before Ramadan	286.1	268.4	124	51.2	5.0	106	–	–	–
	End of Ramadan	331.3	296.5	124	36.5	20.8	106	64.6	20.5	20
	After Ramadan	288.6	265.8	124	–	–	–	60.1	21.5	20
Protein intake (g/d)	Before Ramadan	174.3	124.0	124	55.0	14.5	106	–	–	–
	End of Ramadan	201.0	141.0	124	50.8	11.9	106	24.7	3.0	20
	After Ramadan	179.6	128.6	124	–	–	–	17.9	3.6	20

*n, total number of participants in each category used as frequency weight.

time, about 40–60% of the adult population in Western countries is attempting to lose or maintain weight⁽⁵¹⁾.

Our results demonstrated that studies have heterogeneous findings regarding the effects of fasting on body weight during and after Ramadan. Overall, body weight decreased during Ramadan, which suggests that Muslims do not gain weight as a result of skipping daytime meals during Ramadan but rather lose more than a kilogram of weight; however, the weight lost was regained 6 weeks from the beginning of Ramadan. Muslim men lost more weight than women during Ramadan. A possible explanation may be women's prohibition from fasting during their menstrual periods, which results in fewer days of fasting during Ramadan. Women managed to maintain their body weight after Ramadan but men gained about 1 kg during post-Ramadan weeks. It is suggested that fat oxidation during Ramadan fasting may result in an adaptive mechanism for weight maintenance in women⁽¹³⁾. In both genders, post-Ramadan weight showed insignificant change from baseline body weight.

During Ramadan, changes in the timing of food and fluid intake along with the reduction of meal frequency may result in various physiological changes⁽¹⁾. It is believed that Ramadan fasting often leads to reduced energy intake and weight loss occurs as a result⁽⁹⁾ but our findings do not support this hypothesis. Despite the decreased meal frequency during Ramadan in almost all studies, only one-third of included studies showed decreased energy intake during Ramadan. The studies on West and East Asian populations mostly reported that total daily energy intake reduced during Ramadan, but in African populations total daily energy intake was mostly increased. However, the weight loss at the end of Ramadan was not considerably different among African, West Asian and East Asian populations. It is reported that an increase in body weight after Ramadan might be due to less physical activity and/or more energy intake⁽⁵²⁾. Since the number of studies with information on energy intake and physical activity after Ramadan was inadequate, we were not able to examine this hypothesis.

It is obvious that dietary habits and food choices vary among different cultures; hence, percentages of energy intake from carbohydrate, protein and fat are not similar in different Islamic countries. In relation to macronutrient composition, it is reported that meals are often composed of more fat and less carbohydrate during Ramadan compared with the rest of the year^(14,30). On the other hand, carbohydrate comprised the largest proportion of foods consumed during Ramadan. The increased energy intake in African populations and the reduced energy intake in West and East Asian populations were both the result of increased or decreased intake of all macronutrients. However, the number of studies in different geographical locations which reported macronutrient consumption during Ramadan as well as information on weight variation was inadequate for a clear conclusion about their effects on weight loss.

In different studies various explanations were given for the discrepancies of the reported results; the length and the temperature of the fasting days^(1,53), meal schedules and frequencies⁽¹⁾, eating behaviours and the quality and quantity of food intakes^(6,14), fluid intakes^(5,54), sleeping patterns and duration⁽⁴⁾, physical activity^(14,20) and age⁽⁶⁾ are all reported to have effect on weight loss during Ramadan. The results of our meta-regression model showed that duration of fasting, age, baseline BMI, total energy intake and geographical location have no effect on weight loss in healthy populations during Ramadan. Since the number of studies on the effects of macronutrient consumption, sleep cycle, fluid intake or physical activity on weight variation during Ramadan was not enough for meta-regression, we did not include these studies in our review.

Changes in sleeping hours might change the serum level of leptin, insulin and cortisol; these factors could affect daily energy consumption⁽³⁸⁾ and indirectly may explain some of the body weight variation during and after Ramadan.

Some authors suggest that the body weight changes could be attributed to variations of fluid intake^(11,54).

Dehydration certainly occurs during the fasting hours. Acute changes in total body water are best characterized by repeated measurements of body mass; however, with small losses in body mass over a long period of time, any other changes in body composition may bias the measurement of dehydration. Thus, the separation or the quantification of the effects of fasting on body weight from dehydration as a result of fasting seems to be difficult or impossible⁽⁵⁾.

Metabolic responses, for instance to a glucose load, are slower in the evening than in the morning; moreover, gastric emptying and blood flow are greater during the daytime than at night, which leads to a faster absorption of foodstuffs from the gastrointestinal tract⁽⁵⁵⁾. Thus, another likely explanation for the weight loss may be related to the lower absorption of foods eaten nocturnally during Ramadan.

Smoking is prohibited during fasting hours, therefore limiting the number of cigarettes per day might be related to weight gain among smokers in Ramadan⁽⁵⁶⁾. All of the above explanations might be good reasons for the observed heterogeneity among studies.

Conclusion

The present systematic review shows that the weight lost during Ramadan is relatively small and that body weight variations during Ramadan fasting are mostly reversed after Ramadan, gradually returning to pre-Ramadan status. Ramadan provides an opportunity to lose weight, but structured and consistent lifestyle modifications are necessary to achieve life-lasting weight loss. Although our findings regarding body weight variations as a result of Ramadan fasting were heterogeneous, we believe that restrictions in meal frequencies or energy intake alone cannot explain these variations, and the combination of different factors such as dehydration, changes in diet, physical activity and even sleeping hours may be influential. Hence, further studies are needed to investigate the role of dehydration and changes in diet, sleeping hours and physical activity on body weight during Ramadan.

Acknowledgements

Sources of funding: This work was supported by a grant from the Kerman University of Medical Sciences, Iran through grant number 90/348 (awarded to B.S.). *Conflicts of interest:* The authors declare that there are no conflicts of interest. *Author's contribution:* A.A.H. and B.S. directed the study and were involved in the study design. S.M., M.J.Z. and B.S. were involved in designing the search strategy, data collection and entry. B.S. and A.A.H. carried out the analysis. F.K. and B.S. had primary responsibility for drafting the manuscript and all authors contributed to writing and revising the manuscript. *Acknowledgements:* The authors are grateful to Dr N. Pourdamghan for her

excellent assistance in searching and gathering the literature for this review and Dr M. Karamuzian for her comments on the manuscript.

References

1. Roky R, Houti I, Moussamih S *et al.* (2004) Physiological and chronobiological changes during Ramadan intermittent fasting. *Ann Nutr Metab* **48**, 296–303.
2. Azizi F (2010) Islamic fasting and health. *Ann Nutr Metab* **56**, 273–282.
3. Lamri-Senhadj MY, El Kebir B, Belleville J *et al.* (2009) Assessment of dietary consumption and time-course of changes in serum lipids and lipoproteins before, during and after Ramadan in young Algerian adults. *Singapore Med J* **50**, 288–294.
4. Reilly T & Waterhouse J (2007) Altered sleep–wake cycles and food intake: the Ramadan model. *Physiol Behav* **90**, 219–228.
5. Leiper JB & Molla AM (2003) Effects on health of fluid restriction during fasting in Ramadan. *Eur J Clin Nutr* **57**, Suppl. 2, S30–S38.
6. Trepanowski J, Canale R, Marshall K *et al.* (2011) Impact of caloric and dietary restriction regimens on markers of health and longevity in humans and animals: a summary of available findings. *Nutr J* **10**, 107.
7. Muazzam MG & Khaleque KA (1959) Effects of fasting in Ramadhan. *Am J Trop Med Hyg* **62**, 292–294.
8. Fedail SS, Murphy D, Salih SY *et al.* (1982) Changes in certain blood constituents during Ramadan. *Am J Clin Nutr* **36**, 350–353.
9. Hallak MH & Nomani MZ (1988) Body weight loss and changes in blood lipid levels in normal men on hypocaloric diets during Ramadan fasting. *Am J Clin Nutr* **48**, 1197–1210.
10. Nomani MZ, Hallak MH & Siddiqui IP (1990) Effects of Ramadan fasting on plasma uric acid and body weight in healthy men. *J Am Diet Assoc* **90**, 1435–1436.
11. Sweileh N, Schnitzler A, Hunter GR *et al.* (1992) Body composition and energy metabolism in resting and exercising Muslims during Ramadan fast. *J Sports Med Phys Fitness* **32**, 156–163.
12. Rahman M, Rashid M, Basher S *et al.* (2004) Improved serum HDL cholesterol profile among Bangladeshi male students during Ramadan fasting. *East Mediterr Health J* **10**, 131–137.
13. Mansi KMS (2007) Study the effects of Ramadan fasting on the serum glucose and lipid profile among healthy Jordanian students. *Am J Appl Sci* **4**, 565–569.
14. El Ati J, Beji C & Danguir J (1995) Increased fat oxidation during Ramadan fasting in healthy women: an adaptative mechanism for body-weight maintenance. *Am J Clin Nutr* **62**, 302–307.
15. Finch GM, Day JE, Razak *et al.* (1998) Appetite changes under free-living conditions during Ramadan fasting. *Appetite* **31**, 159–170.
16. Yucel A, Degirmenci B, Acar M *et al.* (2004) The effect of fasting month of Ramadan on the abdominal fat distribution: assessment by computed tomography. *Toboku J Exp Med* **204**, 179–187.
17. Haouari M, Haouari-Oukerro F, Sfaxi A *et al.* (2008) How Ramadan fasting affects caloric consumption, body weight, and circadian evolution of cortisol serum levels in young, healthy male volunteers. *Horm Metab Res* **40**, 575–577.
18. Maislos M, Abou-Rabiah Y, Zuili I *et al.* (1998) Gorging and plasma HDL-cholesterol: the Ramadan model. *Eur J Clin Nutr* **52**, 127–130.

19. Lamine F, Bouguerra R, Jabrane J *et al.* (2006) Food intake and high density lipoprotein cholesterol levels changes during Ramadan fasting in healthy young subjects. *Tunis Med* **84**, 647–650.
20. Haghdoost AA & Poorranjbar M (2009) The interaction between physical activity and fasting on the serum lipid profile during Ramadan. *Singapore Med J* **50**, 897–901.
21. Wells G, Shea B, O'Connell D *et al.* (2011) The Newcastle–Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analysis. http://www.worhica/programs/clinical_epidemiology/oxfordasp (accessed March 2011).
22. Thiessen Philbrook H, Barrowman N & Garg AX (2007) Imputing variance estimates do not alter the conclusions of a meta-analysis with continuous outcomes: a case study of changes in renal function after living kidney donation. *J Clin Epidemiol* **60**, 228–240.
23. The Cochrane Collaboration (2011) Cochrane Handbook for Systematic Reviews of Interventions, Version 5.1.0 [JPT Higgins and S Green, editors]. <http://www.cochrane-handbook.org> (accessed March 2011).
24. Follmann D, Elliott P, Suh I *et al.* (1992) Variance imputation for overviews of clinical trials with continuous response. *J Clin Epidemiol* **45**, 769–773.
25. Stroup DF, Berlin JA, Morton SC *et al.* (2000) Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. *JAMA* **283**, 2008–2012.
26. Sutton AJ & Abrams KR (2001) Bayesian methods in meta-analysis and evidence synthesis. *Stat Methods Med Res* **10**, 277–303.
27. Shoukry MI (1986) Effect of fasting in Ramadan on plasma lipoproteins and apoproteins. *Saudi Med J* **7**, 561–565.
28. Husain R, Duncan MT, Cheah SH *et al.* (1987) Effects of fasting in Ramadan on tropical Asiatic Moslems. *Br J Nutr* **58**, 41–48.
29. Takruri HR (1989) Effect of fasting in Ramadan on body weight. *Saudi Med J* **10**, 491–494.
30. Maislos M, Khamaysi N, Assali A *et al.* (1993) Marked increase in plasma high-density-lipoprotein cholesterol after prolonged fasting during Ramadan. *Am J Clin Nutr* **57**, 640–642.
31. Adlouni A, Ghalim N, Saïle R *et al.* (1998) Beneficial effect on serum apo AI, apo B and Lp AI levels of Ramadan fasting. *Clin Chim Acta* **271**, 179–189.
32. Bigard AX, Boussif M, Chalabi H *et al.* (1998) Alterations in muscular performance and orthostatic tolerance during Ramadan. *Aviat Space Environ Med* **69**, 341–346.
33. Ramadan J, Telahoun G, Al-Zaid NS *et al.* (1999) Responses to exercise, fluid, and energy balances during Ramadan in sedentary and active males. *Nutrition* **15**, 735–739.
34. Roky R, Chapotot F, Hakkou F *et al.* (2001) Sleep during Ramadan intermittent fasting. *J Sleep Res* **10**, 319–327.
35. Ramadan J (2002) Does fasting during Ramadan alter body composition, blood constituents and physical performance? *Med Princ Pract* **11**, 41–46.
36. Fakhrzadeh H, Larijani B, Sanjari M *et al.* (2003) Effect of Ramadan fasting on clinical and biochemical parameters in healthy adults. *Ann Saudi Med* **23**, 223–226.
37. Kassab SE, Abdul-Ghaffar T, Nagalla DS *et al.* (2003) Serum leptin and insulin levels during chronic diurnal fasting. *Asia Pac J Clin Nutr* **12**, 483–487.
38. Kassab S, Abdul-Ghaffar T, Nagalla DS *et al.* (2004) Interactions between leptin, neuropeptide-Y and insulin with chronic diurnal fasting during Ramadan. *Ann Saudi Med* **24**, 345–349.
39. Aksungar FB, Eren A, Ure S *et al.* (2005) Effects of intermittent fasting on serum lipid levels, coagulation status and plasma homocysteine levels. *Ann Nutr Metab* **49**, 77–82.
40. Al-Numair K (2006) Body weight and some biochemical changes associated with Ramadan fasting in healthy Saudi men. *J Med Sci* **6**, 112–116.
41. Dewanti L, Watanabe C, Sulistiawati *et al.* (2006) Unexpected changes in blood pressure and hematological parameters among fasting and nonfasting workers during Ramadan in Indonesia. *Eur J Clin Nutr* **60**, 877–881.
42. Ziaee V, Razaei M, Ahmadinejad Z *et al.* (2006) The changes of metabolic profile and weight during Ramadan fasting. *Singapore Med J* **47**, 409–414.
43. Al-Hourani HM & Atoum MF (2007) Body composition, nutrient intake and physical activity patterns in young women during Ramadan. *Singapore Med J* **48**, 906–910.
44. Furuncuoglu Y, Karaca E, Aras S *et al.* (2007) Metabolic, biochemical and psychiatric alterations in healthy subjects during Ramadan. *Pak J Nutr* **6**, 209–211.
45. Ibrahim WH, Habib HM, Jarrar AH *et al.* (2008) Effect of Ramadan fasting on markers of oxidative stress and serum biochemical markers of cellular damage in healthy subjects. *Ann Nutr Metab* **53**, 175–181.
46. Hajek P, Myers K, Dhanji AR *et al.* (2012) Weight change during and after Ramadan fasting. *J Public Health (Oxf)* **34**, 377–381.
47. Unalacak M, Kara IH, Baltaci D *et al.* (2011) Effects of Ramadan fasting on biochemical and hematological parameters and cytokines in healthy and obese individuals. *Metab Syndr Relat Disord* **9**, 157–161.
48. Poirier P, Giles TD, Bray GA *et al.* (2006) Obesity and cardiovascular disease: pathophysiology, evaluation, and effect of weight loss. *Circulation* **113**, 898–918.
49. Look AHEAD Research Group; Pi-Sunyer X, Blackburn G, Brancati FL *et al.* (2007) Reduction in weight and cardiovascular disease risk factors in individuals with type 2 diabetes: one-year results of the look AHEAD trial. *Diabetes Care* **30**, 1374–1383.
50. Nordmann AJ, Nordmann A, Briel M *et al.* (2006) Effects of low-carbohydrate vs low-fat diets on weight loss and cardiovascular risk factors: a meta-analysis of randomized controlled trials. *Arch Intern Med* **166**, 285–293.
51. Teixeira PJ, Silva MN, Coutinho SR *et al.* (2010) Mediators of weight loss and weight loss maintenance in middle-aged women. *Obesity (Silver Spring)* **18**, 725–735.
52. Frost G & Pirani S (1987) Meal frequency and nutritional intake during Ramadan: a pilot study. *Hum Nutr Appl Nutr* **41**, 47–50.
53. Bakhotmah B (2011) The puzzle of self-reported weight gain in a month of fasting (Ramadan) among a cohort of Saudi families in Jeddah, Western Saudi Arabia. *Nutr J* **10**, 84.
54. Gumaa KA, Mustafa KY, Mahmoud NA *et al.* (1978) The effects of fasting in Ramadan. 1. Serum uric acid and lipid concentrations. *Br J Nutr* **40**, 573–581.
55. Sanders SW & Moore JG (1992) Gastrointestinal chronopharmacology: physiology, pharmacology and therapeutic implications. *Pharmacol Ther* **54**, 1–15.
56. Hughes J (2007) Effects of abstinence from tobacco: valid symptoms and time course. *Nicotine Tob Res* **9**, 315–327.