ORIGINAL ARTICLE

Effects of Ramadan fasting on body composition and arterial stiffness

Yusuf Sezen,[1] Ibrahim Halil Altiparmak,[2] Muslihittin Emre Erkus,[3] Aydemir Kocarslan,[4] Zekeriya Kaya,[5] Ozgur Günebakmaz,[6] Recep Demirbag[7]

Abstract

Objective: To examine the effects of Ramadan fasting on body composition, arterial stiffness and resting heart rate.

Methods: This prospective study was conducted at the Department of Cardiology, Harran University, Sanliurfa, Turkey, during Ramadan 2015, and comprised overweight and obese males. Body composition, arterial stiffness and echocardiography were assessed before and after Ramadan. Body composition was assessed by bioelectrical impedance analysis using segmental body composition analyser. Arterial stiffness and haemodynamic parameters were also measured. SPSS 20 was used for data analysis.

Results: Of the 100 subjects enrolled, 70(70%) were included. The overall mean age was 37±7 years. No significant changes were observed in blood pressures, resting heart rate, aortic pulse wave velocity, aortic augmentation index-75, aortic pulse pressure, brachial pulse pressure, basal metabolic rate, total body water, fat-free mass, and echocardiographic parameters ($p>0.05$ each). Although aortic pulse wave velocity (m/s) and augmentation index-75 (%) decreased after fasting period compared to that of before Ramadan, these reductions did not reach statistically significant levels (8.6±1.8 vs. 8.9±1.9, and 13.6±6.6 vs. 14.7±9.3, respectively; $p>0.05$ each). Body mass index, waist-hip ratio, body water rate, percentage of body fat mass, body fat mass, and visceral fat mass percentage were significantly reduced ($p<0.05$ each) after Ramadan.

Conclusion: Ramadan fasting had beneficial effects on body composition, but did not have any significant effect on arterial stiffness and resting heart rate.

Keywords: Ramadan fasting, Body composition, Arterial stiffness, Overweight, Obese. (JPMA 66: 1522; 2016)

Introduction

Ramadan is the most important lunar month for Islamic faith. Muslims avoid eating, drinking and smoking from dawn to sunset in this blessed month. The duration of Ramadan fasting (RF) on a certain day varies from region to region. This period may last up to 18 hours or more in countries close to the equator, especially in the summer. That is why, people living in these countries are exposed to long-term hunger and thirst for approximately 30 days during Ramadan.[1-3]

Arterial stiffness (AS) results from functional and structural disorders of the vessel wall, and reflects the end-organ damage. Further, the more AS is raised, the more cardiovascular disease (CVD) risk is increased.[4,5] The AS thus is a strong predictor of the cardiovascular events.[6] The parameters of AS primarily include aortic pulse wave velocity (PWV) and augmentation index.[7] The PWV is measured by calculating the travel time of the pulse wave between two reference points. The higher values prove anatomical or functional arterial disorders. On the other hand, the augmentation index displaying compliance of the arteries is defined as a percentage of the height of a reflected wave relative to the incident wave. Its percentage is inversely correlated to arterial compliance. In other words, decreased augmentation index indicates the deterioration of compliance of the arterial system.[8] The resting heart rate (RHR) is also an independent predictor of cardiovascular disease like AS. The raised RHR is correlated with both atherosclerosis and cardiovascular events.[9] Previous studies have investigated the relationship between RHR and RF, and pointed out conflicting changes in RHR before, during and after RF.[10-12]

In Turkey, the daytime is long during the summer (nearly up to 18 hours or more). In some studies, it was shown that the reduction of food and fluid intake would lead to changes in body composition (BC) especially during the long summer days.[3,13-15] On the other hand, other studies demonstrated no significant change in BC.[16-18]

To our knowledge, there is no data about the effects of RF on AS, including PWV, and augmentation index. The current study was planned to simultaneously investigate the effects of RF on BC, AS and RHR in overweight and obese individuals.

Subjects and Methods

This prospective study was conducted at the Department

[1-3,5-7]Department of Cardiology, [4]Department of Cardiovascular Surgery, Harran University, Medical Faculty, Sanliurfa, Turkey.

Correspondence: Ibrahim Halil Altiparmak. Email: ihaltiparmak@gmail.com

of Cardiology, Harran University, Sanliurfa, Turkey, during Ramadan 2015, and comprised healthy-appearing overweight and obese Muslim males. The subjects were enrolled within one week before the fasting month and were followed up a week after the month was over (Figure). Healthy-appearing, non-smoking overweight and obese Muslim males, who intended to fast, were included. The demographic data and medical history were taken, and detailed physical examination, echocardiographic assessment and the measurement of AS and BC were performed in all participants. All measurements were performed twice, i.e. within seven days before and seven days after Ramadan. The time of Ramadan was twenty nine days. Physical examinations, medical histories and echocardiographic assessments in all participants were completely normal (except body mass indexes [BMI]) and they also did not use any medication.

Subjects who had overt clinical disorders (e.g. diabetes mellitus, cardiovascular disorders, renal or hepatic insufficiency and thyroid dysfunction), advanced age, smoking or alcohol consumption, using any medication, and those who did not complete the follow-up period due to any reason were excluded.

This study was carried out in accordance with the suggestions asserted by the Declaration of Helsinki And the study protocol was approved by the institutional ethical committee. Informed written consent was obtained from all the participants.

The following measurements were performed before and after Ramadan: PWV, aortic normalised augmentation index to 75/minute heart rate (AIxao-75), aortic pulse pressure, RHR, BC, systolic blood pressure and diastolic blood pressure.

The RHR (beat/min) and blood pressures (mmHg) were calculated in accordance with suggestions of the European Society of Hypertension (ESH).[19] The volunteers, who took a rest in the supine position at least five minutes, were evaluated by the commercially available TensioMedTM Arteriograph (TensioMed Ltd, Hungary) to calculate these parameters.

The PWV (m/s), AIxao-75 (%), and aortic and brachial pulse pressure (mmHg) were calculated noninvasively by the same device in order to determine AS status and central haemodynamics. Arteriography evaluates the aforementioned parameters of AS by analysing brachial artery pulse wave forms. The device detects automatically brachial artery pulsations by oscillometric principle. The device defines cuff-size (small, medium and large) with respect to the jugulum-symphysis size, height, weight and arm circumference. The jugulum-symphysis size reflects the interval from the aortic root to bifurcation. The parameters of AS were achieved using the appropriate cuff on the dominant arm after at least 15 minutes resting. The calculation of travel time of the pulse wave between the two points symbolises PWV.[20] AIxao-75, known as a percentage of the height of a reflected wave relative to the incident wave, was also determined automatically by the Arteriograph. It represents the arterial compliance, and inversely correlates with the compliance.[8] The other parameter calculated automatically is an aortic pulse pressure, and it also indicates central haemodynamics and AS.

BC was noninvasively assigned by the bioelectrical impedance analysis using the Tanita BC-418MA segmental body composition analyser (Tanita Corporation, Japan). The device has eight electrodes, of which two are on each foot and hand. The segmental analysis of BC can be evaluated through these electrodes.[21] To evaluate, the first step is the measurement of height and waist-hip ratio, which was measured with respect to standard protocol. These values as well as gender and age in all volunteers were entered manually. The second step is the calculation of BC by Tanita BC-418MA. After removing participants' shoes and cleaning the soles of the feet with moist antiseptic wipes, body weight and BC were calculated using an automatic digital scale (Tanita Corporation). Basal metabolic rate (kcal), percentage body fat mass (BFM) (%), BFM (kg), fat-free mass (kg), visceral fat mass (%), total body water (kg), body water rate (%) and metabolic age (years) were taken as output from the device as a cumulative result. BMI was computed as weight (kg)/height (m)^2.

All of the measurements were carried out at a similar time point by the investigators, and the average of at least three measurements was enrolled for each parameter.

All echocardiographic assessments were performed based on the recommendations of the American Society of Echocardiography (ASE) guidelines.[22] It was implemented in the left lateral decubitus position by an ultrasound machine GE-Vingmed Vivid S6 system (GE-Vingmed Ultrasound AS, Horten, Norway) and M4S-RS (1.5-3.6 MHz) cardiac transducer. Left ventricle diameters and wall thickness were measured according to established standards. Left ventricle ejection fractions (LVEF) were calculated using modified Simpson's rule.[22]

Categorical variables were expressed as percentages and continuous variables were expressed as mean ± standard deviation (SD). The distribution of data (the differences of variables before and after RF) was established by Kolmogorov-Smirnov test. Statistical analysis was done using paired t-test for normal distributed data, and Wilcoxon signed-rank test was performed for abnormal distributed data. Bivariate correlation analysis was used to determine correlation between the differences of variable. $P \leq 0.05$ was considered statistically significant. All analyses were conducted using SPSS 20.

Results

Of the 100 subjects enrolled, 70(70%) were included and 30(30%) were excluded. Of those who were excluded,

Table-1: Clinical parameters, anthropometric parameters, body composition and arterial stiffness measurements of before and after Ramadan fasting in all participants (n=70).

Parameters	Before RF (mean ± SD)	After RF (mean ± SD)	Ranges (minimum-maximum)	p value
Resting Heart rate (beats/min)	69.9 ± 8.9	72.4± 7.8	Before RF: 50-90 After RF: 58-90	0.092
Systolic blood pressure (mmHg)	120.2 ± 11.6	121.2 ± 10.2	Before RF: 93-140 After RF: 100-145	0.397
Diastolic blood pressure (mmHg)	73 ± 11	73 ± 9	Before RF: 53-90 After RF: 54-92	0.883
LV end diastolic diameter (mm)	46.2±2.1	46.1±2.0	Before RF: 42-51 After RF: 43-50	0.26
LV end systolic diameter (mm)	32.1±1.9	32.0±1.7	Before RF: 28-36 After RF: 28-35	0.219
LV septal wall diameter (mm)	8.9±1.1	8.9±1.0	Before RF: 7-11 After RF: 7-11	0.894
LV posterior wall diameter (mm)	7.8±0.9	7.6±0.8	Before RF: 6-9 After RF: 6-9	0.054
LV ejection fraction (%)	63.3±2.2	63.6±1.9	Before RF: 60-68 After RF: 60-68	0.081
Body mass index (kg/m2)	27.9 ± 2.6	27.5± 2.5	Before RF: 25.0-33.1 After RF: 23.6-32.8	0.000*
Waist/hip rate	0.99 ± 0.09	0.92 ± 0.04	Before RF: 0.88-1.24 After RF: 0.75-1.01	0.000*
Body composition parameters				
Basal metabolic rate (kcal)	1849± 202	1838 ± 197	Before RF: 1472-2407 After RF: 1418-2339	0.08
Body fat mass (%)	22.5 ± 5.0	21.7 ± 4.6	Before RF: 12.1-38.1 After RF: 14.8-35.8	0.009*
Body fat mass (kg)	18.5±5.2	17.6±4.7	Before RF: 8.2-29.9 After RF: 10.0-27.7	0.002*
Visceral fat mass (%)	8.4±3.1	7.9±2.9	Before RF: 1.0-14.0 After RF: 2.0-13.0	0.000*
Fat-free mass (kg)	63.0±6.9	62.7±6.7	Before RF: 48.5-81.2 After RF: 48.2-79.2	0.262
Body water rate (%)	56.7±3.6	57.4±3.3	Before RF: 45.3-64.3 After RF: 47.0-62.3	0.003*
Total body water (kg)	46.1±5.1	46.0±5.0	Before RF: 35.5-59.4 After RF: 35.3-58.0	0.447
Arterial stiffness parameters				
Pulse wave velocity aortic (m/s)	8.9±1.9	8.6±1.8	Before RF:4.5-13.1 After RF:4.4-13.4	0.187
Augmentation index aortic 75 (%)	14.7±9.3	13.6 ±6.6	Before RF:3.2-37.9 After RF:1.9-34.8	0.199
Pulse pressure aortic (mmHg)	38.6±8.7	38.0±7.4	Before RF:26.4-65.6 After RF:26.6-55.1	0.564
Pulse pressure brachial (mmHg)	46.9±7.8	47.8±7.8	Before RF:34.0-69.0 After RF:32.0-66.0	0.401

LV: Left ventricle. RF: Ramadan fasting. SD: Standard deviation.
* $P \leq 0.05$.

Table-2: The correlation analyses between the changes of aortic pulse wave velocity, body fat mass, fat-free mass, visceral fat mass and the changes of clinical parameters before and after Ramadan fasting (n=70).

	r value	p value
ΔAortic pulse wave velocity		
ΔResting heart rate	0.271	0.023
ΔSystolic blood pressure	0.176	0.144
ΔDiastolic blood pressure	0.103	0.395
ΔBody mass index	0.005	0.970
ΔWaist-hip ratio	0.153	0.300
ΔVisceral fat mass ratio		
ΔResting heart rate	0.112	0.354
ΔSystolic blood pressure	0.334	0.005
ΔDiastolic blood pressure	0.040	0.745
ΔBody mass index	0.615	<0.001
ΔWaist-hip ratio	-0.478	0.001
ΔBody fat mass ratio		
ΔResting heart rate	-0.080	0.513
ΔSystolic blood pressure	0.205	0.088
ΔDiastolic blood pressure	-0.012	0.924
ΔBody mass index	0.419	<0.001
ΔWaist-hip ratio	-0.539	<0.001
ΔBody water ratio		
ΔResting heart rate	0.080	0.511
ΔSystolic blood pressure	-0.195	0.106
ΔDiastolic blood pressure	0.005	0.966
ΔBody mass index	-0.353	0.003
ΔWaist-hip ratio	0.550	<0.001

Δ: Difference of the variables before and after Ramadan fasting.

14(46.67%) could not continue Ramadan fasting, 12(40%) failed to come to the second evaluation on time and 4(13.33%) were out of the province during the second assessment. The overall mean age of the subjects was 37±7 years (range: 22-49 years) and the mean BMI was 27.9±0.6 kg/m2 (range: 25-33.1). The mean daily fasting period was 16.68±0.11 hours. BMI, waist-hip ratio, percentage of BFM, BFM, and visceral fat mass were significantly lower after Ramadan compared with before Ramadan (p<0.001, p<0.001, p=0.009, p<0.002, p<0.001, respectively), while body water rate increased during this period (p=0.003). However, no significant changes were observed in other parameters, including RHR (p=0.092), the basal metabolic rate (p=0.080), the fat free mass (p=0.262) and the total body water (p=0.447). Additionally, a significant change in both systolic blood pressure and diastolic blood pressure was not observed (p>0.05 each). Also, echocardiographic parameters were similar between before Ramadan and after Ramadan (p>0.05 each).

Although PWV were lower after fasting period compared to those of before Ramadan, this did not reach statistically significant level (p=0.187). Similarly, other haemodynamic parameters including AIxao-75, and aortic and brachial pulse pressures slightly changed in this period, but did not reach statistical significance (p>0.05 each) (Table-1).

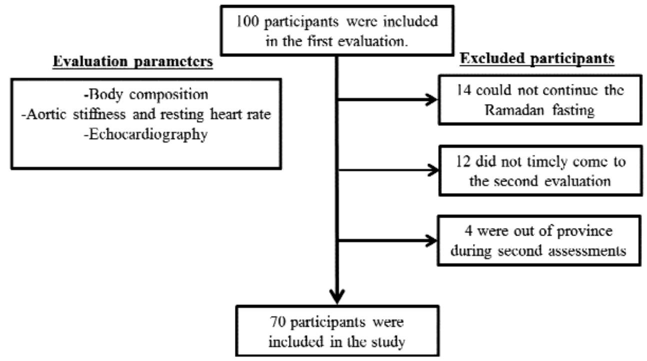

Figure: Diagram showing the study design.

In addition, bivariate correlation analysis for changes before and after Ramadan showed a significant relationship between those parameters; PWV-RHR (p=0.023), visceral fat mass-systolic blood pressure, BMI, and waist-hip ratio (p=0.005, p<0.001, p=0.001, respectively), percentage of BFM-BMI and waist-hip ratio (p<0.001 each), and body water ratio-BMI and waist-hip ratio (p=0.003 and p=0.001, respectively). However, no significant changes were observed between other parameters in bivariate correlation analysis (p>0.05) (Table-2).

Discussion

In the current study, RF gave rise to significant decrease in BMI, waist-hip ratio, visceral fat mass (%), and BFM (kg), but not basal metabolic rate (kcal), fat-free mass (kg), and total body water (kg). Moreover, RF did not have any significant effect on RHR, and parameters of AS (mainly PWV, AIxao-75 and aortic and brachial pulse pressure).

Muslims are exposed to some changes with regard to eating, drinking and sleep pattern during the holy month of Ramadan. Although this condition can be well tolerated by healthy people on short and cool winter days, it might result in some metabolic changes on long and hot summer days. Since eating and drinking are allowed only for night time in Ramadan, not only the feeding time decreases but also sleep pattern is disrupted. On the other hand, fluid loss and decrease in energy intake may be observed during the summer days.[3,23]

Some studies showed the contradictory results about the effects of RF on RHR.[10-12] A study demonstrated considerably decreased RHR after RF with the mean RHR of 63.1 beats/min before RF and 58 beats/min after RF in the subjects engaged in regularly and intensive sport activities.[12] However, the present study comprised only healthy individuals without regular sport activity. On the other hand, a study pointed out that the RHR showed no significant change after Ramadan compared with before Ramadan. The subjects of that study had the same characteristics as in our study (healthy-appearing non-sportive volunteers). Also, the study showed that prolonged fasting time and changes in sleep cycles gave rise to increase in parasympathetic activity.[10] Our study did not show significantly changed RHR. A study by Guvenc et al. involving soccer players also showed no change in RHR in the same time periods.[11] We believe that our study population reflects more accurately the general population than that of Guvenc et al.

Although traditional anthropometric measurements such as BMI and waist-hip ratio may be used, the assessment of BC gives the more valuable information for distribution of fat mass, fat-free mass, total body water and other parameters.[21] Overview of literature demonstrated controversial results about the effects of RF on BC changes. In one group of studies, patients had a considerable change in their BC.[3,13-15] However, in another group, patients had an insignificant change or no change in their BC.[16-18] Karli et al. pointed out that there were no significant changes in body weight, BMI, fat-free mass, and percentage of body fat associated with RF in power athletes.[12] Rohin et al. also reported no significant changes in BC in individuals with different weight.[17] On the contrary, Sadiya et al. investigated the effect of RF on BC and metabolic parameters in participants with metabolic syndrome, and proved that the patients lost weight and reduced their waist circumference.[15] A study done by Norouzy et al. showed considerable changes in BC and anthropometric measurements.[3] When study results were evaluated according to age and sex, it showed that RF led to fat-free mass reductions and weight loss in all groups, but the percentage body fat was considerably lower after RF in males only. Yucel et al. reported that there were no significant differences between before and after Ramadan in terms of the visceral fat tissue area by computed tomography (CT) and other BC parameters in male subjects.[18] However, in our study comprising only male volunteers, fat-free mass was not varied, whereas visceral fat mass, BFM, and BMI were substantially decreased. Additionally, there were significantly positive correlations between the reduction of BMI and the reduction of BFM and visceral fat mass, while there were inverse correlations between the reduction of waist-hip ratio and the above mentioned values. We believe that since participants may be fed abundant fluid and protein rather than carbohydrates and fat-rich diet from sunset to sunrise, the reductions of BFM, visceral fat mass and BMI were shown, and that the cause of inverse relation of them with waist-hip ratio may be due to earlier reduction of waist circumference fat mass than that of hip. Another interesting positive correlation was shown between visceral fat mass and systolic blood pressure, and this result supported previous studies indicating visceral fat mass played a significant role for development of hypertension.[24] However, to say anything definite, diets of individuals may be required to be standardised in suitable proportions. This condition can be explained by other studies. In addition, the present study also revealed a significant reduction in BMI and waist-hip ratio. We consider that acquired dietary habits in Ramadan should be continued throughout the year to sustain these favourable effects.

To our knowledge, no previous study has investigated the relationship between RF and detailed parameters of AS. However, there is only one study addressing the effects of RF on arterial pulse pressure, lipid profile and oxidative stress in hypertensive patients. This study indicated that the RF improved arterial pulse pressure which is a parameter of AS.[25] We evaluated detailed AS parameters including PWV, aortic pulse pressure, brachial pulse pressure and AIxao-75. The present study has showed no significant change in these parameters. In our study, although the aortic pulse pressure increased, it did not reach statistical significance. This result was contrary to the abovementioned study performed with 40 subjects.[25] However, both our sample sizes were larger than that study, and our results were supported by PWV and AIxao-75 without significant changes. Despite both results, we think that there is need for more studies with larger sample sizes.

As a consequence, our results showed that Ramadan fasting significantly ameliorated BC including visceral fat mass, which is a predictor of cardiovascular risk, and that Ramadan fasting reduced PWV without statistically significant results. Taken together, we think that if Ramadan habits can be continued longer, it may have positive effects of RF on AS.

The current study has some limitations as well. First, the sample size was small because the inclusion of the participants was limited to only one week before the onset of Ramadan. Second, the participants were only male subjects because women did not fast during the menstrual periods. Third, dietary and sleep patterns and physical fitness status of the participants were not optimised from sunset to sunrise. Fourth, in terms of assessment of RHR, we did not take into account the exercise capacity and depression-anxiety-stress scales of individuals.

Conclusion

RF did have beneficial impacts on BC but it did not have any significant effect on the parameters of AS and RHR in overweight and obese individuals. However, the lifelong continuation of eating habits like Ramadan fasting may provide beneficial effects on cardiovascular system.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: None.

References

1. Azizi F. Islamic fasting and health. Ann Nutr Metab. 2010; 56:273-82.
2. Mahar SA, Hasan MI, Khan MI, Fawwad A, Hussain S, Maheshwary N, et al. Comparison of hypoglycaemia episodes in people with type-2 diabetes fasting in Ramazan, treated with vildaglipton or sulphonylurea: results of the Pakistani cohort of the VIRTUE study. J Pak Med Assoc. 2014; 64:1297-302.
3. Norouzy A, Salehi M, Philippou E, Arabi H, Shiva F, Mehrnoosh S, et al. Effect of fasting in Ramadan on body composition and nutritional intake: a prospective study. J Hum Nutr Diet. 2013; 26:97-104.
4. Jia G, Aroor AR, Sowers JR. Arterial Stiffness: A Nexus between Cardiac and Renal Disease. Cardiorenal Med. 2014; 4:60-71.
5. Recio-Rodriguez JI, Gomez-Marcos MA, Patino-Alonso MC, Sanchez A, Agudo-Conde C, Maderuelo-Fernandez JA, et al. EVIDENT Group. Association between fat amount of dairy products with pulse wave velocity and carotid intima-media thickness in adults. Nutr J. 2014; 24:13-37.
6. Reference Values for Arterial Stiffness' Collaboration. Determinants of pulse wave velocity in healthy people and in the presence of cardiovascular risk factors: establishing normal and reference values. Eur Heart J. 2010; 31:2338-50.
7. Riggio S, Mandraffino G, Sardo MA, Iudicello R, Camarda N, Imbalzano E, et al. Pulse wave velocity and augmentation index, but not intima-media thickness, are early indicators of vascular damage in hyper cholesterolemic children. Eur J Clin Invest. 2010; 40:250-7.
8. Hlimonenko I, Meigas K, Viigimaa M, Temitski K. Assessment of Pulse Wave Velocity and Augmentation Index in different arteries in patients with severe coronary heart disease. Conf Proc IEEE Eng Med Biol Soc. 2007; 2007:1703-6.
9. Lang CC, Gupta S, Kalra P, Keavney B, Menown I, Morley C, et al. Elevated heart rate and cardiovascular outcomes in patients with coronary artery disease: clinical evidence and pathophysiological mechanisms. Atherosclerosis. 2010; 212:1-8.
10. Cansel M, Ta?olar H, Ya?mur J, Ermi? N, Aç?kgöz N, Eyyüpkoca F, et al. The effects of Ramadan fasting on heart rate variability in healthy individuals: a prospective study. Anatol J Cardiol. 2014; 14:413-6.
11. Güvenç A. Effects of ramadan fasting on body composition, aerobic performance and lactate, heart rate and perceptual responses in young soccer players. J Hum Kinet. 2011; 29:79-91.
12. Karli U, Guvenc A, Aslan A, Hazir T, Acikada C. Influence of Ramadan Fasting on Anaerobic Performance and Recovery Following Short time High Intensity Exercise. J Sports Sci Med. 2007; 6:490-7.
13. Attarzadeh Hosseini SR, Sardar MA, Hejazi K, Farahati S. The effect of ramadan fasting and physical activity on body composition, serum osmolarity levels and some parameters of electrolytes in females. Int J Endocrinol Metab.2013; 11:88-94.
14. Memari AH, Kordi R, Panahi N, Nikookar LR, Abdollahi M, Akbarnejad A. Effect of ramadan fasting on body composition and physical performance in female athletes. Asian J Sports Med. 2011; 2:161-6.
15. Sadiya A, Ahmed S, Siddieg HH, Babas IJ, Carlsson M. Effect of Ramadan fasting on metabolic markers, body composition, and dietary intake in Emiratis of Ajman (UAE) with metabolic syndrome. Diabetes Metab Syndr Obes. 2011; 4:409-16.
16. Ramadan J. Does fasting during Ramadan alter body composition, blood constituents and physical performance? Med Princ Pract. 2002; 11:41-6.
17. Rohin MA, Rozano N, Abd Hadi N, Mat Nor MN, Abdullah S, Dandinasivara Venkateshaiah M. Anthropometry and body composition status during Ramadan among higher institution learning centre staffs with different body weight status. Scientific World J. 2013; 2013:308041.
18. Yucel A, Degirmenci B, Acar M, Albayrak R, Haktanir A. The effect of fasting month of Ramadan on the abdominal fat distribution: assessment by computed tomography. Tohoku J Exp Med. 2004; 204:179-87.
19. Authors/Task Force members, Elliott PM, Anastasakis A, Borger MA, Borggrefe M, Cecchi F, et al. 2014 ESC Guidelines on diagnosis and management of hypertrophic cardiomyopathy: the Task Force for the Diagnosis and Management of Hypertrophic Cardiomyopathy of the European Society of Cardiology (ESC). Eur Heart J. 2014; 35:2733-79.
20. Simková A, Bulas J, Murín J, Kozlíková K, Janiga I. Metabolic syndrome and aortic stiffness. Vnitr Lek. 2010; 56:1000-4.
21. Prins M, Hawkesworth S, Wright A, Fulford AJ, Jarjou LM, Prentice AM, et al. Use of bioelectrical impedance analysis to assess body composition in rural Gambian children. Eur J Clin Nutr. 2008; 62:1065-74.
22. Lang RM, Badano LP, Mor-Avi V, Afilalo J, Armstrong A, Ernande L, et al. Recommendations for cardiac chamber quantification by echocardiography in adults: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2015; 28:1-39.
23. Bahammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. Saudi Med J. 2005; 26:616-22.
24. Sullivan CA, Kahn SE, Fujimoto WY, Hayashi T, Leonetti DL, Boyko EJ. Change in Intra-Abdominal Fat Predicts the Risk of Hypertension in Japanese Americans. Hypertension. 2015; 66:134-40.
25. Al-Shafei AI. Ramadan fasting ameliorates arterial pulse pressure and lipid profile, and alleviates oxidative stress in hypertensive patients. Blood Press. 2014; 23: 160-7.