Eur J Pediatr (2014) 173:1103–1106
DOI 10.1007/s00431-014-2276-8

SHORT COMMUNICATION

Intermittent fasting during Ramadan causes a transient increase in total, LDL, and HDL cholesterols and hs-CRP in ethnic obese adolescents

Nalini Radhakishun · Charlotte Blokhuis · Mariska van Vliet · Ines von Rosenstiel · Olivier Weijer · Martijn Heymans · Jos Beijnen · Dees Brandjes · Michaela Diamant

Received: 27 December 2013 / Accepted: 22 January 2014 / Published online: 13 February 2014

Abstract The radical change of lifestyle during Ramadan fast has shown to affect cardiometabolic risk variables in adults. In youth, however, no studies are available. We aimed to evaluate the effect of Ramadan fast on Body Mass Index (BMI) and the cardiometabolic profile of obese adolescents. A prospective cohort study was conducted. We measured weight, height, body composition, blood pressure, heart rate, glucose, insulin, total cholesterol, low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol, triglycerides, and high sensitivity C-reactive protein (hs-CRP) levels before, during the last week of and at 6 weeks after Ramadan. Twenty-five obese adolescents were included. BMI and glucose metabolism did not change after Ramadan or at 6 week after cessation of Ramadan. At the end of Ramadan, a significant decrease in body fat percentage was observed, while significant increases in heart rate, total cholesterol, LDL cholesterol, HDL cholesterol, and hs-CRP were found (all $P<0.05$). Six weeks after Ramadan, all parameters returned to baseline levels. *Conclusion*: In this sample of 25 ethnic obese adolescents transient cardiometabolic changes were observed during Ramadan fasting. Since most of these changes were reversible within 6 weeks, there seems no harm or benefit for obese adolescents to participate in Ramadan.

Keywords Ramadan · Intermittent fasting · Body Mass Index · Body composition · Adolescents

Communicated by Peter de Winter

N. Radhakishun (✉) · C. Blokhuis · I. von Rosenstiel · O. Weijer
Department of Pediatrics, Slotervaart Hospital, Louwesweg 6, 1066 EC Amsterdam, The Netherlands
e-mail: Nalini.Radhakishun@slz.nl

M. van Vliet · D. Brandjes
Department of Internal Medicine, Slotervaart Hospital, Louwesweg 6, 1066 EC Amsterdam, The Netherlands

N. Radhakishun · M. Diamant
Diabetes Center, Department of Internal Medicine, VU University Medical Center, De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

M. Heymans
Department of Epidemiology and Biostatistics, VU University Medical Center, De Boelelaan 1117, 1081 HV Amsterdam, The Netherlands

J. Beijnen
Department of Pharmacy & Pharmacology, Slotervaart Hospital, Louwesweg 6, 1066 EC Amsterdam, The Netherlands

Introduction

During the month of Ramadan, Muslims abstain from all food and fluids between sunrise and sunset [2]. This radical change in lifestyle has shown to influence the cardiometabolic risk profile in both healthy and overweight adults [2]. Potential effects of Ramadan fasting on the cardiometabolic profile in obese adolescents have not as yet been studied. We hypothesize that participation in the fasting may induce weight loss and an associated improvement in cardiometabolic health. To this end, we determined adiposity variables, blood pressure, plasma glucose, lipids, and high sensitivity C-reactive protein (hs-CRP) before, during and after Ramadan in a pilot study with obese ethnic adolescents.

Methods

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Review Board.

Written informed consent was obtained from all participants, and, if younger than 18 years, their parents/guardians.

Subjects were recruited from the childhood obesity outpatient clinic, high schools, activity centers, and Mosques in Amsterdam. All obese adolescents between 12 and 18 years old who participated in Ramadan fasting of 2012 were eligible to participate in the study. Adolescents with diabetes mellitus, any chronic disease, or known underlying condition potentially causing or contributing to their obesity were excluded.

The first visit took place in the week before (week 0), the second in the last week (week 4), and the third 6 weeks after conclusion of Ramadan (week 10). During each visit, anthropometrics and fasting blood samples were collected. Since Ramadan 2012 was celebrated during the Dutch school holiday, participants were asked to report, if applicable, the period and destination of their vacation. Participants documented the amount of days they fasted and four 24-h dietary questionnaires were administered during the first, second, and last week of Ramadan and one at week 10.

Height was measured using the same standardized stadiometer. Weight and body composition were measured in fasted stated, with the participants in light clothing, standing barefoot on metal foot-plates while holding the handles of the bioimpedance analyzer (BIA; BC-418, Tanita Europe, Amsterdam, NL), which calculates estimates of fat mass, fat free mass (FFM), and total body water (TBW). Body Mass Index (BMI) was standardized using Z-scores according to Dutch reference values, and obesity was defined as Z-BMI >2.3 [7]. Pubertal stage was assessed using a visual representation of the Tanner stages. Blood pressure was measured with an automatic blood pressure device, three times with a 5-min interval at the right upper-arm using an appropriately sized cuff with the participant in the seated position (Welch Allyn, NY, USA).

Fasting blood samples were obtained after an overnight fast of at least 10 h at week 0 and week 10. In week 4 (last week of Ramadan), the blood samples were collected in the evening, after a fast of at least 10 h. Plasma glucose levels, total cholesterol, high-density lipoprotein (HDL) cholesterol, and triglycerides were measured by standardized validated methods (SYNCHRON LX20, Beckman Coulter, Roche, Belgium). Low-density lipoprotein (LDL) cholesterol was calculated by the Friedewald formula. Plasma insulin levels were measured by ADVIA Centaur insulin assay (Siemens, The Netherlands; intra-assay variation, 4.6 %; inter-assay variation, 6 %). Insulin resistance was calculated according the HOMA-IR equation: fasting glucose (mmol/L)*fasting insulin (mU/L)/22.5≥3.5 [9]. Hs-CRP was measured by SYNCHRON CX (Beckman Coulter, Roche, Belgium; intra-assay variation 5.5 %; inter-assay variation 4.5 %).

Sample size calculation was performed with SAS proc power version 9.2. To detect a mean difference of 0.3 in Z-BMI score in a paired sample, with a standard deviation of 0.7, a correlation of 0.5, an alpha error level of 5 %, and a power of 80 % (two-sided test), a sample of 40 subjects was required.

Baseline data were stratified according to sex, and differences were tested by Student's *t*-tests or ANOVA while the difference in caloric intake during and outside Ramadan was tested with the Wilcoxon signed ranks test. Linear mixed model analysis with random slopes was used to assess the differences between week 4 and 10 and baseline while adjusting for age, Z-BMI, mean caloric intake, and fasting hours where appropriate. Due to the small sample size, adjustment for more confounders was not possible. A P value of <0.05 was considered significant. All analyses were performed with SPSS, version 18.0 (for Windows).

Results

The month of Ramadan 2012 lasted for 30 days, i.e., from July 20 to August 19, 2012. Twenty-five participants were included at baseline (Table 1), 23 were present at week 4 (one participant reported unplanned traveling abroad and one a viral infection), and all 25 returned at week 10. The median of days fasted was 25 (range 16–30) days and the median per 24 h of fasting 15 (range 14–16 h). Since women do not fast during their menstruation, the median days fasted for girls was 25 (range 17–30).

Z-BMI did not change after Ramadan (Table 1). A significant decrease in body fat percentage and significant increases in heart rate, total cholesterol, LDL cholesterol, HDL cholesterol, and hs-CRP were found at week 4. All these parameters returned to baseline levels at week 10 (Table 1).

The median caloric intake during Ramadan was 1514 (range 748–3565) kcal and after Ramadan 1448 (range 725–2199) (P=0.045). The mean caloric intake and the hours spent fasting did not have any significant influence on the changes in body composition or any of the cardiometabolic parameters.

Discussion

This is the first study that determined the effect of Ramadan fasting in obese adolescents; we found that a mean fasting of 15 h/day during Ramadan 2012 had no effect on Z-BMI or glucose metabolism. Temporary changes in body composition and transient increases in total, LDL, and HDL cholesterols and hs-CRP were observed, all of which normalized 6 weeks after conclusion of Ramadan fasting. Interestingly, other studies, all of which were conducted in overweight adults have reported weight loss during Ramadan, despite stable [10, 11] or even increased caloric intake [1]. In our cohort, the median reported intake during Ramadan was significantly higher compared to the intake after Ramadan and could partially explain the stable Z-BMI.

In spite of no effect on blood pressure, mean heart rate rose significantly by the end of Ramadan. Although circulating markers of hydration (e.g., hematocrit) were not measured,

Table 1 Parameters before, during, and after Ramadan

	Baseline	T1	T2
N	25	23	25
Pubertal stage (Tanner)	4 (2–5)	4 (2–5)	4 (2–5)
Height (m)	1.65 (1.57–1.78)	1.65 (1.57–1.78)	1.66 (1.57–1.79)
Weight (kg)	90.3 (73.4–129)	88.6 (73.9–129)	90.8 (74.9–127)**
BMI (kg/m^2)	31.7 (28.2–42.0)	31.6 (27.8–42.1)	31.6 (27.8–41.0)*
Z-BMI	3.2 (2.7–4.1)	3.3 (2.7–4.1)	3.3 (2.7–4.0)
Fat percentage (%)	39.6 (26.5–51.5)	37.1 (26.3–46.1)**	39.7 (25.4–48.9)
Fat free mass (kg)	50.5 (45.1–70.1)	51.9 (45.7–72.6)**	52.6 (45.8–70.8)**
Total body water (kg)	37.0 (33.0–51.3)	38.0 (33.5–53.1)**	38.5 (33.5–51.8)**
Systolic blood pressure (mmHg)	122 (105–139)	124 (107–153)	123 (104–142)
Diastolic blood pressure (mmHg)	70 (49–84)	72 (59–93)	71 (60–86)
Heart rate (bpm)	75 (57–93)	80 (59–103)**	78 (60–100)
Fasting plasma glucose (mmol/L)	5.2 (4.7–5.7)	5.2 (4.5–6.9)	5.3 (4.7–6.2)
Fasting plasma insulin (pmol/L)	144 (47–288)	145 (49–236)	144 (55–270)
HOMA-IR	4.74 (1.50–10.1)	4.56 (1.51–10.2)	4.70 (1.76–9.33)
Total cholesterol (mmol/L)	3.94 (2.96–5.71)	4.50 (3.24–6.77)**	4.00 (3.22–5.63)
LDL cholesterol (mmol/L)	2.40 (1.86–3.98)	2.91 (1.95–4.75)**	2.56 (1.60–3.75)
HDL cholesterol (mmol/L)	1.07 (0.65–1.61)	1.11 (0.76–1.73)**	1.06 (0.77–1.53)
Triglycerides (mmol/L)	0.94 (0.35–2.15)	0.84 (0.35–1.79)	0.79 (0.43–1.90)
TC/HDL ratio	3.84 (2.52–5.84)	3.98 (2.49–5.60)	3.92 (2.59–4.95)
HS-CRP (mg/mL)	3.36 (0.24–6.23)	2.59 (0.45–10.0)a*	2.66 (0.67–10.51)a

Data are displayed as median (ranges). A linear mixed model analysis with random slopes was used to calculate the differences between the follow-up visits and baseline. Baseline—week before Ramadan, after an overnight fast of >10 h. T1—last week of Ramadan, after a daytime fast of >10 h. T2—6 weeks after Ramadan, after an overnight fast of >10 h

Z-BMI standard deviation score of Body Mass Index; *HOMA-IR* Homeostasis Model Assessment for Insulin Resistance; *HDL* High-density lipoprotein; *LDL* Low-density lipoprotein

[a] outliers excluded

* *P* value <0.05

** *P* value <0.01

we speculate that the tachycardia response may be due to mild dehydration due to reduced fluid intake, compatible with fasting [12]. The normalization of the heart rate at 6 weeks after Ramadan may support this hypothesis.

Even though body weight remained stable, we observed a decrease in fat percentage after 17–30 days of fasting. This may be due to an increased lipolysis and subsequent fat oxidation during prolonged fasting [5]. Surprisingly, FFM and TBW were significantly higher in the last week of and 6 weeks after Ramadan fasting compared to baseline. This counterintuitive finding could possibly be caused by the slight imprecision of BIA in measurements at different time points (late afternoon in the last week of Ramadan vs. morning at baseline and T2). Moreover, BIA is less accurate when used in obese children [4].

Comparable to other studies in overweight adults [5, 10, 11], no changes were found in plasma triglycerides; however, a significant increase in total, LDL, and HDL cholesterols was observed after Ramadan fast, all of which normalized at follow-up. A previous study among 36 healthy Tunisian adults showed increases in total cholesterol and LDL cholesterol levels after Ramadan, which, unlike our results, persisted at 1-month follow-up [3]. Factors that could explain this are differences in the follow-up period, ethnicity, physical activity, and dietary intake.

Childhood obesity is associated with a low-grade inflammatory state [6], and increments in hs-CRP are an important predictor for the development of atherosclerotic disease [8]. We found an increase of hs-CRP levels at the end of Ramadan. Possible explanations for this finding are low-grade stress through fasting, an altered sleep–wake cycle, increase in fat oxidation or hepatic steatosis [3, 8]. It must be noted that hs-CRP returned to baseline level 6 weeks after Ramadan, and due to the high variability and low specificity of hs-CRP, the clinical significance of the short-term elevation in hs-CRP is limited.

Limitations of this study include the broad range of days fasted during Ramadan (16 to 30 days). Although we could

assume a change in circadian rhythm during Ramadan, we did not measure parameters such as cortisol. Moreover, we did not administer a 24-h dietary questionnaire prior to Ramadan; this could cause a potential bias since compensatory eating could occur after Ramadan. Due to the summer holiday and cultural aspects, the present study has a small sample size. The adolescents in our cohort were mainly from Turkish and Moroccan descent. Although we did not find an effect of ethnicity in our statistic models, these two groups do represent a different population with different eating habits. Finally, we could not include a normal-weight control group, which precludes generalization of our results.

In conclusion, in a group of 25 ethnic obese adolescents, transient cardiometabolic changes were observed during Ramadan fasting. Since most of these changes were reversible within 6 weeks, there seems to be no harm for obese adolescents to participate in Ramadan.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Adlouni A, Ghalim N, Benslimane A, Lecerf JM, Saile R (1997) Fasting during Ramadan induces a marked increase in high-density lipoprotein cholesterol and decrease in low-density lipoprotein cholesterol. Ann Nutr Metab 41(4):242–249
2. Azizi F (2010) Islamic fasting and health. Ann Nutr Metab 56(4): 273–282
3. Barkia A, Mohamed K, Smaoui M, Zouari N, Hammami M, Nasri M (2011) Change of diet, plasma lipids, lipoproteins, and fatty acids during Ramadan: a controversial association of the considered Ramadan model with atherosclerosis risk. J Health Popul Nutr 29(5):486–493
4. Campanozzi A, Dabbas M, Ruiz J, Ricour C, Goulet O (2007) Evaluation of lean body mass in obese children. Eur J Pediatr 167(5):533–540
5. 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(2):302–307
6. Ford ES, Galuska DA, Gillespie C, Will JC, Giles WH, Dietz WH (2001) C-reactive protein and body mass index in children: findings from the Third National Health and Nutrition Examination Survey, 1988–1994. J Peds 138(4):486
7. Fredriks A, Van Buuren S, Wit J, Verloove-Vanhorick S (2000) Body index measurements in 1996-7, compared with 1980. Arch Dis Child 82(2):107–112
8. Hall JE (2010) Guyton and hall textbook of medical physiology. Saunders, Philadelphia
9. Matthews D, Hosker J, Rudenski A, Naylor B, Treacher D, Turner R (1985) Homeostasis model assessment: insulin resistance and B-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 28(7):412–419
10. Sadiya A, Ahmed S, Siddieg HH, Babas IJ, Carlsson M (2011) Effect of Ramadan fasting on metabolic markers, body composition, and dietary intake in Emiratis of Ajman (UAE) with metabolic syndrome. Diabetes Metab Syndr Obes 4:409–416. doi:10.2147/dmso.s24221
11. Salehi M, Neghab M (2007) Effects of fasting and a medium calorie balanced diet during the holy month Ramadan on weight, BMI and some blood parameters of overweight males. Pak J Biol Sci 10(6): 968–971
12. Trabelsi K, el Abed K, Stannard SR, Jammoussi K, Zeghal KM, Hakim A (2012) Effects of fed- versus fasted-state aerobic training during Ramadan on body composition and some metabolic parameters in physically active men. Int J Sport Nutr Exerc Metab 22(1):11–18