Evaluation of the effect of islamic fasting on lung volumes and capacities in the healthy persons

Seyyed-Ali J. Moosavi, MD, Ali Kabir, MD, Ali Moghimi, MD, Ali Chehrei, MD, Mohammad B. Rad, MD.

ABSTRACT

Objectives: To evaluate the changes in pulmonary volumes during and after Islamic fasting.

Methods: It is a cohort study conducted on 117 healthy subjects selected on a random basis from employees, professors and students of Iran University of Medical Sciences, Tehran, Iran, between December 1999 and January 2000. All of them underwent spirometry 10 days prior to Ramadan, 2 times during Ramadan, and one time 10 days post-Ramadan. In first visit, in addition to spirometry they underwent medical examination to make sure they are healthy. All of their spirometries and background information were collected. Repeated measurements analysis of varience method was used to compare the measurements.

Results: Approximately 69% of subjects were male and the mean age was 23.9 years. Mean fasting time was 27.8 days. The mean difference in forced expiratory volume in 1 second (FEV1%) was significant between the 4 visits (p=0.01). The mean FEV1% increased both during fasting and after Ramadan (p=0.017). The mean vital capacity and peak expiratory flow rate values increased during Ramadan significantly (p=0.043, p<0.001). Although the mean maximum mid-expiratory flow decreased in the beginning of Ramadan and significantly increased subsequently (p=0.02), MEF50% (p=0.004) and MEF75% (p=0.047) increased in the beginning of Ramadan and decreased subsequently.

Conclusion: As a whole, fasting increases lung volumes and might improve pulmonary function. This finding seems to be relevant to the changes in weight during Ramadan.

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From the Department of Internal Medicine, Pulmonology Ward, Iran University of Medical Sciences, Nikan Health Researchers Institute, Tehran, Iran.

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Address correspondence and reprint request to: Dr. Ali Kabir, Agha-Rahimi Alley, Sattarkhan St, PO Box 14155/3651. Tehran, Iran. Tel. +98 (21) 66516995. Fax. +98 (21) 44468645. E-mail: aikabir@yahoo.com

Ramadan fasting is one of the most important religious duties in Islam. During this month, Moslems avoid eating and drinking from sunrise up to sunset. There are many Islamic discourses and narratives in psychosomatic effects of fasting, which during past 2 decades have caught the interest of researchers in different ways. Refrainment from eating and drinking could be stressful or at least different from usual daily routine, which makes physiologic and functional changes in the organs. If these changes are desirable, fasting could be used to improve organ function and applied as a tool in the treatment or control of diseases. Many studies have been conducted to study fasting relationship with many diseases such as diabetes, thyroid disorders,[1-3] Gilbert syndrome,[4] peptic ulcer,[5] and evaluate the effect of fasting on weight or serum uric acid level[6] and pregnancy.[7] Despite the fact that people fasting generally experience significant improvement in their respiratory function, but only few people observe closely in this study. Few researches performed on animal models to evaluate the effect of long time starvation on pulmonary function and it shows emphysematous changes in animals. The possible mechanism could be decreased in surfactant level. Therefore, the purpose of this study is to evaluate the changes of lung volumes and capacities, according to conventional spirometry, in normal subjects fasting in Ramadan.

Methods. This cohort study was performed between December 1999 and January 2000 (Ramadan 1420 hijra) in Medical Faculty, University of Medical Sciences, Tehran, Iran, on students, professors and employees of faculty (as healthy persons). Sampling was carried out by a simple randomization method. All included subjects were healthy non-smoker according to their history and physical examination, with ideal condition for fasting, and were able to carry out their cooperation in whole period of study. We

excluded the following cases: smoker (7.9%), asthmatic (2.1%), chronic bronchitis (1.4%), and developed pneumonia (1.4%).

In the beginning of the study, a calendar was given to the subjects containing visit dates. In female subjects, the criteria for admission to the study were appropriate health condition, and the lack of presence of menstrual period bringing on religious prohibitions (Muslims are not permitted fast during menstruation period). The inclusion criteria included presence at all visits, not being fast in the first and fourth visits and being fast at least 3 days before the second and third visits.

The first visit was carried out 10 days prior to Ramadan. At first visit in addition to the full examination regarding respiratory tract, the subjects were addressed with relevant questions and medically examined so that the data on height, weight, gender, age, smoking history, any record of possible pulmonary disease, and presence of chest deformities such as kyphoscoliosis were collected. The second, third and fourth visits were carried out respectively at first half of Ramadan, the second half of Ramadan, and 10 days after Ramadan. All spirometries were carried out by 2 mobile Fukuda spirometers. In each visit, forced expiratory volume in one second (FEV1), forced vital capacity (FVC), peak expiratory flow rate (PEFR), vital capacity (VC), proportion of FEV1 to VC (FEV1/VC), maximum mid-expiratory flow (MMEF), MEF25%, MEF50% and MEF75% were measured. According to predicted values for their age, gender, height and weight, the percentage of obtained values were recorded and expressed as percentage of parameter. Subjects did not have to fast for at least 3 days in first and last visit and it was necessary to fast for at least 3 days in second and third visits. Study subjects were reminded by phone before the second, third and fourth sessions to make sure that they would attend the visit sessions. The time of spirometry was from 12 mid-day up to 4 pm. The sample size calculation came out to involve 118 healthy individuals given alpha=0.05, power = 80%, and clinical difference equal to 0.3 of standard deviation, using comparing means formula, and with pre-assumption of 20% loss. Firstly, 145 subjects were entered into the study. At last, 117 subjects met the eligibility criteria and completed all 4 visits.

Informed consent was obtained from each cases included in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki. The safety procedures was explained to the patients.

Statistical analysis. Quantitative variables were described as mean (95% confidence interval) and qualitative ones by relative frequency. We used paired sample t-test and chi-square test to compare the means and ratios. Pearson correlation coefficient was used to evaluate correlation between quantitative parameters. To compare the mean values of variables concerning lung volumes in 4 different visits, repeated measures analysis of variance method was used. Linear mixed model analysis was used to determine the effect of repeated covariates such as weight and fasting days. We considered the probability values <0.05 as statistically significant.

Results. Of the 117 cases, 77 (65.8%) were males and 40 (34.2%) were females. The mean age was 27.9 years (ranged, 26.2-29.6 years). The mean weight value before Remadan was 67.6 kg (range, 65.7-69.5 kg) and after Ramadan 67.1 kg (range, 65.2-69 kg). There was a significant difference (p<0.001) between pre- and post-Ramadan mean weights. The mean height was 167.1

Table 1 - Comparison of volumes and capacities in 4 different visits.

Volumes and capacities	Before ramadan	First half of ramadan	Second half of ramadan	After ramadan	Sig.
FEV1	87.5 (84.4-90.6)	90.7 (87.7-93.6)	91.4 (88.6-94.2)	92 (88.9-95.1)	0.017
FVC	85.4 (82.2-88.6)	86.2 (82.8-89.5)	88.3 (85.2-91.3)	88.6 (85.4-91.8)	NS
VC	85.8 (82.8-88.9)	84.5 (80.5-88.6)	88.7 (85.7-91.7)	88.7 (85.6-91.7)	0.043
FEV1/FVC	81.4 (78.6-84.2)	87 (84.6-89.4)	84.4 (82.3-86.5)	83.8 (81.8-85.7)	0.002
PEFR	71.1 (66.5-75.8)	83.4 (79.3-87.5)	88.8 (84.8-92.8)	89.4 (85.8-93.1)	<0.001
$MEF_{75\%}$	93.1 (86.9-99.2)	101.3 (94.8-107.8)	98.3 (92.2-104.4)	95.2 (90-100.4)	0.047
$MEF_{50\%}$	88.8 (83.2-94.4)	96.4 (91.5-101.4)	94.6 (89.1-100.2)	94.7 (89.5-99.9)	0.004
$MEF_{25\%}$	89.3 (82-96.5)	100.3 (93.3-107.3)	102.1 (94.8-109.4)	125.9 (72.6-179.3)	NS
MMEF	88.3 (83-93.7)	95.7 (90.7-100.6)	94.6 (89.2-100.1)	93.2 (88-98.4)	0.007

FEV1 - forced expiratory volume in one second, FVC - forced vital capacity. VC - vital capacity. PEFR - peak expiratory flow rate, $MEF_{25\%}$ - mid-expiratory flow during 25% of emitted volume, $MEF_{50\%}$ - mid-expiratory flow during 50% of emitted volume, $MEF_{75\%}$ - mid-expiratory flow during 75% of emitted volume, MMEF - maximum mid-expiratory flow, NS - not significant

Table 2 - Significant correlation between height, weight, and lung volumes and number of fasting days.

Parameters	Fasting days	
	Significant correlation	Correlation coefficient
Weight 1	0.001	0.365
Weight 2	0001	0.352
Weight 3	<0.001	0.399
Weight 4	<0.001	0.409
Height	<0.001	0.398
$MEF_{50\%}$*	0.02	-0.249
MMEF*	0.032	-0.231

*at the third visit (Second half of Ramadan), $MEF_{50\%}$ - mid-expiratory flow during 50% of emitted volume

cm (range, 164.9-169.2 cm). The mean fasting days were 26.2 days (range, 25.1-27.3 days). There was a significant difference between the mean of FEV1% and VC% in 4 different visits (p=0.017, p=0.043), which during fasting and after Ramadan showed increment. There was no significant difference in mean FVC% among visits. The mean FEV1/FVC% in different visits showed significant difference as well (p=0.002). The mean PEFR% increased during fasting especially after Ramadan (p<0.001). There was a significant difference in the mean MMEF% between different visits, (p=0.007). Although the mean MMEF% decreased in early Ramadan and increased thereafter; there was no significant difference in the mean MEF25% in 4 different visits. The mean MEF50% also changed significantly during the study period (p=0.004). The mean MEF50% decreased in early Ramadan and increased in the third and fourth visits. Similarly, the mean MEF75% differed significantly (p=0.047). During Ramadan, the mean MEF75% increased but after Ramadan period it decreased; however, it did not reach its level of pre-Ramadan. Fasting days was correlated with VC% at the first half of Ramadan (r=0.240, p=0.025), with FEV1/FVC% at the first (r=-0.225, p=0.036) and second (r=-0.270, p=0.011) half of Ramadan, with height, MMEF and MEF50% at the second half of Ramadan and with weight in 4 visits significantly (**Table 2**). Weight loss had only a significant effect on increase in MMEF (p=0.017), MEF50% (p=0.011), and FEV1/FVC% (p=0.002). The significant effect of fasting days on different volumes and capacities are summarized in **Table 2**. Considering the effect of both weight and fasting days, these 2 factors came out to have a significant effect on MMEF (p=0.04), MEF50% (p=0.023), PEF (p=0.014), VC (p<0.001), FVC (p=0.04), and FEV1 (p=0.037). Gender differences in male and female socio-demograhic and spirometry findings are summarized in **Table 3**.

Table 3 - Gender differences in participant sociodemographic and spirometry findings.*

Parameters	Men	Women	*P*-value
Weight†	70.4 ± 1.17	62.2 ± 1.36	<0.001
Height†	172.2 ± 0.95	157.2 ± 1.68	<0.001
PEF†	75.2 ± 2.96	63.2 ± 3.53	0.014
MMEF†	92.6 ± 3.39	80.2 ± 4.19	0.028
Weight‡	69.9 ± 1.19	61.6 ± 1.35	<0.001
FEV1‡	93.6 ± 1.76	85 ± 2.53	0.006
FVC‡	89.8 ± 2.11	79.2 ± 2.42	0.002
PEF‡	88.7 ± 2.64	73.2 ± 2.77	<0.001
Weight§	69.5 ± 1.19	61.1 ± 1.37	<0.001
FVC§	90.6 ± 1.84	83.8 ± 2.72	0.039
PEF§	92.9 ± 2.52	80.9 ± 3.02	0.004
Weight**	69.8 ± 1.2	61.8 ± 1.35	<0.001
FEV1/FVC**	82.3 ± 1.23	86.6 ± 1.46	0.035
PEF**	92.6 ± 2.39	83.4 ± 2.65	0.017
Fasting days	27.1 ± 0.7	23.9 ± 0.7	0.01

*mean±SE, †at the first visit (before Ramadan), ‡at the second visit (first half of Ramadan), §at the third visit (second half of Ramadan), **at the fourth visit (After Ramadan), FEV1 - forced expiratory volume in one second, FVC - forced vital capacity. VC - vital capacity. PEFR - peak expiratory flow rate, MEF - maximum mid-expiratory flow, MMEF - maximum mid-expiratory flow, NS - not significant

Discussion. Our results show that fasting increases the lung volumes and capacities in healthy persons. Measurements showed an increasing trend in the means of FEV1%, PEFR%, VC%, FEV1/FVC% and MMEF% during fasting as compared to pre-Ramadan values. Further, several animal models have been designed for evaluation of long-time starvation effect on respiratory tract function, but few human model studies has been conducted. Siddiqui et al[8] studied 46 healthy non-smoker males to evaluate the effect of fasting on lung function values. Their results indicated that no significant change was seen in lung function during Ramadan as compared to the pre-Ramadan period. Forced vital capacity was decreased significantly in the post-Ramadan period compared to Ramadan and this period was associated with a significant increase in body mass. In addition, they concluded in comparison with the pre-Ramadan baseline values, that there was no changes in spirometry during Ramadan fasting in their subjects. In another study conducted by Wheatly and Shelly[9] on Malian Moslems, discontinuation of bronchodilators in Ramadan resulted in exacerbation of their disease. Subhan et al[10] carried out a similar study with lower sample size on women.[10] They believe that fasting has no effect on expiratory flow rates. Our study

is one of the largest that focused on both males and females; it is also a unique study considering the use of a mix model analysis in determining the effect of weight, as a covariate in each visit, on lung volumes. It has been suggested that body weight affects the pulmonary function values. Hakala et al[11] showed that weight loss reduces airway obstruction as well as PEFR variability in obese patients with asthma. Another study revealed similar result.[12] To explain the mechanisms resulting in changes in pulmonary volumes factor, which first comes to the mind, is the changes in the body weight. Nutritional intake and frequency of meals usually change during fasting. Although the total food consumption is limited during the month of Ramadan, more main dishes are prepared at home and more desserts are usually consumed. Furthermore, many individuals reduce their physical activity during the month of Ramadan. As a result, the total body metabolism is affected and lipid metabolism and blood lipid levels change during this month.[13] Yet, there are controversial data on the effect of Ramadan on body weight. The study of Harkema et al[14] on 38 healthy volunteers revealed that there is no significant change in weight, body mass index and abdominal fat distribution. However, in young and female individuals there was a reduction in visceral fat compartment. In our study, the mean weight of subjects was significantly higher after Ramadan. In spite of this event, all pulmonary volumes even VC increased while fasting. Siddiqui et al[8] seem that loosing body weight is not the major mechanism in explaining volume changes.

In animal models, feeding with one third to one fifth of daily food with enough water for 10 days, is being considered as food deprivation.[14-19] Change in recoil elasticity of lung in these models happens due to tissue damage and this results in a rise in compliance capacity-the reason for volume increasing.[15,17,20] Other explanations for these changes are decrease in elastin and collagenous level due to loss of primary substrate.[14-17] In addition, increase in function of destructive and anti-proteolytic enzymes are mentioned as probable causes.[15] These changes lead to an increasing pulmonary function, which cannot be improved by refeeding due to irreversible nature of changes.[15-17] There are different explanations for the mechanisms of these changes in various studies; such as increase in surface elasticity force,[15-17,20] increase in DNA contents[18] and depletion of whole lung protein RNA contents[17] and surfactant due to decrease in phospholipids, mitochondrial disturbances and loss of necessary substrates. These courses may be, for a long time starvation, not for the short course.[21-22] Other probable mechanisms to explain changes in lung volumes during month of Ramadan includes decrease in contact with food allergens, flattening of diaphragm due to stomach emptiness, decrease smoking, and decrease gastroesophageal reflux. In addition, starvation as a stress cause increase in catecholamine and this by itself has bronchodilator role. These points should be considered in further investigations. There are some confounding factors affecting our results. In our study, all subjects were aware of study goals. This might raise concern for religious prejudice, which might inspire subjects to carry more efforts in spirometry testing, during Ramadan. Nevertheless, randomized selection makes this factor less effective. In addition, spirometries were carried out by 2 spirometers, which could bring some errors and biases. Calibration of instruments made the errors minimum. To counterbalance the possible biases, we used the same spirometer for each subject in different visits. In the pilot study, there was no significant difference between the 2 spirometers while measuring each person's parameters.

We conclude that fasting does not aggravate bronchospasm in healthy subjects. Moreover, it might improve the pulmonary function values. According to the result of this study and similar animal models, we suggest to focus on histological changes and biochemical alterations in future studies in order to find the mechanisms process. In addition, it should be noted that this study must be performed on healthy subjects. In spite of the positive effect of fasting on lung volumes, our results cannot generalized patients with pulmonary disease. These result will be used in future studies to evaluate the effect of fasting.

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