# Does Ramadan fasting affect expiratory flow rates in healthy subjects?

*Mirza M. F. Subhan,* PhD, *Qamar A. Siddiqui,* MBBS, MPhil, *Mohammed N. Khan,* BSc, *Salman Sabir,* MSc.

## ABSTRACT

**Objectives:** To assess whether Ramadan fasting affects the expiratory flow rates in healthy subjects, and to know if these effects correlate to a change in other variables.

**Methods:** This unmatched case-control longitudinal study includes 46 non-smoking healthy subjects who undertook lung function testing at the Aga Khan University, Pakistan. Expiratory flow rates and body mass were measured in 3 Islamic months, corresponding to November 2001 to January 2002.

**Results:** There was a significant reduction in body mass in Ramadan compared to pre and post Ramadan. No significant changes in expiratory flows were seen during Ramadan as compared to the pre Ramadan period. However, forced expiratory flow rates at 75% of vital capacity ($FEF_{75}$) and between 75% and 85% of vital capacity ($FEF_{75-85}$) showed a significant increase in the post Ramadan period compared to Ramadan. Changes in $FEF_{75}$ were negatively correlated to changes in body mass between Ramadan and post Ramadan.

**Conclusion:** This study shows that Ramadan fasting will not affect expiratory flow rates in healthy subjects. Post Ramadan values did show an increase in $FEF_{75}$ and $FEF_{75-85}$, possibly due to changes in body water and fat content. The reductions in body mass were most probably due to lack of nutrition and not dehydration as the fasts were performed in winter. Collection of reference values or early phase clinical trials measuring expiratory flow rates should not be affected by Ramadan fasting.

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Lung function testing has become a part of the routine health examination in pulmonology, public health screening, occupational and sports medicine. Spirometry is the most basic, widely used, cost effective test in pulmonology. Measurements typically assess lung volumes and flows and discriminate restrictive from obstructive categories of respiratory disease.[1]

As fasting is one of the 5 major pillars of Islam, up to 400 million Muslims worldwide observe the fast during the Islamic month of Ramadan.[2] The Lunar Islamic months are of 29-30 days and have a total of 355 days in a year. Therefore, relative to the Gregorian calendar, Ramadan can rotate to either the winter or summer seasons. The total hours of fasting from dawn to sunset varies according to the season and also the geographical location.

The effects of Ramadan fasting on public health are of importance to physicians and health care personnel wherever there is a sizable Muslim population. Various studies have seen the effects of Ramadan fasting on changes in body function, including body

From the Department of Physiology (Subhan), King Saud University, Riyadh, *Kingdom of Saudi Arabia*, Department of Physiology (Siddiqui), Baqai Medical University, Department of Biological and Biomedical Sciences (Khan), and the Department of Community Health Sciences (Sabir), Faculty of Health Sciences, Aga Khan University, Karachi, *Pakistan*.

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Address correspondence and reprint request to: Dr. Mirza M. F. Subhan, Assistant Professor, Department of Physiology (29), College of Medicine, PO Box 2925, King Saud University, Riyadh 11461, *Kingdom of Saudi Arabia*. Tel. +966 (1) 4671605. Fax. +966 (1) 4672567. E-mail: mfsbeg@ksu.edu.sa

mass,[3] fluid and electrolyte balance,[3-5] lipid levels,[6] glucose metabolism,[7] and exercise.[8] Two studies have investigated the effects of Ramadan fasting on spirometric variables. In one, Ramadan variables were compared with post-Ramadan variables.[9] The limitations of this study are that only 13 subjects were studied, that post-Ramadan values were taken as baseline and that PEF was the only expiratory flow measured. The other showed that PEF and $FEF_{25-75}$, did not change before, during and after Ramadan fasting.[10]

In a Muslim population, it is important to compare expiratory flow rates during Ramadan fasting to non fasting states in healthy subjects, particularly when collecting data on reference values in normal and also in clinical trials, involving healthy subjects. No study has investigated the effect of Ramadan fasting on the expiratory flow rates $FEF_{25}$, $FEF_{50}$, $FEF_{75}$, and $FEF_{75-85}$.

The aim of this study was to see whether Ramadan fasting affects normal expiratory flow rates and if there were changes, did these correlate with any anthropometric or spirometric variable. We, therefore, studied the effects of Ramadan fasting on expiratory flow rates on pre and post-Ramadan time points.

**Methods.** This was a prospective longitudinal case-control study, in which unmatched healthy subjects underwent lung function testing. Tests was performed during a 10-day period before Ramadan (during the Islamic month of Sha'ban), then during Ramadan and after Ramadan (during the Islamic month of Shawwal). In the year 2001-2002 these 3 Islamic months corresponded to the Gregorian months of November, December and January, respectively.

Forty-six non-smoking healthy male subjects were recruited by personal request from the staff and students of the Aga Khan University (AKU). This study was conducted at the Aga Khan University, Karachi, Pakistan. Their mean age was 24.2 years (SD ± 6.4), range 16-41 years. Informed consent was obtained before the study commenced and the study was approved by the AKU ethical committee and performed according to the Declaration of Helsinki (1989). All subjects completed a questionnaire, which included anthropometric data and a consent form. Body mass and height in indoor clothing and without shoes were measured (Seca, Hamburg, Germany). The weighing machine was regularly checked with a 25 kg standard weight. Female subjects were not included as Muslim laws (Shar'iah) forbid women to fast during their menses and lung function is also slightly lower during menses.[11]

A history and physical examination was performed to select healthy subjects and to exclude those with gross abnormalities of the vertebral column or thoracic cage, known history of malignancy, diabetes mellitus, respiratory, neuromuscular or cardiovascular disease and those who had undergone major abdominal or thoracic surgery. Subjects who had a $FEV_1$/FVC ratio lower than 70% or an abnormal body mass index (BMI) were also excluded. In addition, subjects with current or previous drug or tobacco (smoked or chewed) addictions or who chewed betel nut were also excluded. Betel nut chewing is common in Pakistan and has been associated with asthma.[12]

Pulmonary function tests were performed on an electronic spirometer (Compact Vitalograph, Buckingham, UK). All these tests were performed after 11 am and preferably between 2 and 4 pm to minimize diurnal variation.[13] Four FEF values were measured, all in l/s. $FEF_{25}$, the maximal flow rate when 75% of the FVC remains to be expired, is a related, but less commonly used alternative to PEF.[11] The $FEF_{50}$, maximal flow rate when 50% of the FVC remains to be expired, and the $FEF_{75}$, the maximal flow rate when 25% of the FVC remains to be expired, are both thought to show the flow properties in airways of diameter more than 3 mm and less than 3 mm, respectively.[11] Both are commonly assessed during respiratory surveys. Both the $FEF_{75}$ and the $FEF_{75-85}$, the mean flow rate between expiration of 75% and 85% of the FVC, are therefore thought to reflect small airway caliber.[11] All these 4 tests do have low reproducibility.

Apart from the expiratory flows, FVC, $FEV_1$, $FEV_1$/FVC% ratio and PEF, $FEF_{25-75}$ were also measured. Their data has been previously presented.[10]

The apparatus was calibrated daily with a 1 liter calibration syringe (Vitalograph, UK) and operated within a temperature range of 20-23°C. The maneuver was explained to the subjects and 3-5 maneuvers were performed after adequate rest. Maneuvers were performed in an upright sitting position without a nose clip, as a very insignificant amount of air is expelled through the nose during a forceful expiration,[11] and disposable mouthpieces were used for each individual. Tests were conducted according to American Thoracic Society recommendations.[14] The subject was asked to take in a deep breath as hard as possible and then expire forcefully into the mouthpiece of the spirometer as rapidly as possible. The highest expiratory flow values were chosen, irrespective of the test. All lung volumes were corrected to body temperature and pressure saturated with water vapor.

Comparisons of 5 variables of anthropometry and lung function were made between pre Ramadan,

Ramadan fasting and post Ramadan values. The results were obtained by applying repeated measures analysis of variance (ANOVA). Bonferroni's correction was used to adjust for type-1 errors. The pulmonary function data was correlated against changes in body mass. Linear regression was applied to this correlation, and the equation y=mx+c was derived with the correlation coefficient (r), where 'y' equals expiratory flow rate, 'x' equals body mass and 'c' is a constant. The 'r' value determined the level of significance of the correlation. On exploration of the data, outliers at both ends were found in box plots and were excluded from the regression analysis, if they were greater than 3 standard deviations from the mean. The Statistical Package for Social Sciences software version 10.01 was used. The level of probability taken as significance was 5% ($p$<0.05).

**Results.** The subjects' mean height was 172.5 ± 1.1 cm (± SEM) and BMI was 23.5 ± 0.57 kg $m^{-2}$ (± SEM). Their mean body mass in the 3 time points (Pre Ramadan, Ramadan and Post Ramadan) is displayed in **Table 1**. Body mass in Ramadan was significantly lower relative to pre Ramadan ($p$=0.04) and post Ramadan ($p$=0.01). There was no significant difference in body mass between pre Ramadan and post Ramadan readings.

The mean expiratory flow rates are shown in **Table 1**. Relative to pre Ramadan values, Ramadan fasting showed no significant changes in any expiratory flow variable. The $FEF_{75}$ and $FEF_{75-85}$ both showed a significant increase post Ramadan relative to Ramadan ($p$=0.02 and $p$=0.035). The $FEF_{25}$ and $FEF_{50}$ showed no significant changes during Ramadan fasting compared to post Ramadan. There were no significant changes in any expiratory flow rates between pre and post Ramadan.

Regression analyses were performed to see any correlations between differences in body mass and expiratory flow. Regression analysis between the differences in body mass and $FEF_{75}$ ($r^2$=0.108) for Ramadan and post Ramadan showed a significant correlation ($p$=0.03). In this correlation there were 2 outliers (>3 SD), which were subsequently removed.

**Discussion.** This study appears to be the first to investigate the effects of Ramadan fasting on $FEF_{25}$, $FEF_{50}$, $FEF_{75}$ and $FEF_{75-85}$ forced expiratory flow rates in healthy subjects. Other distinctive aspects of this study over a previous study[9] are that the present study used pre Ramadan values as the baseline and all subjects in the present study were non-smokers.

**Table 1 -** Mean values (± SEM) for body mass and expiratory flow rates during pre Ramadan, Ramadan fast and post Ramadan (n=46).

| Variable | Pre-Ramadan (n=46) | Ramadan (n=46) | Post-Ramadan (n=46) |
|---|---|---|---|
| Body mass (kg) | 70.48 ± 2.20* | 69.96 ± 2.22 | 70.87 ± 2.14† |
| $FEF_{25}$ (l $s^{-1}$) | 7.78 ± 0.26 | 7.59 ± 0.25 | 7.68 ± 0.27 |
| $FEF_{50}$ (l $s^{-1}$) | 4.50 ± 0.18 | 4.50 ± 0.19 | 4.59 ± 0.19 |
| $FEF_{75}$ (l $s^{-1}$) | 1.70 ± 0.12 | 1.60 ± 0.09 | 1.85 ± 0.11* |
| $FEF_{75-85}$ (l $s^{-1}$) | 1.13 ± 0.11 | 1.08 ± 0.08 | 1.26 ± 0.10* |

*significantly different from Ramadan values ($p$<0.05)
†significantly different from Ramadan values ($p$<0.01)

The present study shows that there were no changes in expiratory flow rates during Ramadan fasting, relative to pre Ramadan values, however, post Ramadan values were significantly increased, relative to Ramadan.

Duncan et al[9] have shown that apart from significant reductions in PEF and the ratio of dead space to tidal volume (%VD/VT), there were no effects of Ramadan fasting on pulmonary function. Apart from PEF, they did not measure any other expiratory flow rates. Possible reasons why this study showed a significant fall in PEF could include the fact that their study was most likely performed in summer. No details of when the study commenced were given but the paper was published in 1990. Therefore, it was most likely the study was conducted in 1988 or 1989, which meant that the 2nd week of Ramadan was on approximately the 30th of May or 10th of June, respectively. The weather in Malaysia is tropical and in summer, hot and humid. At a higher temperature early fatigue can set in, which may result in a decrease in submaximal effort, which can decrease PEF.[15-17] Also, the duration from dawn to sunset in summer is longer; therefore, longer fasting hours could also have decreased the PEF by causing more fatigue and dehydration.

Limitations of this previous study[9] are that only 13 subjects were studied, that post-Ramadan values were taken as the baseline and some subjects could have been smokers, as the authors mention "none of the subjects were heavy smokers". The present study recruited only life-time non-smokers, as apart from the direct negative effect of smoking on lung function, evidence also suggests smokers are more irritable than non-smokers in Ramadan[18] and psychological stress has been shown to affect pulmonary function in healthy subjects.[19]

The significant decrease in body mass during Ramadan fasting in the present study has been previously reported.[20,21] Other studies have also shown decreases in body mass,[3,5,9] albeit, they did not reach statistical significance. Contradicting these studies is one which showed no change in body mass[22] and another which showed an increase in body mass,[23] both with Ramadan fasting. There are many complications with comparisons of changes in body mass, which can lead to variations in body mass loss during Ramadan fasting. These include the subject's diet, season during Ramadan (winter/summer), duration of actual fast, subject's physical activity, the time measurement was taken during the day, when measurements were made in the month of Ramadan and whether baseline measurements were made pre or post Ramadan.

A disturbance in fluid and electrolyte balance during Ramadan fasting could also affect normal physiological lung function. Hussain et al[3] have ruled out the possibility of dehydration by measuring the fluid intake and 24 hour urinary output during their study. Another study showed that subjects were dehydrated during the first week of Ramadan, as shown by increases in serum electrolytes and protein, yet these differences normalized in the last week of Ramadan.[21] In another study by Ramadan et al,[5] fluid balance was better maintained in the active subjects compared to the sedentary subjects, as the latter subjects had significant increases in their blood osmolarity at the end of Ramadan fasting.

In a study where healthy subjects were hypohydrated by administering a diuretic, PEF, $FEF_{25}$ and $FEF_{50}$ increased.[24] The hypohydration produced was supported by a significant increase in hematocrit, blood urea nitrogen and creatinine. These values returned to normal on rehydration. Interestingly, the maximum increases in $FEF_{25}$, $FEF_{50}$ and PEF mirrored the maximum fall in body weight, with $FEF_{50}$ increasing the most. The authors suggest that the reason for this change might be a loss of water in the airway mucosa and bronchovascular sheath, causing a potential fall in airway resistance. They concluded that hypohydration caused an increase in the lung function, which is mechanistically opposite to pulmonary edema, where excess lung water decreases flow rates. It is unclear if this mechanism could explain the increases in post Ramadan $FEF_{75}$ and $FEF_{75-85}$ in the present study, as markers of hydration or airway resistance were not measured.

Post Ramadan fasting, both $FEF_{75}$ and $FEF_{75-85}$ increased significantly, relative to Ramadan variables. The fact that all FEF values were higher post-Ramadan relative to Ramadan does show there is internal consistency, albeit only 2 showed significant increases. An advantage of these 2 expiratory flow rates is that both are effectively independent of effort.[11] Although mean data showed an increase in both post Ramadan body mass and $FEF_{75}$, using linear regression, there was a significant correlation between post Ramadan changes in body mass and $FEF_{75}$, where a fall in body mass was related to an increase in $FEF_{75}$, and vice versa. This relationship may not necessarily be causal and it is possible that there is a common underlying mechanism accommodating both these variables. Changes in body hydration[24] being responsible for this relationship cannot be ruled out.

Changes in body mass have been shown to result in changes in lung function, where a reduction of weight in obese asthmatics improved lung function, primarily FVC and $FEV_1$.[25] Chinn and co-workers[26] have shown that increases in BMI were associated with decreases in both $FEV_1$ and FVC; they did not measure expiratory flow rates. The authors mention the body mass changes in their subjects were primarily an increase in body fat and they suggest that increases around the abdomen, specifically in males, can lower lung function. Subjects do lose body fat after Ramadan fasting[21] though it is unclear as to whether this change is related to changes in expiratory flow rates and also it is not known where the sites of fat removal are. Therefore whether this could explain the post Ramadan increase in FEF values in the present study is uncertain.

Limitations of the present study are that the sample size was relatively small and only males were studied. However, given the large number of Muslim patients and an increase in the prevalence and detection of respiratory diseases, we feel this study addresses an important concern. The fact that no effect of Ramadan fasting on expiratory flow rates was seen in these healthy subjects, it would not be justified to extrapolate this to patients with respiratory disease. Further work needs to be conducted on selected patient groups to rule out any effect of Ramadan fasting on their lung function.

In conclusion, the present study found no change in expiratory flow rate variables during Ramadan fasting. Significant alterations in post Ramadan $FEF_{75}$ and $FEF_{75-85}$ relative to Ramadan fasting did occur and possible mechanisms for these include changes in both body water and fat content, though both need further clarification. The reductions in body mass were most probably due to lack of food and liquid ingested, and not due to dehydration as the fasts were performed in winter.

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