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The effect of Ramadan fasting on nasal mucociliary activity and peak nasal inspiratory flow

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Abstract

Purpose In this study, we aimed to investigate the effect of Ramadan fasting (RF) on nasal mucociliary clearance (MCC) and peak nasal inspiratory flow (PNIF).

Methods Sixty-two (41 male and 21 female) healthy subjects who stated that they would fast continuously during the month of Ramadan were included in this prospective study. Day 0 (baseline), 1st day (after one day of RF), and 29th (after 29 days of RF) nasal mucociliary clearance time (MCT) with saccharine test and PNIF values were determined. Subject weights (SW) were measured on Day 0 and Day 29. The obtained data were analyzed statistically.

Results The mean of SW on day 0 was 78.53 ± 10.95 kg, and the mean of SW on Day 29 was 78.69 ± 10.87 kg. There was no significant difference in terms of SW ($p = 0.251$, $p > 0.05$). A significant difference was found between the MCT and PNIF values measured on different study days ($p < 0.05$). The MCT values for Day 29 were significantly higher than the values for other days ($p < 0.05$). There was no significant difference between the MCT values on the first day and the baseline ($p = 0.891$, $p > 0.05$). The PNIF values for Day 29 were significantly higher than the values for other days ($p < 0.05$). The PNIF values on the first day were significantly higher than the baseline ($p = 0.008$, $p < 0.05$).

Conclusion The present study showed that RF leads to MCT prolongation and PNIF increase. Ramadan fasting causes deterioration in nasal airway defense and improvement in nasal respiration.

Keywords Fasting · Mucociliary clearance · Nasal obstruction*/diagnosis · Nose/physiology* · Saccharin/pharmacokinetics*

Introduction

Fasting is defined as voluntarily abstaining from eating, drinking, or both for varying periods. Fasting may be short-term, long-term/prolonged, or intermittent, typically lasting between 12 h and 3 weeks [1]. Intermittent fasting (IF) is a term used to describe periods of fasting that are repeated at regular intervals, lasting longer than a day, that limit energy intake to a specific period [2]. There are three types of IF including complete alternate-day fasting, modified fasting regimens, time-restricted feeding [3]. Time-restricted feeding allows free feeding for a specified period between 4 and 8 h and prohibits caloric intake outside this period [3]. Intermittent fasting is very popular nowadays. It is a type of nutrition that is frequently applied by chronic sinusitis patients as well as by the entire population. However, in our clinical practice, we noticed that the complaints of chronic sinusitis patients increased who followed an IF diet.

Ramadan is the ninth month of the Islamic lunar (Hijri) calendar. In this holy month, which lasts for 29 or 30 days, Muslims are required to fast between sunrise (sahur) and sunset (iftar) except for those with special circumstances such as children, the elderly, pregnant, and lactating women, the sick, and travelers [4, 5]. Eating and drinking are prohibited between sahur and iftar, but it is free outside this period [4, 5]. Ramadan fasting is a kind of time-restricted intermittent fasting. The Lunar Calendar is 11 days shorter than

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the solar calendar, so the beginning of Ramadan is 11 days earlier than the previous year [5]. Depending on this feature and the geographical location of the countries, the duration of Ramadan intermittent fasting (RIF) varies between 12 and 18 h, depending on the changing daytime [6].

Numerous studies have shown the effects of RIF on physiological and pathological conditions. In many of these studies, the effects of RIF on lower airway functions have been examined [6–9]. Although these studies have different results, recent studies have shown that RIF does not affect lower respiratory spirometry results in healthy individuals and chronic obstructive pulmonary disease (COPD) patients [10]. In the literature, although there are several studies examining the effects of RIF on various systems, there are limited studies examining the relationship between nasal functions and RIF [11].

One of the main nasal functions is mucociliary clearance (MCC), which is the first and most important defense mechanism of the respiratory tract [12]. Nasal MCC is defined as the foreign particles in the inhaled air that may be harmful held by the mucosal surfaces and removed from the nasal cavity to the nasopharynx by the ciliary activity [12]. The indicator of MCC is the mucociliary transit time (MCT) determined using various test methods including saccharin, dyes, and radioactive substances [13]. The prolongation of this period, which varies between 12 and 15 min in normal people, is interpreted as impaired MCC [14].

Nasal congestion is one of the most common symptoms in otorhinolaryngology and it is associated with the respiratory function of the nose [15]. Objective methods such as rhinomanometry (RM) and peak nasal flow measurement can be used to evaluate nasal airway obstruction, which is characterized by increased nasal resistance and decreased airflow [15].

This study aims to investigate the effect of RIF, which is an example of intermittent fasting, on MCC time and Peak Nasal Inspiratory Flow (PNIF) values.

Materials and methods

This prospective single cohort study was conducted on volunteers who applied to Dr. Lutfi Kirdar Kartal Training and Research Hospital between May 2018 and June 2018 with the approval of Dr. Lutfi Kirdar Kartal Training and Research Hospital Ethics Committee (decision number: 89513307-1009-175).

Populations, inclusion, and exclusion criteria

All participants of the study applied to the Otorhinolaryngology Clinic of Dr. Lutfi Kirdar Training and Research Hospital. Healthy volunteers who stated that they would fast continuously during the month of Ramadan (29 days) were included in this study. A detailed anamnesis was taken from all participants and a complete otorhinolaryngological examination was performed by the same otorhinolaryngologist. Informed consent forms were obtained from subjects.

The subjects under the age of 18 and over the age of 60 years, having a pathology (otological; nasal; naso/oropharyngeal) detected in their endoscopic examination; history of head trauma, neurological disease, psychiatric disease, chronic disease such as allergy, diabetes mellitus, COPD or asthma; upper respiratory tract infection during the previous 3 months; having a history of ear or upper respiratory tract surgery; history of any regular drug use in the last 6 months; history of taste and smell disorders and those smoking, non-compliance with Ramadan fasting rules and who could not complete the study for any reason were excluded from the study.

Sample size and sampling technique

The minimum sample size was estimated based on the study of Develioglu et al. [11]. The minimum sample size with a 95% confidence interval and 5% tolerable error assumptions was 62.

People who applied to our clinic, for the pre-employment hearing test, were separated into subgroups according to whether they will fast or not. Those with diseases and habits that may affect the investigated parameters were excluded from the fasting subgroup. Among them, 62 subjects were randomly selected.

Procedures and data collection

Study design

Day 0 (Baseline): Detailed anamnesis of the subjects was taken. Subjects were in their normal daily routine. A complete endoscopic otorhinolaryngology examination was performed. Nasal MCT was measured with the saccharine test, and PNIF was measured with PNIFmeter.

Day 1 (First day of study): After the first RIF, the tests were repeated.

Day 29 (Last day of study): On the last day of the experiment, the tests were repeated after the fasting period of the subjects.

To ensure standardization, the tests of the patients were performed by the same otolaryngologist after a 30-min rest in the evening in the same room with a temperature of 20–24 °C and 60–70% humidity.

Methods

Endoscopic examination The nasal examination was performed to exclude the presence of pathology. Nasal cavities were first evaluated with a speculum (Hartmann nasal speculum; catalog number, 400500; Karl Storz SE & Co. KG, Germany). Afterward, the nasal mucosa, turbinates, nasal septum, pharynx, tonsils, and tongue were evaluated with a 3.5 mm flexible rhino-fiberscope (catalog number, 11001RD; Karl Storz SE & Co. KG, Germany).

Saccharine clearance test The subject was placed in a sitting position with the head above after resting. The subject was instructed to not move her/his head, to not sniff, to not sneeze, to keep her mouth open, and breathe through both mouth and nose. For the clearance test, 5 mg saccharin (Sakarin-oro, Oro İlaç, Turkey) was placed on the medial surface 0.5 cm behind the anterior part of the inferior turbinate with forceps (Hartmann ear forceps; catalog number, 161000; Karl Storz SE & Co. KG, Germany). The subjects were allowed to swallow every 30 s. The time that the subject stated that she/he tasted saccharin was determined as MCT (second) [11]. The MCT varies between 12 and 15 min in healthy people [14].

PNIFmeter Ten minutes after the saccharine test, PNIF values were measured with PNIFmeter (Clement Clarke International Limited, England). After the patients were seated in the examination chair and the PNIFmeter mask was placed to fully cover the mouth and nose, full and rapid inspiration was performed after deep expiration with the mouth closed. To ensure patient compliance, the test was repeated three times and the mean value was recorded as liters/minute. The normal PNIF value was reported to be 129 L/min [16].

Statistical analysis

The minimum sample size was calculated by using the G * Power software 3.1 [17]. SPSS 21 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Normal distribution of data was analyzed with the Kolmogorov–Smirnov test and Levene's tests were used to assess homogeneity. The paired-samples *t* test, the Friedman test, and the one-way ANOVA test were used for statistical analysis of repeated measures. The Wilcoxon test and the post hoc Tukey HSD test were used to compare the two paired groups. The statistically significant level was accepted as a p value < 0.05.

Results

A total of 62 subjects, 41 male and 21 female, were included in the study. All subjects completed the study. The mean age of the subjects was 37.7 ± 11.08 (min: 21, max: 70) years. The subjects fasted a mean of 16.95 ± 0.13 h/day (min: 16.95, max: 17.38) throughout the study. The mean weight of the subjects at the beginning of the study was 78.53 ± 10.95 (min: 56, max: 98.2) kg, and the mean weight determined at the end of the study was 78.69 ± 10.87 (min: 56, max: 98) kg. There was no statistically significant difference between the subject weights at the beginning of the study and the end of the study (paired samples *T* test; $p = 0.251$, $p > 0.05$).

A statistically significant difference was found in the nasal MCT measurements of the subjects on different days ($p = 0.002$, $p < 0.05$). The MCT values for the 29th day of the study were statistically significantly higher than the baseline and the first-day values ($p = 0.003$; $p = 0.011$, respectively, $p < 0.05$). There was no statistically significant difference between the first-day values and the baseline values ($p = 0.891$, $p > 0.05$) (Tables 1, 2).

A statistically significant difference was found in the PNIF measurements of the subjects on different days

Table 2 Statistical evaluation of test parameters

Compared days	Test parameters	*p*
Day 0–1st	MCT (s)	0.891
	PNIF (L/min)	0.008*
1st–29th	MCT (s)	0.011**
	PNIF (L/min)	0.00001*
Day 0–29th	MCT (s)	0.003**
	PNIF (L/min)	0.00001*

*Wilcoxon Signed Ranks Test, $p < 0.05$

**Post Hoc Tukey HSD, $p < 0.05$

Table 1 Evaluation of nasal mucociliary clearance time (MCT) and peak nasal inspiratory flow (PNIF) measurements

Parameter		Study day			*p*
		Day 0 (base)	1st	29th	
MCT (s)	Mean ± SD (median)	695.32 + 197.44 (720)	711.93 + 207.29 (735)	817.74 + 202.27 (840)	0.002*
PNIF (L/min)	Mean ± SD (median)	119.1 + 19.39 (121)	120.18 + 20.21 (125)	125.7 + 19.83 (130)	0.00001**

*One way ANOVA test, $p < 0.05$

**Friedman test, $p < 0.05$

($p = 0.00001$, $p < 0.05$). The PNIF values for the 29th day of the study were statistically significantly higher than the baseline and the first-day values ($p = 0.00001$; $p = 0.00001$, respectively, $p < 0.05$). The first study day PNIF values were significantly higher than the baseline values ($p = 0.008$, $p < 0.05$) (Tables 1, 2).

Discussion

Ramadan fasting, a religious activity practiced by most of the 1.9 billion Muslims worldwide, is the most frequently practiced IF in the World [17]. It is known that RIF, which is a kind of time-restricted IF, affects many systems of the organism differently [18–21]. In this study, we examined the effects of Ramadan fasting on nasal functions. As a result of our study, we determined that the MCT and PNIF values on the 29th day of the RIF were significantly higher than the values at the beginning and the first day of the study ($p < 0.05$). In addition, we found that PNIF values on the first day of the study were significantly higher than the baseline values ($p = 0.008$, $p < 0.05$) (Tables 1, 2).

The three main functions of the nose are olfaction, airway defense, and respiration. A nose without a respiratory function cannot perform its other functions [22]. Nasal airway obstruction, the most common problem in otorhinolaryngology practice, causes a decrease in nasal airflow and the inability of the nose to fulfill its respiratory function [15, 22]. Although there are different methods to measure nasal airflow and evaluate nasal obstruction, anterior active (ARRM) is the most commonly used and most accurate in clinical practice [15, 23]. PNIF measurement is an objective, easy to apply, quick, and inexpensive test method to evaluate nasal airflow and patency with a good correlation with AARM in healthy and obstructed noses [15, 23, 24]. An increase in PNIF is consistent with a decrease in nasal resistance [25].

Nasal MCC is the primary and main defense mechanism of the respiratory system including the nose and paranasal sinuses. Nasal MCC is defined as the retention of harmful particles and pathogens in the inhaled air by the mucus cover and their removal from the nasal cavity to the nasopharynx with epithelial ciliary movements [12]. MCC, one of the most important nasal functions, can be evaluated with in vivo tests using substances such as radioactive materials, radiopaque Teflon discs, dyes, and saccharin [14]. The saccharin test method, which determines the mucociliary clearance time as an indicator of MCC, is the most frequently used in clinical studies, because it is a simple, safe, inexpensive, and easily applicable test [11, 13].

Normal functioning of nasal MCC, the deterioration of which causes many diseases, especially prolonged respiratory tract infections, consists of two components: mucus production and transport [26]. Upper airway surface liquid (ASL) consists of two layers: a superficial gel layer and the underlying periciliary layer, which has a lower viscosity and covers the epithelial ciliary cells [26, 27]. The efficiency of MCC depends on the volume, composition, and viscosity of the ASL, a sufficient ciliary beat frequency, and appropriate interaction between epithelial cilia and AS [27]. The MCC is adversely affected by conditions that impair ciliary functions, cause dehydration in ASL and elevate mucus viscosity such as infections, inflammatory diseases, environmental factors, and chronic diseases (cystic fibrosis, etc.) [26–28].

There are many studies in the literature examining the effects of RIF on many organs and systems [18–21]. Although there are many studies examining the effect of RIF on lung functions, which are one of the organs of the respiratory system, there are limited studies examining the effect on the functions of, another respiratory organ, the nose [6–11]. We designed this study to determine the effect of RIF on nasal airflow and nasal MCC. We evaluated nasal MCC function with saccharine test and nasal respiratory function with PNIF. In this study, factors such as being over 60 years of age, presence or history of nasal pathology, and smoking, which were shown to have significantly decreased MCC, were accepted as exclusion criteria [29]. The subjects participating in the study were informed to continue their daily routines of Ramadan. The tests were administered by the same person at the same time in fasting and non-fasting periods to avoid any difference in nasal functions depending on the time of application and the person who applied it.

Ramadan IF, which is a non-calorie restriction IF, affects daily life, especially eating habits, sleep duration and periods, and physical activity levels [4, 11, 30]. In various previous studies, the physiological and metabolic changes related to RIF were reported [18–21, 30]. There are studies in the literature examining the effect of RIF on body weight [31, 32]. Several studies reported a weight loss at the end of Ramadan, with several other studies reporting weight gain [31, 32]. In our study, no significant weight change was detected at the end of Ramadan ($p > 0.05$). In the study of Matsui et al., hydration was reported as the main variable affecting MCC [33]. The effects of RIF on body hydration have been examined in different studies and it has been determined that it causes dehydration [34, 35]. This dehydration impairs MCC by causing mucosal dryness and changes in the viscoelastic properties of the mucus layer [36]. In our study, the MCT values detected at the end of Ramadan were found to be significantly lower than both the initial and the first-day values. This can be explained by RIF-induced dehydration. There was no significant difference between the MCT values determined at the end of the first IF day and the initial values, similar to the study of Develioglu et al. [11]. This can be explained by the fact that dehydration must be progressive for impaired MCC.

In the English literature review, we did not encounter any study showing the effect of fasting and dehydration on upper respiratory tract resistance. When we investigated the relationship between MCC and airway flow, we found that MCC was faster within the congested airway, but the reason for this was still unclear [37]. There are few studies in the literature examining the effect of fasting on lower airway resistances, flows, and volumes [6–10]. However, the results of these studies differ. In one of these studies, it was claimed that dehydration seen in the respiratory tract mucosa due to fasting reduces airway resistance and leads to an increase in respiratory airflow [8, 9]. In our study, PNIF values that increased due to RIF are consistent with this informations. While no significant change in nasal MCT is observed due to 1-day IF, the significant change in PNIF values may suggest that the respiratory function of the nose is more sensitive to IF and dehydration.

The present study, in which we examined the relationship between RIF and nasal functions, has some limitations. The first limitation of the study was the relationship that we think exists between chronic sinusitis and IF is observational. The second limitation of the study was the use of a PNIFmeter for nasal flow measurements. Although PNIFmeter correlates with RM in the determination of nasal flow and resistance, it cannot replace RM in clinical practice. In addition, PNIF measurements require optimal subject cooperation. For this cooperation, the patient must learn the method. To minimize the effect of this limitation in our study, we repeated the measurements three times and averaged the measurements. Another limitation was that we did not subjectively question the effect of fasting on nasal functions with a method similar to the visual analog scale (VAS) and/or the Nasal Obstruction Symptom Evaluation (NOSE) scales. If we had done this, we could have determined the effect of fasting on quality of life. Another limitation was that we could not generalize the results of RIF to all IF types. Because unlike most types of IF, RIF does not require calorie restriction. In addition, daily habits which can affect all body functions, change during RIF [4, 11, 30]. The most important limitation of our study was that we could not objectively detect dehydration, which we claimed to cause nasal function changes, which we detected during RIF. The most important limitation of our study was that we could not objectively detect dehydration, which we claimed to cause nasal function changes, which we detected during RIF. Measuring the daily amount of fluid consumed by the subjects is necessary for more comprehensive studies on this topic.

Conclusion

In the present study, it was determined that RIF caused deterioration of nasal MCC and increased nasal airflow. Impairment of nasal MCC may contribute to the occurrence of infections during RIF. Therefore, it may be recommended to apply nasal humidification methods to increase nasal hydration during RIF. More comprehensive studies with larger numbers of subjects are needed to determine the mechanisms that cause changes in nasal mucociliary clearance and nasal airflow due to RIF.

Author contributions The data collection and analysis were performed by DC, MGY, and HBY, the statistical analysis was performed by YZY. The draft of the main text was written by DÇ and SU and all authors commented on previous versions of the manuscript. The authors read and approved the final form of manuscript.

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Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article. This manuscript is original and it, or any part of it, has not been previously published; nor is it under consideration for publication elsewhere.

Ethics approval All procedures in this study were in accordance with the Helsinki Declaration. The present study was approved by Dr. Lutfi Kirdar Kartal Training and Research Hospital Ethics Committee (decision number: 89513307-1009-175).

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