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ORIGINAL RESEARCH

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As a phenomenon: Ramadan fasting improves olfactory performance

Doğan Çakan MD[1,2] | Hüseyin Baki Yılmaz MD[3] | Harun Cansız MD[1] | Haluk Çevik MD[1] | Michael C. F. Tong MD[2] | Begüm Bahar Yılmaz MD[4] | Zeliha Kübra Çakan MD[5]

[1]Department of Otorhinolaryngology, Istanbul University-Cerrahpaşa, Istanbul, Turkey

[2]Department of Otorhinolaryngology–Head and Neck Surgery, The Chinese University of Hong Kong, Hong Kong, China

[3]H. Baki Yılmaz Clinic, Istanbul, Turkey

[4]Department of Otorhinolaryngology, Çam ve Sakura City Hospital, Istanbul, Turkey

[5]Division of Oncology, Department of Internal Medicine, Istanbul University-Cerrahpaşa, Istanbul, Turkey

Correspondence
Doğan Çakan, M.D, Cerrahpaşa Medical Faculty, 34300, Kocamustafapaşa, Fatih, Istanbul, Turkey.
Email: dogan.cakan@iuc.edu.tr

Abstract

Objective: The present study objectived to investigate the influence of Ramadan fasting (RF) on olfactory function.

Methods: Sixty-two participants were included in the current prospective study. The odor threshold and identification performances were determined by using the Connecticut Chemosensory Clinical Research Center (CCCRC) test initially (day 0) and on the first and last day (30th) of RF. Body weight (BW)s were measured initially and at the end of the study. The results were analyzed statistically.

Results: The average of baseline and last-day BWs were 78.38 ± 12.96 and 78.36 ± 12.39 kg, respectively. No significant difference was determined in terms of BWs ($p = .932$, $p > .05$). In the evaluation of CCCRC test outcomes, significant differences were observed in the scores of butanol thresholds ($p = .0001$), odor identification ($p = .0001$), food-related odors identification ($p = .0001$), and the number of normosmic individuals ($p = .0001$) at different times ($p < .05$). The thresholds scores ($p = .0001$, $p = .0001$), the identification scores ($p = .0001$, $p = .0001$), food-related odors identification scores ($p = .0001$, $p = .0002$), and the number of normomic individuals ($p = .001$, $p = .001$) detected on 30th day were significantly higher than on 0th and 1st days; respectively ($p < .05$). Additionally, the threshold scores ($p = .0001$), the identification scores ($p = .003$), food-related odors identification scores ($p = .007$), and the number of normosmic individuals ($p = .018$) detected on day 1 were significantly higher than on day 0 ($p < .05$).

Conclusion: The current study demonstrated that Ramadan fasting enhances the olfactory detection threshold and odor identification scores, significantly improving the identification of food-related odors. The results may indicate that Ramadan fasting improves olfactory performance.

Level of evidence: Level II.

KEYWORDS
fasting, nose/physiology, olfaction, olfaction disorders/diagnosis, olfactory perception

1 | INTRODUCTION

Fasting is defined as restricting the consumption of liquids, food, or both for varying periods, observed in people's daily lives due to mandatory environmental conditions, and traditional or religious reasons throughout human history.[1,2] Fasting is classified as short-term or prolonged-term, depending on its duration. The fasting period can range from a few hours to several weeks.[3] Intermittent fasting (IF) is a type of short-term fasting originating from religious traditions.[4] IF is divided into subtypes, including whole-day fasting, time-restricted feeding, alternate-day fasting, and modified fasting methods.[1,5]

Ramadan is the 9th month of the Hijri calendar. During Ramadan, Muslims are obliged to fast from sunrise to sunset. However, there are exceptions for individuals with special circumstances, such as menstruating women, pregnant or breastfeeding women, children, individuals with certain medical conditions, and travelers.[6,7] During Ramadan fasting (RF), individuals are prohibited from eating, drinking, smoking, engaging in sexual intercourse, or taking medication from sunrise to sunset. These prohibitions are lifted outside of this designated fasting period.[6,7] With these features, RF is a special type of time-limited eating without calorie restriction.[2] The lunar Hijri calendar, unlike the solar Gregorian calendar, comprises either 354 or 355 days. This difference causes Ramadan to begin approximately 11 days earlier each year compared to the previous year. Consequently, due to this calendar disparity and the fluctuation in daylight hours based on latitude, the duration of RF can vary between 7 and 20 h in different regions.[7,8] Numerous studies have indicated that RF influences various organ systems due to its impact on daily life.[6–11] Nevertheless, there is a scarcity of studies examining its effects on nasal functions.[12–14]

Olfaction, one of the oldest senses, enables reaching food, identification of potential dangers, and regulating social behavior by interacting with the environment.[15] This primary function of the nose can be influenced by factors such as age, hunger state, as well as various pathologies including infections, traumas, and tumors.[15,16] Although subjective methods such as self/hetero questionnaires are used to evaluate olfaction, objective psychophysical olfactory tests are considered the gold standard.[17] Some of these tests include the University of Pennsylvania smell identification test (UPSIT), the Sniffin' stick test (SST), and the Connecticut Chemosensory Clinical Research Center (CCCRC) test. However, there is no universally accepted gold standard test among psychophysical olfactory tests.[18]

The objective of the current study is to examine the impact of RF on olfaction, a fundamental function of the nose, utilizing the CCCRC test as an objective testing method.

2 | MATERIALS AND METHODS

The current prospective cohort research was conducted on subjects who presented to Cerrahpaşa Medical Faculty Hospital between March 10 and April 9, 2024. The present study received approval from the Clinical Research Ethics Committee of Cerrahpaşa School of Medicine (approval number: 949494). After an informational briefing on the study, individuals gave their consent by signing informed consent forms. All procedures of the present study were performed under the principles stated in the Declaration of Helsinki.

2.1 | Study population and criteria

The subjects applied to the outpatient clinics of the Department of Otorhinolaryngology, and Internal Medicine. The cohort size was determined according to the study conducted by Develioglu et al.[12] The minimum required subject number was determined to be 62, with a 95% confidence interval. This study employed the stratified sampling method for establishing the population. Individuals who applied to the departments were categorized into subgroups based on whether they intended to fast or not. The subjects were randomly selected from the fasting subgroup according to the study's criteria. This study included healthy individuals who expressed their intention to observe fasting continuously for 30 days during Ramadan. Subjects younger than 18 years and older than 60 years, those with any otorhinolaryngological pathology, any smell disorder such as hyposmia or anosmia, a history of nasal trauma or surgery, acute or chronic upper respiratory tract infections such as sinusitis, nasal inflammation such as allergies, noncompliance with Ramadan fasting rules, inability to complete the 30-day fasting period for any cause, and smokers were excluded from this study.

2.2 | Study design

Day 0 (baseline): A comprehensive medical history was obtained from all subjects. Moreover, the body weight (BW)s of subjects were recorded, followed by a thorough endoscopic rhinological examination. CCCRC tests were performed.

Day 1 (initial day of RF): Tests were repeated immediately after sunset during the post-fasting period before participants received any liquids or food.

Day 30 (final day of RF): The subjects underwent a repetition of the tests at post-fasting period such as initial day and the BWs of subjects were recorded.

2.3 | Nasal examinations and data collection

Following a 30-min rest period, the olfactory tests were conducted in the evening hours (day 0: at 19:13, day 1: at 19:13, and day 30: at 19:44) in a standardized room environment (temperature: 22 ± 2°C, humidity: 40%–60%). Endonasal examinations were conducted employing a 0-degree, 2.7 mm endoscope (Karl Storz SE & Co. KG, Germany).

2.4 | The olfactory testing

Olfaction was assessed using the CCCRC test. The CCCRC test comprises the butanol threshold and the odor identification tests.[19,20]

2.4.1 | Butanol threshold test

Two identical, brown-colored bottles were provided to participants. One of the bottles contained a diluted concentration of butanol, whereas the other contained water. The highest concentration of butanol (bottle 0) consisted of 4% butanol in deionized water. Subsequent decreased concentrations (bottles 1–9) were attained through dilution at a ratio of 1:3 with deionized water. The tests were performed as described in the literature.[19] The numbers of the bottles were considered as scores. Once the individual accurately identified the same butanol concentration five sequential times, the score was noted for one nostril. Scores of seven and higher were standardized as seven, resulting in scores ranging from 0 to 7. The final score was the average score of nostrils.[19]

2.4.2 | Odor identification test

Brown bottles contained common household odorants: soap, coffee, cinnamon, mothballs, peanut butter, chocolate, and Vicks. A list was compiled with the correct items along with an equal number of distractors, including rubber, burnt paper, cinnamon, baby powder, wood shavings, soap, spearmint, black pepper, coffee, chocolate, peanut butter, grape jam, mothballs, ketchup, and Vicks. Individuals were asked to describe the odors they perceived from the provided list. The ability to correctly recognize the odor of Vicks indicated functional trigeminal nerve activity. As all individuals readily identified it, it was not utilized in the final scoring. The scores ranged from 0 to 7 based on the correctly recognized items. The final score was the average score of nostrils.[19]

Ultimately, the scores from both the threshold and identification tests were averaged to derive a combined score reflecting nasal olfactory ability. The final scores were categorized as follows: 0–1.75, anosmia; 2–3.75, severe hyposmia; 4–4.75, moderate hyposmia; 5–5.75, mild hyposmia; and 6–7, normal olfaction.[19]

2.4.3 | Separation of identification test

The odor identification test scores were categorized based on whether the test odors were food-related (coffee, cinnamon, peanut butter, and chocolate) or not (soap, baby powder, and mothballs).

2.5 | Statistical analysis

The minimum subject number was determined using the G* Power program.[21] Data analysis was conducted using the SPSS version 22.0 (IBM, USA). Normal distribution and homogeneity assessment of the data were performed utilizing Kolmogorov–Smirnov and Levene's tests, respectively. Statistical analysis employed paired sample *t*-test, Friedman, and Wilcoxon Signed Ranks tests. The significance threshold was set at a *p*-value of less than .05.

3 | RESULTS

The study comprised 62 participants, consisting of 49 males and 13 females. The mean age of participants was 35.6 ± 10.32 (minimum: 18, maximum: 60) years. The average RF duration was 14.07 ± 0.43 hours (h) per day (minimum: 13.37 h on the first day, maximum: 14.77 h on the last day). At the baseline, the mean BW of the participants was 78.38 ± 12.96 (minimum: 51, maximum: 104) kg, and at the end of the study, it was 78.36 ± 12.39 (minimum: 52, maximum: 100) kg. There was no significant difference in the BWs between the beginning and end of the study (paired sample *t*-test, $p = .932$).

The olfactory test results are presented in Tables 1 and 2. In the evaluation of the CCCRC test outcomes, a significant difference was observed in the butanol threshold scores across different days ($p = .0001$). The butanol threshold score on the 30th day was significantly higher than on the 0th and 1st days scores ($p = .0001$; $p = .0001$, respectively). Furthermore, the butanol threshold score on day 1 was significantly higher than the value obtained at baseline ($p = .0001$). Besides, a significant difference was observed in the odor identification test scores across different days ($p = .0001$). The identification test score on the 30th day was significantly higher than on other days ($p = .0001$; $p = .0001$, respectively). Moreover, the identification test score on day 1 was significantly higher than the day 0 score ($p = .003$) (Tables 1 and 2).

In the assessment of the CCCRC test outcomes categorized, 19 (30.6%) participants were categorized as normosmic, 36 (58.1%) subjects as mildly hyposmic, and 7 (11.3%) as moderately hyposmic on day 0. Thirty-two (51.6%) participants were categorized as normosmic, 29 (46.8%) participants as mildly hyposmic, and 1 (1.6%) participant as moderately hyposmic on day 1. Forty-nine (79%) participants were categorized as normosmic, whereas 13 (21%) participants were categorized as mildly hyposmic on the 30th day (Figure 1).

Additionally, participants were classified as normosmic and hypo/anosmic according to test results. Nineteen (30.6%) participants on day 0, 32 (51.6%) participants on day 1, and 49 (79%) participants on day 30 were classified as normosmic. In the evaluation of classified olfactory testing results, a significant difference was detected across study days ($p = .0001$). The number of participants classified as normosmic on the 30th day was significantly higher compared to on 1st and 30th days ($p = .001$; $p = .001$, respectively). Additionally, the number of participants classified as normosmic on day 1 was significantly higher than on day 0 ($p = .018$) (Tables 3 and 4).

In the evaluation of separated identification test outcomes, there was a significant difference in test scores for the identification of food-related odors subgroup across different days ($p = .0001$). The separated identification test score on the 30th day was significantly

TABLE 1 The analysis of olfactory test outcomes.

	Study days			
	Mean ± SD (median, min–max)			
Parameter	Day 0	First	30th	p*
Butanol threshold score	5.419 ± 0.932 (5.5, 4–7)	5.983 ± 0.877 (6, 4–7)	6.161 ± 0.853 (6, 4–7)	.0001
Odor identification score	5.532 ± 0.881 (5, 3–7)	5.79 ± 0.943 (6, 4–7)	6.193 ± 0.764 (6, 4–7)	.0001
Food-related odors identification score	2.935 ± 0.674 (3, 4–2)	3.145 ± 0.698 (3, 2–4)	3.516 ± 0.593 (4, 2–4)	.0001
Non-food-related odors identification score	2.581 ± 0.497 (3, 2–3)	2.645 ± 0.482 (3, 2–3)	2.667 ± 0.471 (3, 2–3)	.211
The CCCRC test score	5.475 ± 0.686 (5.5, 4.5–7)	5.88 ± 0.667 (4.5, 5–7)	6.177 ± 0.607 (6, 5–7)	.0001

*Friedman test $p < .05$.

TABLE 2 The statistical comparison of the olfactory test outcomes by study days.

	Compared days		
	p*		
Parameter	0–1	1–30	0–30
Butanol threshold score	.0001	.0001	.0001
Odor identification score	.003	.0001	.0001
Food-related odors identification score	.007	.0002	.0001
The CCCRC test score	.0001	.0001	.0001

*Wilcoxon signed ranks tests $p < .05$.

higher than on day 0 and day 1 scores ($p = .0001$; $p = .0002$, respectively). Moreover, the separated identification test score on day 1 was significantly higher than the value obtained at baseline ($p = .007$). However, there was no significant difference in the non-food-related subgroup ($p = .211$) (Tables 1 and 2).

4 | DISCUSSION

Ramadan fasting is the most widely observed fast, practiced by billions of Muslims worldwide.[6,7,22] Previous studies have revealed that RF can affect primary nasal functions.[13,14] In this study, the impact of RF on olfaction was investigated. The results of the CCCRC test demonstrated that RF positively influences nasal olfactory performance by improving both the odor threshold and the identification of various odors. Furthermore, the present study demonstrated that although RF improves the identification of food-related odors, it does not alter the recognition of non-food-related odors.

Olfaction serves as a crucial sense for locating food, perceiving environmental cues to detect dangers or threats, and facilitating social communication, despite being commonly regarded as one of the less significant senses by most individuals.[23–25] Multidimensional olfactory perception encompasses the detection and identification of odor stimuli, as well as the assessment of odor familiarity and pleasure. Olfactory sensitivity is generally denoted as the threshold for odor detection or recognition, representing the level of stimulus necessary to detect and identify an odor, respectively.[15,26] Olfactory testing has become an integral component in diagnosing disorders stemming from various internal and external factors that can affect this critically important sense.[15]

Although it is universally acknowledged that olfactory tests should include features such as odor threshold assessment, odor identification, and odor discrimination, and must align with the nutritional and cultural habits of the population, there is still no globally accepted gold standard test.[17,18,27–29] In the United States, the UPSIT is the most employed and is considered the gold standard, whereas, in Europe, the SST is most used and is regarded as the gold standard.[17,18,24,30] The CCCRC test stands as one of the most frequently utilized smell tests globally, encompassing both the smell detection threshold and the identification of various odors. This test enables the evaluation of olfaction both quantitatively and qualitatively.[18–20,31]

Ramadan fasting influences both the physical and mental dimensions of the organism.[22,32] Previous studies have demonstrated that nose is affected by RF.[12–14] In the study by Ulusoy et al.,[14] the effects of 16-h RF on olfaction were examined using the SST. It was determined that olfactory identification, thresholds, and discrimination scores observed during RF were higher than those observed during satiety. In the mentioned study, which found that RF improved odor sensitivity, only 1 day of RF was examined, and the effects at the end of this month-long routine were not investigated. Furthermore, the impact of RF on food-related and non-food-related odors has not been examined. The present study was designed to address these gaps in the literature. The UPSIT test was not chosen for this study because it solely consists of odor identification without assessing the threshold value, and due to its high cost.[31] The SST, which assesses both odor threshold and identification, was not preferred due to its cost.[31] Instead, the CCCRC test, which provides a qualitative and quantitative evaluation of odor similar to the SST, was selected, because the CCCRC test is cost-effective and validated for the Turkish population.[19,31] To ensure standardization parameters influencing olfaction, such as age and smoking, were included among the study criteria.[9,33]

Olfaction is influenced by numerous intrinsic and extrinsic factors.[34] Several studies have demonstrated the effect of BW on olfaction.[34,35] Although some previous studies have reported that RF leads

FIGURE 1 The distribution of participants according to the CCCRC test results.

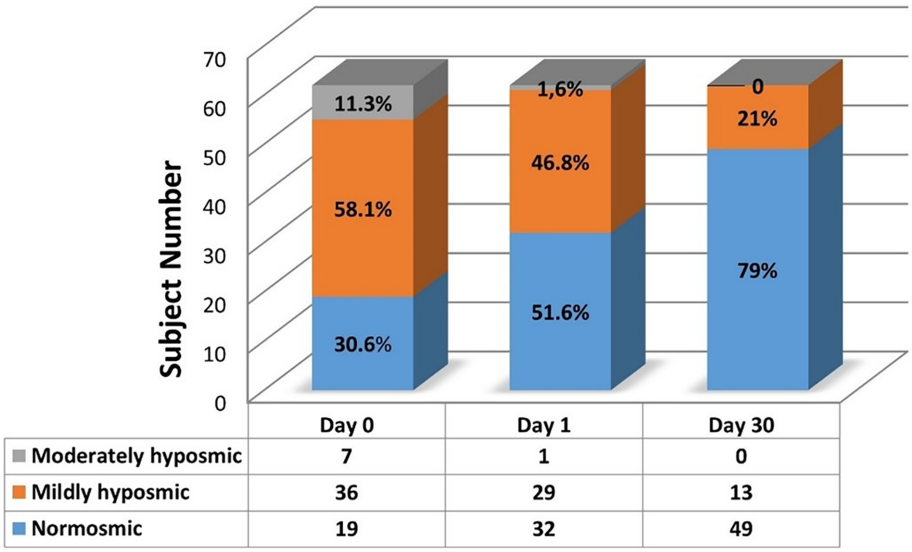

TABLE 3 The evaluation of classified olfactory testing results.

Study days	Normosmic, *n* (%)	Hypo/anosmic, *n* (%)	*p**
Day 0	19 (30.6)	43 (69.4)	.0001
Day 1	32 (51.6)	30 (48.4)	
Day 30	49 (79)	13 (21)	

*Pearson chi-square test $p < .05$.

TABLE 4 The statistical comparison of subclasses results by study days.

Compared days	*p**
0–1	.018
1–30	.001
0–30	.001

*Pearson chi-square test $p < .05$.

to reductions in fat tissue and BW, others have shown that RF does not cause BW changes and may even result in weight gain.[8,13,36] In this study, there was no significant change in the BWs.

The relationship between metabolic functions associated with energy balance and olfaction is complex.[34,35] Various studies have demonstrated that alterations in hormone levels and hormone receptors resulting from changes in metabolic status can affect odor sensitivity.[15,37] These hormones, which convey nutritional status to the brain, exert influence at multiple points along the olfactory pathways.[15,33–35] Receptors for insulin, leptin, and ghrelin, hormones associated with nutrition and energy metabolism, have been identified on the olfactory bulb (OB).[34,35] Leptin reduces odor discrimination performance by inhibiting the neural activity of cells in the olfactory pathways.[34,35] There exists a positive relationship between ghrelin and olfaction. A decrease in the level of ghrelin, which influences the OB, results in reduced olfactory sensitivity and suppression of activity in brain regions stimulated by odor, including the olfactory cortex.[34,35] Among the nutrition-related hormones, the impact of insulin on the olfactory system is most well-defined.[34,35] Elevated insulin levels in the blood suppress neuronal activity in the OB, primary olfactory cortex, and hypothalamus, resulting in decreased olfactory sensitivity and odor perception.[34,35] Additionally, increased insulin resistance is associated with poor olfactory performance.[38] It is known that plasma levels of leptin and insulin, as well as insulin resistance, decrease, whereas plasma level of ghrelin increases because of various fasting types.[1–4]

Numerous studies have demonstrated that fasting and starvation enhance olfaction, including RF.[14,15,39–41] In some of these studies conducted using various objective tests, the presence of these effects on both food-related and non-food-related odors was also investigated.[39–41] Some of these studies have indicated that olfactory sensitivity increased to food-related odors in the fasting state, whereas no such change occurred for non-food-related odors. However, contrasting results were obtained in other studies, where this increase was observed for neutral odors rather than food-related odors.[39–41] This study has demonstrated an improvement in olfaction due to 1 day and 1 month RF, which was the first in the literature. Moreover, it was found that this improvement was attributed to increased sensitivity to food-related odors, which also represents a novel finding in the literature. Additionally, an increase was observed in the number of participants who were classified as normosmic according to the CCCRC test at the end of Ramadan.

The mechanism underlying the effect of hunger and fasting on olfaction has been predominantly explained in most studies by the hormonal changes mentioned above.[14,15,39–41] However, RF differs from other fastings due to its unique characteristics, such as the restriction of water intake, absence of calorie restriction, and alterations in the sleep–wake cycle. Studies investigating the relationship between RF and plasma insulin levels have yielded varying results.[42–44] In some of these studies, insulin levels decreased during RF, whereas in others, they remained unchanged. However, the consistent finding across these studies is that RF reduces insulin

resistance.[1–4,42–44] The same variability in results applies to ghrelin and leptin levels. Although some studies suggest an increase in plasma ghrelin levels during RF, others report no change or even a decrease.[45–48] Similarly, although several studies indicate a decrease in leptin levels, others suggest the opposite.[44,47–49] Consequently, while the present study outcomes may be explained by hormonal changes, it is important to note that these results may not be generalizable to other fasting types.

The current study has several limitations. Firstly, the outcomes of this study cannot be generalized to all types of fasting. Additionally, the study did not measure the amount of calories consumed by the participants. The second limitation is lack of a control group. To avoid this limitation, the study group was formed with participants who were healthy enough to be a control group for any odor study. Although the study outcomes were obtained objectively, another limitation is that the impact of smell changes on the daily lives of the participants was not subjectively evaluated. The absence of an assessment regarding the permanence of the observed effects limits the overall value of the study. Repeating the tests during a post-Ramadan follow-up period to assess the permanence of the effects is necessary for more comprehensive future studies. The most important limitation of the study is the biological mechanisms underlying the results, such as hormone plasma levels, were not investigated. Although efforts were made to mitigate these limitations through an extensive literature review, further comprehensive studies are necessary to eliminate these limitations.

5 | CONCLUSION

A limited body of research exists examining the impact of RF on nasal functions. The present study objectively demonstrated that RF enhances the olfactory detection threshold and odor identification scores, significantly improving the identification of food-related odors. Nevertheless, more comprehensive studies with larger participant cohorts are required to elucidate the mechanisms underlying these outcomes.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest pertinent to the content of this article. This manuscript is original and has not been previously published in its entirety or in part, nor is it presently under consideration for publication elsewhere. All authors reviewed and consented to the final version of the manuscript.

ORCID

Doğan Çakan https://orcid.org/0000-0002-6283-2916
Begüm Bahar Yılmaz https://orcid.org/0000-0001-9521-9520

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