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Original Article

Physiology Section

Perception of Taste and Smell in Sitting and Standing Posture among Healthy Individuals: A Cross-sectional Study

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ABSTRACT

Introduction: Taste and smell are vital senses interlinked to each other that stimulate the desire to eat food. The physiological stress of a standing posture might alter taste and smell sensitivity, compelling individuals to eat more until satiety is achieved.

Aim: To determine and compare the perception of taste and smell in sitting and standing postures among healthy individuals.

Materials and Methods: This cross-sectional study was conducted in the physiology laboratory of Velammal Medical College, Tamil Nadu, India, over a duration of two months from February 2021 to April 2021. The study included 100 medical students (both genders) aged between 18-21 years. For taste assessment, the Sip spit rinse test was performed, where taste strips were impregnated with sweet and salty solutions of different concentrations (0.05-0.00625 g/mL). Odour threshold was measured with various dilutions of rose water (1:10000 to 1:1) using olfactometer. Taste and smell thresholds in standing and sitting postures were analysed using the Paired sample T-test and Lin's concordance test, using Statistical Package for Social Sciences (SPSS) version 22.0 A significance level of 0.05 was used to interpret the p-value.

Results: A statistically significant difference ($p<0.001$**) was observed for taste threshold, with a higher mean value in the standing position (0.0108) compared to the sitting position (0.0086). No statistically significant difference was observed for olfactory threshold in both sitting and standing postures ($p>0.05$). Additionally, no significant gender difference was found for taste and smell threshold values ($p=0.418$).

Conclusion: Standing posture decreases taste sensitivity with no significant change in olfactory sensitivity.

Keywords: Flavour, Health, Odourant, Salts, Sensitivity, Sugars, Threshold

INTRODUCTION

Flavour is a complex combination of olfactory, gustatory, and trigeminal sensations perceived during tasting. The sight and sound of food affect the eating experience. Interestingly, the sixth sense, the "vestibular system," also plays an important role in appreciating flavour. Although we consume food to meet the body's metabolic needs, smell stimulates the desire to eat food. Taste and smell chemoreceptors perform numerous functions, including analysing various nutrients in food, enhancing an individual's appetite, eliciting physiological responses in digestion (such as salivation), influencing emotions and memory, helping to identify food and potential mating partners, protecting us from spoiled food, environmental pollutants, and disease, and constantly renewing the chemoreceptors [1].

Population-based studies indicate that the prevalence of smell and taste dysfunction varies between 2.7% to 24.5% and 5% [2,3], which can reduce appetite, resulting in weight loss, malnutrition, and worsened physical and mental health. Olfactory stimulation improves postural stability in elderly individuals [4]. Additionally, 70% of odours also stimulate the trigeminal nerve [5]. The smell of foods stimulates appetite by triggering cephalic phase activation via the vagus nerve and increasing gastrointestinal secretions. A decrease in olfactory perception could encourage excess consumption of energy-dense foods, even without physiological needs, resulting in obesity [6]. Vice versa, obesity is associated with a decrease in olfactory bulb volume and a lack of neuroproliferation [7]. The increased levels of adipokines and high insulin resistance in obesity reduce olfactory perception [7]. Reduced olfactory sensitivity impairs the quality of life of an individual.

Results are controversial regarding gender differences in olfaction, with some studies showing higher smell perception in females, while others claim no such difference [8,9]. Olfactory sensitivity was higher in the upright position compared to the supine position but remained intact while sitting [10].

Taste sensitivity regulates nutrient digestion, absorption, and the release of hormones related to hunger and satiety. There are five modalities of taste sensation: sweet, salt, sour, bitter, and umami. Studies have also shown that taste sensitivity is altered in the standing position [11]. It is the same special sense that influences individuals to avoid nutrient-rich foods and prefer fast foods due to their mouthfeel and added flavours [12]. Obese individuals are highly sensitive to salt and sweet sensations than other modalities [13]. Also, many studies have focused on changes in taste sensitivity in both physiological and pathological conditions [14,15]. Taste and smell sensitivity are lost in conditions such as diabetes, hypertension, cardiovascular diseases, chronic kidney disease, stroke, Parkinsonism, and Alzheimer's disease. To compensate for diminished sweet and salt sensitivity, individuals tend to use more sugar and salt.

The posture during eating affects taste and smell thresholds. In many countries, including India, there is a growing trend of eating while standing due to the increased availability of fast-food restaurants, the introduction of buffet systems, and roadside eateries. When sitting cross-legged on the floor, muscle contraction increases blood flow to the heart and gastrointestinal tract, ensuring proper digestion and absorption. The resting state increases parasympathetic activity, aiding digestion and absorption. Slow absorption of carbohydrates prevents a significant rise in insulin spikes, avoiding lipogenesis [16-18]. Sitting posture also strengthens the lumbar region, reducing stress. Additionally, bending while eating contracts the core muscles of the stomach, enabling digestion as well as reducing stomach capacity. Hence, fullness is reached rapidly, decreasing appetite and energy intake [19].

As most fast-food restaurants do not provide adequate seating facilities, individuals often consume their food in a standing posture within minutes and proceed with their daily routine. However, people fail to realise that posture influences food intake by modifying digestion activity [20,21]. This is why the practice of sitting on the floor and eating food was followed in earlier times.

The physical stress of standing releases the stress hormone cortisol. Studies have shown that acute stress and the standing posture reduce sensitivity to both salt and sweet taste modalities [21,22]. Although standing helps burn extra calories (50 calories/hour), overeating can compensate for this [23]. There are no studies available on the effect of smell threshold in the standing position.

Therefore, the present study aimed to investigate the effect of standing and sitting on taste and smell thresholds.

MATERIALS AND METHODS

This was a cross-sectional study conducted in the Department of Physiology at Velammal Medical College Hospital and Research Institute, Tamil Nadu, India, involving 100 medical students of both male and female genders. The study was conducted over a duration of two months, between February 2021 and April 2021. Approval for the study was obtained from the Research and Ethical committees of the institution (IEC No: VMCIEC/22/2020, dated 24-11-2020), and informed written consent was obtained from all participants.

Inclusion criteria: The study included 1st to 3rd-year Bachelor of Medicine, Bachelor of Surgery (MBBS) students in the age group between 18-21 years, healthy individuals with a normal threshold of taste and odour perception. Males and females with a normal Body Mass Index (BMI) (between 18.5-24.9 kg/m^2) were involved in the study.

Exclusion criteria: Patients suffering from hypogeusia, ageusia, hyposmia, anosmia, upper respiratory tract diseases like the common cold, sinusitis, other respiratory infections, chronic diseases like neurodegenerative disorders, diabetes, hypertension, cardiovascular diseases, chronic kidney disease, stroke, Parkinsonism, and Alzheimer's disease were excluded.

Study Procedure

Every day, 2-3 subjects were tested in both sitting and standing postures between 4-5 pm to complete the study in two months.

Study on taste: Taste Strips (Burghart strips) of two different tastes were used, impregnated in four different known dilutions of 0.05, 0.025, 0.0125, and 0.00625 [24,25]. The participants were asked to rinse their mouth with distilled water and wipe their tongue.

Firstly, the taste strip impregnated with a sweet solution, sucrose, was tested. The volunteer had to perceive the taste by keeping the taste strip on the tongue in a standing position for about 10 seconds. After perceiving the taste, the volunteer was asked to spit it out and rinse the mouth again to taste the strip in a sitting position (erect posture). The dilution at which they were able to identify the taste (taste threshold) was recorded.

The same procedure was then repeated with the salt solution.

Study on smell: Olfactory sensation was performed on the same day after the taste test for accurate results. The odorant used was rose water, consisting of about 10 different known dilutions ranging from 1:10000 to 1:1. The participants were asked to sniff the olfactometer (Ambala Agencies, Haryana) containing the diluted solution (rose water) in both standing and sitting positions. The dilution at which they were able to identify the smell was recorded.

STATISTICAL ANALYSIS

The data was entered into Microsoft Excel and analysed using SPSS version 22.0 Taste and smell thresholds in standing and sitting postures were analysed using the Paired Sample t-test/ Wilcoxon's signed-rank test. Gustatory and olfaction thresholds between males and females were compared using the unpaired sample t-test. The concordance in the levels of gustatory and olfaction between standing and sitting positions was analysed using Lin's concordance correlation coefficient. An arbitrary cut-off of 0.05 was used to interpret the significance of the p-value.

RESULTS

The number of male and female participants and their anthropometric measures is shown in [Table/Fig-1].

Parameters	Values
Gender	
Male	40 (40%)
Female	60 (60%)
Total	100 (100%)
Age (Mean±SD) in years	20.22±0.54
Height (Mean±SD) in cms	165.89±9.21
Weight (Mean±SD) in kg	60.65±9.89
BMI (Mean±SD) kg/m^2	22.01±2.06

[Table/Fig-1]: Demographic and anthropometric parameters of study participants.

A significant difference in the perception of taste (both sucrose and salt) in the sitting versus standing posture was found as shown in [Table/Fig-2]. The taste threshold is increased in the standing posture compared to sitting. No significant difference was observed in the perception of olfaction between the standing and sitting postures.

Perception test	Mean	Std. Deviation	p-value
Taste test (Salt)			
Standing	0.010876000	0.0077251703	<0.001**
Sitting	0.008631250	0.0061959118	
Taste test (Sucrose)			
Standing	0.014250000	0.00828	<0.001**
Sitting	0.011377500	0.00678	
Smell test			
Standing	Median=0.001	IQR=0	0.418
Sitting	Median=0.001	IQR=0	

[Table/Fig-2]: Comparison of taste and smell outcomes in standing and sitting positions.
Data expressed as mean and standard deviation; Paired sample t-test/Wilcoxon signed rank test; p-value <0.05 considered significant

The present study results indicate a significant increase in taste threshold in the standing posture for both sweet (p<0.001*) and salt (p<0.001*) sensations, as shown in [Table/Fig-2].

A poor correlation among the taste tests for salt, sucrose, and the olfactory test was found as shown in [Table/Fig-3].

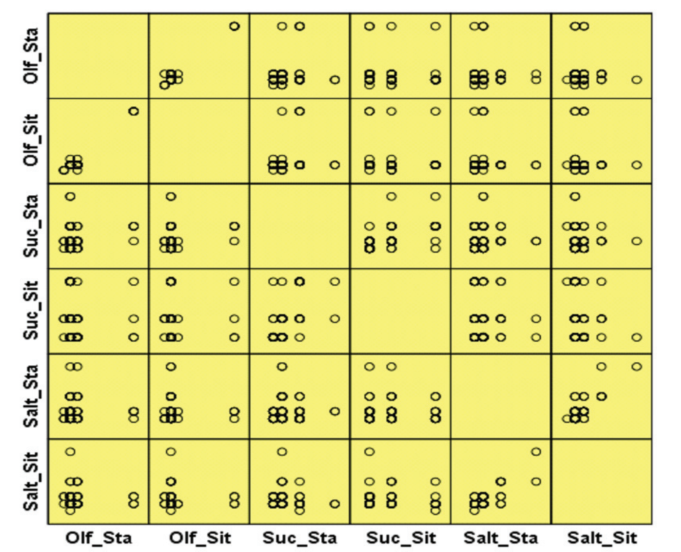
Perception test	Lin's concordance
Taste test (Salt)	
Standing	0.552
Sitting	
Taste test (Sucrose)	
Standing	0.590
Sitting	
Smell test	
Standing	0.339
Sitting	

[Table/Fig-3]: Lin's concordance of gustatory and olfaction tests.

Scatter plot for concordance between standing and sitting position levels in Taste and Smell (olfaction test) has been presented in {Table/ Fig-4]. No significant difference was observed between males and females for taste and smell sensation in the standing and sitting positions as shown in [Table/Fig-5].

DISCUSSION

The present study shows that taste sensitivity was decreased in the standing posture compared with the sitting posture. The results of the present study coincide with those of a previous study conducted



[Table/Fig-4]: Matrix scatter plot for concordance between standing and sitting position levels in Taste and Smell (olfaction test).

Position	Gender (n=100)	Mean	Std. Deviation	p-value
Smell-Standing	Males (n=40)	0.0018650	0.00278702	0.709
	Females (n=60)	0.0020833	0.00290699	
Smell-sitting	Males (n=40)	0.0013125	0.00307314	0.519
	Females (n=60)	0.0016783	0.00254812	
Taste standing (sucrose)	Males (n=40)	0.014375000	0.0082770535	0.903
	Females (n=60)	0.014166667	0.0083668113	
Taste sitting (sucrose)	Males (n=40)	0.012500000	0.0069337525	0.178
	Females (n=60)	0.010629167	0.0066376385	
Taste standing (salt)	Males (n=40)	0.010002500	0.0079821672	0.359
	Females (n=60)	0.011458333	0.0075603738	
Taste sitting (salt)	Males (n=40)	0.008281250	0.0045616108	0.647
	Females (n=60)	0.008864583	0.0071079484	

[Table/Fig-5]: Comparison between male and female participants with respect to gustatory and olfaction outcomes.
Data expressed as mean and standard deviation; Unpaired sample t-test; p-value <0.05 considered significant

on 350 participants in the standing versus sitting posture, where a decrease in taste perception and temperature sensation was observed in the standing posture [23]. The standing position also affects the amount of food consumed. In the sitting posture, foods were perceived as tastier and more favourable due to increased taste sensitivity and more intense temperature. Because of this, satiety is reached sooner, and individuals tend to consume less [23].

Standing induces physical stress as greater muscle contraction occurs in the feet, legs, and trunk to support the entire body weight, and the centre of gravity is far from the support base. During sitting, as the body weight is supported by the back, pelvis, and buttocks, the body is more relaxed [26]. Hence, the possible mechanism for the increased taste threshold/reduced taste sensitivity in the standing position is physical stress. While standing, due to the effect of gravity, blood pools in the lower limbs, thereby decreasing venous return to the heart. As cardiac output and systolic blood pressure decrease, the baroreceptor mechanism comes into action. Activation of the rostral ventrolateral medulla and the hypothalamic paraventricular nucleus of the hypothalamus not only stimulates the sympathetic nervous system but also favours the release of cortisol [27].

Existing literature shows the effect of cortisol in reducing sweet, salt, and sour sensitivity. Stress increases the number and activation of glucocorticoid receptors in type 2 taste receptor cells (Tas1r3), particularly for sweet and umami tastes [28]. To compensate for the reduced taste sensitivity due to taste bud desensitisation, individuals may engage in overconsumption of sugar and salt to achieve the same taste sensation as those who are more sensitive, leading to increased food intake [29]. This can create a vicious cycle as frequent consumption of sugary foods may cause individuals to prefer higher sugar concentrations over time, putting them at risk for long-term health complications, including obesity.

There was no statistically significant difference (p-value=0.418) in the values of olfactory perception between the standing and sitting positions. The present study results are consistent with studies on the effect of physical stress on olfactory sensation, indicating that stress from physical exercise does not modulate olfactory function [30]. However, olfactory sensitivity can be reduced by emotional stress (non fear-inducing) and increased by stress related to fear [31,32].

Taste and olfactory threshold values in different postures did not differ significantly between males and females (p-values for smell in standing and sitting positions were 0.709 and 0.519, and for sweet and salt taste in standing and sitting positions were 0.903, 0.178, 0.359, and 0.647, respectively). Only young adults were chosen for the present study, as odour perception tends to decrease with age [33]. The study was conducted regularly between 4-5 pm to minimise the circadian effect, as peak sensitivity of smell and taste is typically achieved between the afternoon and the middle of the night.

Strength of the study: The study is the first of its kind to investigate the perception of both taste and smell thresholds in sitting and standing positions.

Limitation(s)

A larger sample size could have provided a better understanding of odour perception in different postures. Taste perception was only assessed for sweet and salt, without considering other taste modalities. Odour perception was evaluated solely with rose water, which may differ from responses to other odorants. The study participants were exclusively medical students. Hence, the results cannot be generalised, as taste and smell sensitivity may vary among different racial and ethnic groups.

CONCLUSION(S)

The present study results reveal that taste perception for both sweet and salt sensations decreased in the standing posture compared to the sitting posture. Olfactory sensation remained the same in both sitting and standing postures.

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