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ORIGINAL ARTICLE

Contribution of Different Tastes on 100 mL Water Swallow Test

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ABSTRACT

Introduction: The complex sensory motor activity of swallow consists of transferring food from the mouth to the stomach. Several evidences on swallow biomechanics reveal different tastes leading to variations in swallow. However, there exists dearth of studies exploring this area using simple noninvasive effective procedure like 100 mL water swallow test.

Aims: The present study focused to observe swallow ability across 100 mL neutral, sweet, salt, sour, and bitter liquids in healthy young adults.

Materials and methods: A total of 30 healthy adults within the age of 18 to 23 years participated. All were given lukewarm neutral, sweet, sour, salt, and bitter tastes to swallow individually in a handheld 120 mL cup. Simultaneously, the clinician monitored total time taken to swallow and number of hyolaryngeal movements to calculate volume per swallow, time per swallow, and swallow capacity. Subjects also ingested 10 mL of each taste to estimate the taste threshold which were rated on a minima of 0- point to a maxima of 10-point visual analog scale.

Results: Statistical test and repeated measures of Analysis of Variance (ANOVA) revealed no significance at 95% confidence level. However, clinical difference was noted with neutral taste having highest volume per swallow, increased swallow capacity, and least time per swallow. Following this, sweet taste had higher volume per swallow and swallow capacity while sour taste had increased time per swallow.

Conclusion: The present study helps in understanding the wide dynamic nature of swallow which modulates the physiology as per the bolus ingested.

Keywords: 100 mL water, Healthy adults, Swallow, Tastes.

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INTRODUCTION

Swallowing is one of the compulsory routinely performed complex activities by human beings. This semiautomatic process begins by ingesting wholesome nutritious food from the mouth into the stomach as bolus, in addition to expelling toxic and noxious substance. Despite the metabolic needs, swallowing turns out as a pleasurable activity by modifying the gustatory, olfactory, and visual afferent inputs that enhance the flavor perception.[1] Though every flavor has its own taste threshold, it varies from tongue to tongue, and it helps in triggering the swallow mechanism differentially.[2] The sensory input for taste begins at the periphery level, in the tongue, which houses the taste buds. At this afferent level, the food substance has the potential to initiate swallow as well as modify the swallow pattern at the brainstem motor plan circuitry.[3] Hence, afferent inputs from the oropharynx are crucial for timely coordinated swallow.[4]

Research reveals several afferent inputs influence the quantity of food consumption. One among such is taste. Universally, there are four different tastes, namely, sweet, sour, salt, and bitter.[5] Literature, on experimental evidence, suggests that there exist differences in sensitivity of taste perception which help to differentially trigger the swallow mechanism. For instance, a study on rats reported heightened swallow reflex elicited from sour stimuli.[6] On the same line of thought, literature provides evidence of elevated taste thresholds for sour liquids, thereby leading to an early onset of oral phase.[7] The authors corresponded the early onset to increased pre-swallow stimulus input to the central pattern generator that in turn leads to quicker summating of the threshold necessary to trigger swallow. Contrasting to these evidences, when sour stimuli were presented mixed with sweet taste the effects of reduced aspiration and increased oral preparatory phase disappeared.[4] These views collectively help us understand that taste modulates swallow behavior to a greater degree. However, individual variations do exist largely because of preferential taste and varying food habits.

Various outcome measures have successfully evidenced difference in swallow behavior for each tastes. Using surface electromyography (sEMG), researchers reported that salt bolus had higher submental muscle contraction in comparison to sweet and sour bolus.[8] Supporting this view, Leow and colleagues also reported that sour, salt, and bitter tastes resulted in increased swallow duration than sweet taste.[5] Despite the similar

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results quoted, contrasting results are also evidenced in literature. In their attempt on observing effect of citrus taste on swallow mechanism, Hamdy et al measured 50 mL water test performance in dysphagic and healthy adults.[9] The results revealed that the speed of swallow and overall swallow capacity decreased rather than facilitating swallow. Similarly, using 100 mL water swallow test a study investigated effect of taste on swallow behavior in 20 healthy young adults.[10] The authors provided experimental evidence on plain water having highest speed of swallowing compared to sweet, sour, and salt liquids that had decreased swallowing speed. Collectively, studies help us understand that bolus properties, such as temperature, volume, and texture tend to differentially modify our swallow behavior by varying the biomechanical and/or temporal related measures.[11] Moreover, this area of research has not been extensively explored using simple bedside test like 100 mL water swallow test. Unlike many objective tests, the 100 mL test stands apart by measuring finer aspects of swallow like volume per swallow, time per swallow, and swallow capacity. There also exists dearth of studies exploring modulation of swallow for different taste along with less clinical exploration and research evidence.[12] Adding to these views, inconsistent results are also cited in literature mainly due to large differences in the methods adopted.[3] Varying methodologies raise issues pertaining to the sensitivity in threshold of the taste stimuli.[5] Therefore, the study was undertaken to investigate influence of sweet, sour, salt, bitter, and neutral tastes on swallow ability among healthy young adults by using 100 mL water swallow test.

MATERIALS AND METHODS

Participants

A total of 30 undergraduate students participated in the cross-sectional study design. All the subjects were gender-matched and well within the age range of 18 to 23 years (mean age 20.5 years). None of the subjects reported of any speech, language, and neurological problems and had no history of any surgery done to the oropharyngeal apparatus. Manipal Manual for Swallowing Assessment was administered to rule any swallow impairment.[13] The Institutional Ethics Committee approval was obtained prior to conducting the study. In addition, subjects who duly signed the informed consent sheet were only taken as study participants.

Stimuli

Each subject was given 100 mL of sweet, sour, salt, and bitter tastes individually to achieve swallow ability. The stimuli were prepared by dissolving sucrose, citric acid, sodium, and caffeine powder as tastings to lukewarm water to assess sweet, sour, salt, and bitter tastes respectively. These tastings were added to obtain the respective taste and is reported in previous literature evidences.[14] Each taste was prepared 1 hour before the commencement of the data collection. None of the taste stimuli was carried on to next session. Following the stimuli preparation, it was ensured that all the samples were free from bolus residue of tastings by using a filter cap.

Procedure

For the data collection, subjects were seated comfortably in a straight back chair. Prior to testing, each subject was given 10 mL of individual tastes in a disposable plastic spoon to ingest. The 10 mL was measured using a standard measurable cup for every taste. Each subject was given sweet, sour, salt, and bitter tastes in random order to swallow and scale for its taste threshold on a visual analog scale. The instructions were given to score the taste for maxima of 10 and minima of 0. Maxima were defined as the taste threshold that is above the subjects' personal preference of the respective taste, and minima were defined as the taste level which is below the subjects' preferred taste. No subjects were given a second trial for estimating the taste threshold in order to prevent desensitization of the palate. Furthermore, subjects were given water to rinse their mouth after each taste to remove its aftereffects followed by a 2-minute intertaste interval.

After estimating the threshold of each taste subjects completed the 100 mL water swallow test.[15] All subjects were given to swallow 100 mL of liquid in a 120 mL capacity disposable plastic cup. The subjects were instructed to ingest quickly and continuously without any spillage. These instructions were given specifically keeping the task as sequential swallow in mind.[16,17] During 100 mL water swallow test, a Speech-Language Pathologist simultaneously observed two online parameters: the total time taken by the participant to swallow and the total number of swallows. A handheld digital stopwatch was used to monitor the total time taken to swallow the 100 mL in seconds format. The commencement of the swallow timing began with the cup touching the subjects lower lip and ended when the cup was withdrawn from the lips. Whereas for the total number of swallows, the Speech-Language Pathologist visualized the number of hyolaryngeal elevations. Every one elevation and one depression of hyolarynx was counted as one swallow. Subjects were also duly told to ensure there remains no liquid residue in the cup, hence to swallow full 100 mL.

After swallowing each taste, lukewarm water was given to every subject to rinse the mouth to prevent any lingering aftertaste and adaptation which otherwise can affect swallow performance. Each participant was subjected to swallow one taste after another with a 5-minute intertaste interval to avoid adverse after effects. The data collection was done over a period of 2 days time frame with random presentation of each taste. Subjects who swallowed complete 100 mL with no spillage or liquid residue in the cup were only taken for further data analysis. A total of 150 tokens (30 subjects × 5 swallows) were collected from all the subjects individually which lasted 30 minutes/session. The data obtained from the 100 mL taste swallow was used to calculate three parameters: volume per swallow, time per swallow, and swallow capacity on an offline basis. The mathematical calculations for each of the parameter used were as follows:

Volume per swallow = 100 mL/total number of hyolaryngeal movements

Time per swallow = Total time taken to swallow 100 mL/total number of hyolaryngeal movements

Swallow capacity = 100 ml/total time taken to swallow 100 mL

RESULTS

All the subjects were successfully able to swallow each of the tastes with no liquid residue in the cup. None of the subjects reported nausea and/ health issues 24 hours after swallow. Descriptive statistical analysis revealed neutral taste to have highest volume per swallow, least time per swallow, and increased swallow capacity in comparison with other four tastes. The mean with standard deviation (SD) are mentioned in Table 1. Repeated measures of Analysis of Variance (ANOVA) results revealed no statistical significance at 95% confidence level for all 100 mL water swallow test measures across different tastes. However, the mean raw scores revealed clinical difference. On the continuum within the four tastes, sweet taste had higher volume per swallow followed by sour, salt, and bitter. In time per swallow, salt taste had increased time for swallow after which it was sour, bitter, and sugar. Lastly, the results revealed increased swallow capacity for sweet taste followed by bitter, sour, and salt.

In the estimation of taste threshold, mean value of 5.75, 5.86, 5.55, and 6.2 was obtained for sweet, sour, bitter, and salt tastes respectively. This gives us an understanding that the participants had similar taste threshold. Thereby indicating also that there was no overpowering of taste thresholds that would have led to the differences obtained in the study.

DISCUSSION

Results obtained in our study give us an overview that despite sweet, sour, salt, and bitter being basic tastes they have broad differences in the range of primary afferent sensations.[18] This gives us clear-cut view that our swallow physiology varies its motor plan according to the stimuli. In addition, the results of the study can be attributed to differences in cognitive qualities and physiological changes associated with each taste.[19] Experimental evidence suggests that sweet taste is associated with positive feeling along with a higher pleasant value.[20] Hence, these factors contribute to swallowing by facilitating increased volume of sweet taste consumption that is evidenced in our study results. Apparently, this is not observable for sour, bitter, and salt taste because of lesser pleasant value that would suppress the desire to consume it. Consequently resulting in lesser amount of volume per swallow.

On the contrary, for time per swallow, our study results showed that salt, sour, and bitter taste had increased time for swallowing. This could perhaps be associated with the negative feelings associated with these tastes. Under such circumstances where there is swallowing of salt, sour, and bitter tastes, our peripheral afferent mechanism is biologically tuned to perceive this as a harmful agent, consequently leading to elevated stimulation for triggering the neurons responsible for initiating swallow. These physiological changes are part of the body's biologic defense mechanism that modifies the motor plan by slowing the pacing of swallow, thereby resulting in a more efficient and controlled but prolonged swallow.[3] This is also possible because of the peripheral mechanism that houses special sensory receptors designed to detect both undesired, as in bitter, sour, and salt at one extreme, and desired, like sweet, at another extreme.[18] Therefore, due to the differential placement, the sensory receptors play a major role in the early detection of food as a harmful agent. Under these assumptions, the changes were observed comparatively less for sweet taste sweet taste that had faster pacing of swallow. Hence, it can

Table 1: Mean with SD for 100 mL water swallow test across neutral, sweet, salt, sour, and bitter tastes

	Neutral	*Sweet*	*Salt*	*Sour*	*Bitter*
Volume per swallow	19.35 ± 7.68	17.78 ± 7.97	17.27 ± 8.68	17.27 ± 7.89	16.97 ± 5.43
Time per swallow	1.05 ± 0.3	1.12 ± 0.26	1.59 ± 2.4	1.24 ± 0.49	1.14 ± 0.3
Swallow capacity	17.78 ± 7.5	16.02 ± 7.82	15.27 ± 6.97	15.27 ± 6.89	15.62 ± 9.62

be understood that the categorization of the taste into positive and negative qualities modulates the swallow performance to a great degree.

In addition, literature also suggests hesitancy to swallow when a subject is given 100 mL quantity may have contributed towards. So, having given such high quantity contributes toward increased time per swallow.[21] This has practical implication in rehabilitating individuals with dysphagia, i.e., reducing the input to teaspoon quantity. Existing literature reports that by introducing small quantity of sour liquids one can expect controlled supraglottic penetration and/or swallow. Thereby consequently leading to reduced risk of aspiration that dictates facilitation of swallow 1.6 times greater than that observed in plain water.[3]

Furthermore, the survival instincts of human beings have evolved our perception of food intake. Priority is given to consume high-calorie food, like sweets, which is essential for survival.[22] This perhaps is the reason toward preference for sweet taste being evidenced very early in the intrauterine stages of development and continues to be preferential in children, persisting throughout adulthood.[23,24] These reasons can be used to infer that humans are primed to consume sweet food. Hence, this biological need along with associated positive feeling provide series of summating effect of increased swallow capacity for sweet taste. This, however, is inhibited for sour, bitter, and salt tastes because of its lesser caloric value. Further, in case of sour, bitter, and salt tastes, we can hypothesize that there would be an additional delay in initiating the swallow due to the higher amount, i.e., 100 mL, of liquid to be swallowed. Similar results are also reported in literature for 50 mL sour liquids.[9,10] In relation to this, a study reported that by having smaller amount of liquids one tends to reduce the swallow demands, thereby placing an physiological environment that is advantageous to enhance swallow performance.[25] However, further biomechanical evidences are needed to fully comment upon the statement. Moreover, the results of the current study can not be directly compared with existing literature due to differences in quantity of volume considered, i.e., 50 mL *vs* 100 mL.[9]

In the study, it was also noted that all the subjects had similar ratings of taste thresholds for each of the tastes. Hence, we can rule out the influence of overpowering stimulants reported to be the root cause for differences in previous research attempts.[5] But the concentration of the stimuli was not monitored finely which would be a limitation of the study. Moreover, once the subject has swallowed a taste it is natural for the same taste to be persistent for some time because of sensory overload that is reflected cognitively and physiologically. This leads to a process of adaptation that may have spurious effect on the next series of taste to be swallowed. Therefore nullifying or modulating the swallow behavior based on the previous taste effect. Evidences for such physiological modulations were provided by a few authors who reported reduced oral and pharyngeal phase for swallow of sweet–sour bolus in comparison to sour bolus alone.[3] In terms of cognitive perspective, despite similar ratings of taste thresholds, the negative feelings associated with each taste would have induced some form of aversion toward the stimuli. This perhaps would have led to the subjects focusing more upon stimuli taste than performing the task even after specific instruction given to focus only upon swallow.[26] Hence, these opinions support the findings that sensory input, and feedback is very crucial for swallowing in addition to the roles by brainstem and cortex.[27] Therefore, leading to inhibition of swallow activity that is reflected in our study results as decreased swallow capacity observed for bitter, salt, and sour stimuli. However, in our study we controlled adaptation of the previous taste by giving lukewarm water to rinse the mouth which is expected to remove the aftertaste effects. In addition, a 5-minute intertaste time interval was given which is expected to prevent any cognitive influence on swallow.

CONCLUSION

The study investigated differences in swallow ability across neutral, sweet, sour, salt, and bitter taste in 30 healthy adults using 100 mL water test. The results of clinical raw data were suggestive of sweet taste to have increased volume per swallow and swallow capacity, and sour taste to have longer time per swallow. The results of the current study are noted because of the differences in cognitive and physiological qualities seen among each taste. These have practical applications in the rehabilitation of individuals with dysphagia. In the study, taste threshold was also estimated to ensure that there is no overpowering of stimuli which may the swallow performance. Further studies are warranted across how swallow gets influenced under different concentration of tastes in rehabilitation of individuals with dysphagia. It would also be interesting to observe whether different quantities of each of the tastes vary swallow behavior in the same manner.

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