RESEARCH ARTICLE

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Effect of Oral Somatosensory Training on Oral Somatosensory Dysfunction in Head and Neck Cancer Survivors

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Abstract

Objective: The objective of this study was to determine the effect of an oral somatosensory training (OST) program on oral somatosensory dysfunction (OSD) in neck and head cancer survivors. **Materials and Methods:** One hundred and eight people with altered tastes were enrolled in this research based on inclusion and exclusion criteria and were randomized into groups A and B. Group A received conventional exercises whereas group B received OST. Focal sensations, subjective total taste acuity (STTA), objective taste test, range of motion (ROM), manual muscle testing (MMT), and MD Anderson Symptom Inventory-Head and Neck module (MDASI-HN) questionnaire were employed as outcome measures. To validate the outcomes, pre- and post-assessments of the above measures were conducted. Statistical analysis was done using SPSS statistical software (version 26.0). **Results:** The results showed significant improvement in temperature ($p= 0.0037, 0.0099, 0.0007, 0.0006$), two-point discrimination ($p<0.0001, 0.0010, 0.0112$), light touch sensation ($p<0.0001, 0.0006, 0.0055$), STTA and ROM ($p<0.0001$), MMT scores depressors, elevators, retractors and lateral deviation and protrusion ($p<0.0001$) of patients undergoing OST as compared to conventional training. Also, the MDASI-HN questionnaire revealed the five most severe items in Group B being dry mouth, food taste problems, difficulty swallowing, mucus problems, and choking, and showed a significant decrease in the mean difference from 4.33±0.77, 8.4±0.40, 6.20±0.62, 5.92±0.69, 2.31±0.46 to 2.38±049, 3.09±0.44, 2.61±0.49, 2.48±0.50, and 0.27±0.45 as compared to Group A. **Conclusion:** The study concluded that OST program had shown a significant effect in improving OSD among head and neck cancer survivors.

Keywords: Oral Somatosensation- dysgeusia- two-point discrimination- light touch sensation- temperature sensation

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Introduction

Cancer is an occurrence of unchecked, aberrant cell growth which enters and damages nearby tissue [1]. The disease is primarily found in affluent countries, with a prevalence of 350–500/100,000. On the other hand, India is estimated to have a substantially lower cancer incidence rate—100/100 000 [2]. The cancer of neck and head (HNC) accounts for 25–30% of all cancer cases in India, compared to 3-4% in the West, despite the fact that breast, colorectal, pancreatic, prostate, and lung cancers are the most frequent subtypes in the developed world [3]. Globally, HNC rank sixth in frequency of occurrence [2]. However, these are the third most prevalent cancers in women and the most prominent cancer in Indian males, according to population-specific cancer databases [2]. Over 90% of HNC have squamous cell histology, which is characterized by tumors mostly of the larynx, pharynx, and oral cavity [4]. Historically, both alcohol and tobacco usage have been linked to these cancers; however, a significant percentage of these cancers, especially those of the oropharynx, are now caused by prolonged contact with the human papilloma virus (HPV) [5]. On the other hand, adverse effects and cancer-related issues can arise for patients receiving certain treatments. In addition to greatly enhancing prognosis, the growing use of multidisciplinary treatment involving radiation, surgery, and intensive systemic medication may lead to a high incidence of acute and long-term adverse effects associated with treatment [6].

A primary side effect of these treatments is impaired taste alteration, which significantly lowers quality of life (QOL). It is a major contributor to morbidity and has an impact on patients' diets through decreased oral intake, appetite reduction, and even weight loss. A diminished or total lack of taste was observed by up to two thirds of cancer patients [7]. For a number of reasons, the precise process causing the taste changes in individuals with cancer are yet unknown. Furthermore, these illnesses probably have a complex origin. Due to the destruction of the taste receptor

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cells, radiation therapy and chemotherapy might result in taste abnormalities. Radiation therapy can cause dysgeusia by weakening the papilla epithelium or by changing the configuration of taste pores [8]. The temporal mandibular joint, masticatory muscles, and oral cavity mucosa are among the tissues and structures that radiation and surgery might damage and which are necessary for jaw ROM [9].

Taste buds, which are predominantly found on the dorsum of the tongue but are also present on the lips, his cheekbones, palate, oropharynx, and the larynx, mediate the sense of taste. The five recognized basic tastes that make up taste perception are umami, bitter, sweet, sour, and salty. The tongue's circumvallate, foliate, and fungal papillae are specialized structures that resemble taste buds and are each linked to groups of 50–100 taste receptors. Hypogeusia, dysgeusia and ageusia are examples of taste changes. Basic flavors can be sensed in all parts of the tongue that have taste buds [10, 11].

Previous research indicated considerable taste loss 4-5 weeks after beginning RT treatments, however the speed of recovery is still debatable [12]. Some studies discovered that majority of individuals recovered within 1-4 months of RT, whereas others found that recovery was incomplete or non-existent even after several years [7, 11, 13]. The rate of recovery and the increase in QoL are affected by the size of the excision and the remaining amount of tissue of the tongue [13]. The most prevalent taste disorders appear to have an effect on the "bitter" and "sour" qualities of taste. discovered that patients who had head and neck radiotherapy 1-2 years ago had 41%, 50%, 27%, and 27% taste loss for the qualities bitter, salty, sweet, and sour, correspondingly [14]. In spite of treatment-related adverse effects, poor dental hygiene, a lack of saliva, and nicotine or consumption of alcohol are all potential causes of diminished taste sensitivity. Several researches have revealed that a change in perception of taste influences patients' dietary behavior before and after therapy [15]. Likewise, some research have indicated that changes in saliva flow rates are one of the main drivers of flavor alteration, while some have discovered the opposite. Saliva facilitates oral health and fundamental processes such as food digestion, mastication, swallowing, salivation, speech facilitation, oral mucosa protection, and remineralization of hard tooth tissues [10].

Food sensation combines gustatory sense, olfactory and somatosensation. Oral receptors detect somatosensory signals such as touch, temperature, and pain. These inputs are mostly sent to the brain and spinal cord via the nerve responsible for trigeminal sensation, after which they are transformed into tactile and thermal perceptions. The brain and spinal cord integrates taste and oral somatosensory data to provide a comprehensive understanding of food sensation. Studies on multimodal perception highlight the significance of oral-somatosensation in food evaluation and the relationship between somatosensory and chemosensory functioning [16]. OSD is one of the many difficulties that HNC survivors frequently face after treatment, and it has a significant negative influence on their QOL. OST highlights the sensory channels involved in actions like swallowing, speaking, and tasting, in contrast with conventional training methods that fail to concentrate on the sensory elements of mouth function. These alterations may affect their QOL and the efficacy of their treatment by causing weight loss, decreased appetite, and nutritional deficiencies. For HNC survivors, this focused method has the potential to improve functional results, taste alteration, and sensory awareness. Additionally, by recognizing the complex relationship between sensory information and functional results, OST provides a patient-focused approach to rehabilitation. This training approach may treat underlying sensory impairments by focusing on the sensory components of oral function, which could enhance the effectiveness of rehabilitation efforts.

Furthermore, because OST is simple, it is a practical and affordable intervention that may be used in a variety of therapeutic settings with a broad patient population. Essentially, this research closes a significant knowledge gap on the rehabilitation approaches used by individuals who have survived HNC and emphasizes the significance of customized interventions that give specific attention to the sensory elements of oral function. OST is a promising way to improve QOL and improve results for those with special needs through specific intervention and empirical research. Most studies on taste alterations in cancer survivors concentrate on such people, but little has been discovered about their oral-somatosensory perceptions. Qualitative research found that patients reported somatosensory issues in addition to changes in taste. To enhance the QOL for HNC survivors who experience taste modification, an OST approach is necessary. This study aims to assess the effect of OST on OSD in HNC survivors.

Materials and Methods

Study participants and sampling

This present study was a cross-sectional study and included 108 participants with HNC of both genders, ranging in age from 18 to 80 years, were randomly assigned to one of two groups using a simple randomized sampling approach and computer-generated SPSS software. This research enrolled patients with HNC who had controlled diabetes, taste alterations, somatosensory complaints, lingual nerve intact, had undergone chemotherapy, radiotherapy and hemi-mandibulectomy surgery (anterior portion) (after 1 week to 3 months). Patients with fibrosis, scarring, limited mouth opening, having a history of eating disorders, decreased salivary gland function or impacted salivary output (such as Sjogren's disease or iodine cancer therapy) and patients who had undergone total glossectomy were excluded.

Procedure

Participants were chosen based on the inclusion and exclusion criteria. Before participating in the current research, all of the patients gave both verbal and written consent after receiving information of the intervention's benefits and the study's procedure. An ethical approval was obtained by Institution and the experiments reported in the manuscript were performed in compliance with the ethical standards of the Helsinki Declaration. 108 participants were assigned at random two groups, i.e., 54 in

single group. Group A was given conventional exercises, whereas, Group B was given OST. Pre-assessment was done using Sensory evaluation, Objective taste test, STTA, ROM, MMT and MDASI-HN questionnaire of both groups. The treatment protocol of experimental group is illustrated in the Table 1 [1, 6, 17-22]. Both the groups performed this exercise protocol for about 12 weeks. Later using the same outcome measures as mentioned above, post-assessment was done.

Data Collection Tools

Testing focal sensations

Focal sensations like temperature, two-point discrimination and light touch were tested bilaterally at specific sites on the tongue. These focal sensation measures were taken on the dorsal surface of the tongue, three times each at the specific tongue sites. The overall scores for were calculated based on three stimulus attempts at each tongue site. To test temperature, dental mirrors were placed into beakers of water kept at constant temperatures either warmed to 550C on a hot plate or cooled to 30C in an ice bath. The dental mirrors were placed on the specific tongue sites for duration of 1 s. Participants responded by reporting warm or cold. Two-point discrimination was tested using a sterile unfolded paper clip. The experimenter randomly placed one or two points on the tongue surface. A fixed distance between the ends of each two-point was set at 3.0 mm. Participants responded by reporting they felt one or two points.

Light touch was tested using a 2.83 (0.07 g mm2 of force) Semmes Weinstein Touch-Test sensory evaluator tool according to manufacturer and testing procedures and to previously validated sensory protocols. Participants responded by reporting 'yes' (felt something) or 'no' (did not feel anything) [23].

Objective evaluation (Taste test)

The four fundamental taste characteristics were measured in order to assess the patients' taste acuity. It was necessary for the patient to move the entire solution about in their mouth without swallowing it. After rinsing the mouth with water, the various solutions were taken. Pure sucrose was utilized for the sweetness, chloride of sodium for the saltiness, tartar acid for sourness, quinine powder for bitterness [24].

Subjective evaluation of taste

Subjective Total Taste Acuity

It is a method to evaluate the general taste clarity, where a score of zero denotes no alteration, while a score of four indicates a nearly complete absence of taste function [11].

Range of motion

ROM is frequently used as the measurement in clinical trials of individuals with neck and head carcinoma. Inch tape is an accurate and valid method of measuring ROM, making it convenient and accessible outcome measure in clinical trials and physiotherapy practice.

Manual muscle testing

MMT is a very commonly used method for documenting impairments in muscle strength. The examiner in the application of force to the subject's resistance evaluates the muscle groups being studied as subjectively "weak" or "strong" on a five point scale [25].

MD Anderson Symptom Inventory-Head and Neck module questionnaire

It is a proven, quick, patient-reported outcome evaluation instrument. It has 28 elements divided into three subscales: 13 core items assessing the intensity of general symptoms common to all cancers, nine items unique to the MDASI-HN questionnaire, and six items assessing how severely symptoms interfere with everyday activities. The interference items are graded on a 0-10 numeric scale ranging from "did not interfere" to "completely interfere" [26].

Statistical analysis

The outcome parameters were assessed before the commencement of the trial. Both manual and statistical tools (SPSS version 26.0) were employed in the study's analysis. Descriptive data statistics including mean, percentage, and standard deviation were employed in the statistical evaluation of the collected data. Using an inch tape, TMJ mobility was measured and computed using ROM. The individual's MMT was used to examine and compute muscle strength. The demographic data were computed as a percentage, whereas the sensory assessment, STTA and MDASI-HN questionnaire analysis and calculations were analyzed using mean and standard deviation. The pre and post intervention within the group was statistically evaluated using the paired t test.

Results

This study included 108 HNC survivors who experienced taste changes.

Demographic variables

Among the 108 participants with taste changes, 78 were male (72.22%) and 30 of them were female (27.77%)). Participants between the ages of 38-47 years were the more frequent cases. Fifty of the participants were without lifelong non-smokers (46.29%), 28 were ex-smokers (25.92%), and 30 of them were current smokers (27.77%). Eighty-three of the individuals were alcohol users (76.85%) and majority of the individuals had squamous cell tumor histology (78.7%). Fifty participants (46.29%) had oral cavity has their primary tumor site and only six (5.5%) had other tumor site (Table 2).

Focal sensations

The comparison of the mean values of temperature sensation score within the group for these patients with taste alteration was seen for affected tip, unaffected tip, affected body, and unaffected body of Group A with a p value of 0.0489, 0.0399, 0.0129, 0.0129, whereas for Group B was 0.0037, 0.0099, 0.0007, 0.0006 which showed significant improvement than Group A.

Table 1. Treatment Protocol for Head and Neck Cancer Survivors Undergoing Oral Sensorimotor Training

Number of weeks	Treatment	Minutes/ Repetitions
Week 0	Ultrasound	6 minutes
	Quick stretch	3 repetitions each
	Tapping	3 repetitions
	Quick icing	3 quick strokes for each muscle belly
	Fast brushing	Apply 5 seconds and repeat after 30 seconds. 3 repetitions for each muscle
	Light touch	Apply 5 strokes with light brush and give rest for 30 seconds. 3 repetitions.
	Taste training- patients were tasted blindfolded specific drinks like different juices and teas and food like pretzel sticks	15 minutes
	Patient and relative education about oral hygiene, how to keep tongue clean and try to drink 1.5-2.1 liters per day	5 minutes
	Nutritional counselling by flavour enhancing nutrition	60 minutes
Week 1-2	Ultrasound	6 minutes
	Quick stretch	5 repetitions each
	Tapping	5 repetitions
	Quick icing	3 quick strokes for each muscle belly
	Fast brushing	Apply 5 seconds and repeat after 30 seconds. 5 repetitions for each muscle
	Light touch	Apply 5 strokes with light brush and give rest for 30 seconds. 5 repetitions.
	Active exercises of tongue -	1 set × 10 repetitions
	Reaching tongue and forth	
	Tongue to cheek	
	Tongue to mouth corners	
	Jaw side to side movement	
	Mouth opening	
	Breathing exercises	1 set × 10 repetitions
Week 3-5	TMJ mobilization- Grade 1	3 set × 10 repetitions
	Quick stretch	10 repetitions each
	Tapping	5 repetitions
	Quick icing	3 quick strokes for each muscle belly
	Fast brushing	Apply 5 seconds and repeat after 30 seconds. 10 repetitions for each muscle
	Light touch	Apply 5 strokes with light brush and give rest for 30 seconds. 10 repetitions.
	Taste training- patients were tasted blindfolded specific drinks like different juices and teas and food like pretzel sticks	15 minutes
	AROM exercises of tongue, palate, larynx and constrictor muscles	2 set × 10 repetitions
	Breathing exercises	2 set × 10 repetitions
	Patient education	5 minutes
Week 6-9	TMJ mobilization- Grade 2-3	3 set × 10 repetitions
	Prolonged stretch	10 minutes
	Inhibitory tendon pressure	5 repetitions
	Prolonged ice	10 minutes
	Slow rolling	5 repetitions
	AROM exercises of tongue, palate, larynx and constrictor muscles	3 set × 10 repetitions
	Tonicity exercises of tongue, palate, larynx and constrictor muscles	3 set × 10 repetitions
	Tongue PNF	3 set × 10 repetitions
	Breathing exercises	3 set × 10 repetitions

Table 1. Continued

Number of weeks	Treatment	Minutes/ Repetitions
Week 10-12	TMJ mobilization- Grade 2-3	3 set × 10 repetitions
	Prolonged stretch	10 minutes
	Inhibitory tendon pressure	10 repetitions
	Prolonged ice	10 minutes
	Slow rolling	10 repetitions
	Tongue base resistance training	3 set × 10 repetitions
	Breathing exercises	3 set × 10 repetitions
	Patient education	5 minutes
	Nutritional counselling by flavour enhancing nutrition	60 minutes

respectively (Table 3).

The comparison of mean values of two-point discrimination sensation score within the group for these patients with taste alteration was seen for affected tip and affected body of Group B showed a significant improvement with a p value of <0.0001, while for unaffected tip and unaffected body showed a p value of 0.0010 and 0.0112 as compared to Group A (Table 4).

The comparison of mean values of light touch sensation score within the group for affected tip and unaffected tip of Group B showed a p value of <0.0001, but the affected body and unaffected body exhibited p values of 0.0006 and 0.0055,whereas Group A showed slight improvement for affected tip, unaffected tip, affected body and unaffected body with a p value of 0.0399, 0.0326,0.0129,0.0239,

Table 2. Demographic Characteristics of Head and Neck Cancer Survivors

Characteristics	No. of Individuals (%)
Age	
18-27 years	0 (0%)
28-37 years	10 (9.25%)
38-47 years	36 (33.33%)
48-57 years	18 (16.66%)
58-67 years	24 (22.22%)
68-80 years	20 (18.51%)
Gender	
Male	78 (72.22%)
Female	30 (27.77%)
Smoking status	
Lifelong non-smokers	50 (46.29%)
Ex-smoker (quit ≥ 1 year ago)	28 (25.92%)
Current smoker (quit < 1 year ago)	30 (27.77%)
Alcohol use	
Yes	83 (76.85%)
No	25 (23.14)
Tumor histology	
Squamous cell	85 (78.70%)
Adenocarcinoma	7 (6.48%)
Other	16 (14.81%)
Tumor site	
Oral cavity	50 (46.29%)
Nasopharynx	16 (14.81%)
Oropharynx	10 (9.25%)
Hypopharynx	8 (7.40%)
Larynx	18 (16.66%)
Other	6 (5.55%)

Table 3. Temperature Sensation Affected Pre and Post Intervention of Group A and B

Temperature	Pre test	Post test	p value
Affected tip			
Group A	2.20±0.62	2.38±0.49	0.0489
Group B	2.09±0.70	2.70±0.46	0.0037
Unaffected tip			
Group A	2.64±0.48	2.75±0.43	0.0129
Group B	2.59±0.49	2.90±0.29	0.0007
Affected body			
Group A	2.03±0.64	2.24±0.43	0.0399
Group B	2.01±0.65	2.44±0.50	0.0099
Unaffected body			
Group A	2.70±0.46	2.89±0.39	0.0129
Group B	2.68±0.46	2.94±0.23	0.0006

Table 4. Two-point Discrimination Sensation Affected Pre and Post Intervention of Group A and B

Two-point Discrimination	Pre test	Post test	p value
Affected tip			
Group A	2.07±0.54	2.22±0.41	0.0101
Group B	2.12±0.58	2.51±0.50	<0.0001
Unaffected tip			
Group A	2.61±0.49	2.72±0.45	0.0129
Group B	2.70±0.46	2.88±0.31	0.001
Affected body			
Group A	2±0.64	2.24±0.43	0.0143
Group B	2.05±0.68	2.55±0.50	<0.0001
Unaffected body			
Group A	2.66±0.47	2.81±0.39	0.0195
Group B	2.77±0.41	2.94±0.23	0.0112

Table 5. Light touch sensation Affected Pre and Post Intervention of Group A and B

Light touch	Pre test	Post test	p value
Affected tip			
Group A	1.81±0.39	2.01±0.59	0.0399
Group B	1.70±0.46	2.24±0.51	<0.0001
Unaffected tip			
Group A	2.61±0.52	2.83±0.50	0.0326
Group B	2.66±0.47	2.96±0.19	<0.0001
Affected body			
Group A	1.64±0.75	1.75±0.72	0.0129
Group B	1.68±0.50	2.03±0.47	0.0006
Unaffected body			
Group A	2.33±0.64	2.42±0.49	0.0239
Group B	2.38±0.49	2.72±0.45	0.0055

Table 6. Objective Evaluation of Taste (Taste Test) Affected Pre and Post Intervention of Group A and B

Objective evaluation of taste	Pre test	Post test	p value
Salt			
Group A	2.27±0.49	3.48±0.57	<0.0001
Group B	2.35±0.51	4.53±0.50	<0.0001
Sweet			
Group A	2.66±0.47	3.53±0.50	<0.0001
Group B	2.5±0.51	4.24±0.43	<0.0001
Sour			
Group A	2.61±0.49	3.87±0.80	<0.0001
Group B	2.79±0.40	4.68±0.46	<0.0001
Bitter			
Group A	2.40±0.49	3.81±0.72	<0.0001
Group B	2.37±0.48	4.57±0.49	<0.0001

Table 7. Subjective Total Taste Acuity (STTA) Affected Pre and Post Intervention of Group A and B

Subjective Total Taste Acuity (STTA)	Pre test	Post test	p value
Group A	3.27±0.45	2.87±0.33	<0.0001
Group B	3.16±0.42	2.03±0.43	<0.0001

respectively (Table 5).

Objective evaluation of taste

The comparison of mean values of taste test (objective evaluation) within the groups was seen for the salt, sweetness, sourness and bitterness of Group A and B was $p < 0.0001$. The pre test mean scores of Group B showed significant improvement from 2.35±0.51, 2.5±0.51, 2.79±0.40, 2.37±0.48 to 4.53±0.50, 4.24±0.43, 4.68±0.46 and 4.57±0.49 as compared to Group A, respectively (Table 6).

STTA

For individuals with taste alteration, a comparison of the averages scores of the pre and post values of STTA was observed. STTA score in Group B were decreased with a mean difference of 3.16±0.42 to 2.03±0.43and $p<0.0001$ (Table 7).

Table 8. Range of Motion (ROM) Affected Pre and Post Intervention of Group A and B

ROM	Pre test	Post test	p value
Mouth opening			
Group A	21.35±5.61	31.01±4.32	<0.0001
Group B	21.48±5.69	38.01±4.34	<0.0001
Left lateral deviation			
Group A	3.90±1.71	6.44±1.48	<0.0001
Group B	3.98±1.74	7.90±1.78	<0.0001
Right lateral deviation			
Group A	4.09±1.41	6.92±1.68	<0.0001
Group B	3.92±2.17	7.96±2.44	<0.0001
Protrusion			
Group A	2.75±1.06	5.48±1.20	<0.0001
Group B	2.44±1.23	6.77±2.03	<0.0001

Table 9. Manual Muscle Testing Affected Pre and Post Intervention of Group A and B

MMT	Pre test	Post test	p value
Depressors			
Group A	3.37±0.73	3.77±0.60	<0.0001
Group B	3.12±0.64	4.25±0.44	<0.0001
Elevators			
Group A	3.37±0.70	3.75±0.61	<0.0001
Group B	3.24±0.69	4.16±0.37	<0.0001
Retractors			
Group A	3.07±0.74	3.55±0.69	<0.0001
Group B	3.05±0.83	3.62±0.7	<0.0001
Protrusion			
Group A	3.03±0.77	3.40±0.65	0.0002
Group B	3.16±0.79	3.59±0.76	0.0002
Lateral deviation			
Group A	3.03±0.77	3.42±0.66	<0.0001
Group B	3.11±0.81	3.55±0.74	<0.0001

ROM

The comparison of mean values of ROM score within the group for the patients with taste alteration was seen for mouth opening, left lateral deviation, right lateral deviation, and protrusion of Group A and B and $P < 0.0001$ (Table 8).

MMT

The comparison of mean values of MMT score within the group for the patients with taste alteration was seen for depressors, elevators, retractors and lateral deviation of Group A with $p < 0.0001$ and for protrusion was $p = 0.0036$, whereas, for Group B was $P < 0.0001$ for all the muscles of the TMJ (Table 9).

Table 10. MD Anderson Symptom Inventory-Head and Neck Module (MDASI-HN) Questionnaire- Core Items Affected Pre and Post Intervention of Group A and B

MDASI-HN core items	Group A			Group B		
	Pre test	Post test	p value	Pre test	Post test	p value
Dry mouth	4.05±0.85	2.81±0.39	<0.0001	4.33±0.77	2.38±049	<0.0001
Difficulty remembering	2.18±0.64	1.77±0.41	0.0013	2.07±0.69	1.48±0.50	<0.0001
Numbness/tingling	2.14±0.65	1.90±0.29	0.0222	2.25±0.67	1.5±0.50	<0.0001
Sleep disturbance	2.11±0.53	1.87±0.33	0.0143	1.98±0.68	1.33±0.47	<0.0001
Lack of appetite	1.98±0.49	1.07±0.26	<0.0001	2.05±0.59	1.94±0.23	<0.0001
Fatigue	1.25±0.48	0.81±0.39	<0.0001	2.35±0.51	1.55±0.50	<0.0001
Drowsiness	0.88±0.69	0.48±0.50	0.0005	1.07±0.63	0.35±0.48	<0.0001
Pain	2.24±0.43	1.83±0.37	<0.0001	2.12±0.55	1.27±0.45	<0.0001
Distress	0.55±0.50	0.61±0.49	0.4964	0.98±0.62	0.14±0.35	<0.0001
Sadness	1.16±0.63	0.83±0.37	0.001	1±0.64	0.37±0.48	<0.0001
Shortness of breath	1.25±0.48	0.94±0.23	<0.0001	1.03±0.69	0.27±0.45	<0.0001
Nausea	0.74±0.52	0.29±0.46	<0.0001	0.83±06	0.22±0.41	<0.0001
Vomiting	1.05±0.59	0.09±0.29	<0.0001	0±0.000	0.05±0.23	<0.0001

Table 11. MD Anderson Symptom Inventory-Head and Neck Module (MDASI-HN) Questionnaire- Specific Items Affected Pre and Post Intervention of Group A and B

MDASI-HN specific items	Group A			Group B		
	Pretest	Posttest	p value	Pre test	Posttest	p value
Problem tasting food	7.44±0.60	4.27±0.73	<0.0001	8.4±0.40	3.09±0.44	<0.0001
Difficulty in swallowing/chewing	6.33±0.67	3.38±0.49	<0.0001	6.20±0.62	2.61±0.49	<0.0001
Problem with mucus in mouth /throat	5.22±0.57	2.40±0.49	<0.0001	5.92±0.69	2.48±0.50	<0.0001
Choking/coughing	2.11±0.50	1.59±0.49	<0.0001	2.31±0.46	0.27±0.45	<0.0001
Difficulty with voice	1.62±0.48	1±0.00	<0.0001	2.05±0.56	0.59±0.49	<0.0001
Constipation	1.22±0.71	1.03±0.19	0.0769	1.27±0.62	0.20±0.40	<0.0001
Problem with teeth/gums	1.35±0.55	1.07±0.26	0.003	1.25±0.48	0.11±0.31	<0.0001
Mouth/throat sores	0.51±0.50	0.27±0.45	0.0143	0.57±0.49	0.07±0.26	<0.0001
Skin pain/burning /rash	0.48±.50	0.40±0.49	0.2519	0.55±0.50	0.16±0.37	<0.0001

MDASI-HN questionnaire

The comparison of mean values of the MDASI-HN questionnaire for patients with taste alteration within the groups was done and p value showed <0.0001. In Group B, overall the five most rated severe items by mean ± SD were dry mouth (4.33±0.77), problems tasting food (8.4±0.40), difficulty swallowing (6.20±0.62), problem with mucus in mouth (5.92±0.69), and choking (2.31±0.46) were pre test values and reported at moderate to severe levels by 25,19,19,18 and 12 %, were decreased and showed significant improvement to 2.38±049, 3.09±0.44, 2.61±0.49, 2.48±0.50 and 0.27±0.45 as compared to Group A (Table 10-12).

Discussion

A comprehensive evaluation of the taste alterations was conducted, along with measurements of the jaw's ROM when opening and shutting the mouth, a swelling check, and a MMT test to gauge the masticatory muscles'

Table 12. MD Anderson Symptom Inventory-Head and Neck Module (MDASI-HN) Questionnaire- Symptom Interference Items Affected Pre and Post Intervention of Group A and B

MDASI-HN symptom interference items	Group A			Group B		
	Pre test	Post test	p value	Pre test	Post test	p value
Normal work	2.11±0.53	1.47±0.49	<0.0001	2.20±0.56	0.96±0.77	<0.0001
Enjoyment of life	2.48±0.50	1.72±0.45	<0.0001	3.07±0.50	1.59±0.49	<0.0001
Walking	2.38±0.49	1.72±0.46	<0.0001	1.70±0.50	0.40±0.49	<0.0001
General activity	0.87±0.70	0.22±0.41	<0.0001	0.46±0.50	0.20±0.40	<0.0001
Mood	0.59±0.59	0.66±0.58	<0.0001	1.05±0.78	0.25±0.44	<0.0001
Relation with others	0.51±0.50	0.59±0.49	0.0444	0.98±0.65	0.31±0.46	<0.0001

strength. It was found after the evaluation that a cancer patient receiving radiotherapy experienced notable alterations in taste. While radiotherapy is a vital long-term treatment, it is not without its drawbacks. The radiation has caused the taste changes to worsen. The degree of damage could be lessened and quality of life could be improved, though, if physical rehabilitation is done combined with the radiation treatment. An overview of research on the oral somatosensory experience of patients with HNC and the possible causes of somatosensory abnormalities in this population was carried out. Subjective evaluations revealed changes in oral somatosensory perception, including sensitivity to specific temperatures, textures, and spices. According to the study's findings, a thorough evaluation of cancer patients' perceptions of food would enable the creation of customized nutritional therapies that will enhance their eating experiences and QOL [16].

In this research, many of the 54 participants in Group B reported taste changes, and the individuals were offered taste enhancement training and nutritional counseling as part of the exercise program. Many people experienced difficulties swallowing, and swallowing exercises were given to them as well. The MDASI-HN score for Group A revealed five most rated severe items were dry mouth, problems tasting food, difficulty swallowing, problem with mucus in mouth and choking and reported at moderate to severe levels by 25,19,19,18, and 12%. Considering overall of the findings, we can conclude that taste enhancement training for HNC with taste alteration is effective. In comparison to Group A, Group B improved more in terms of taste alterations, ROM, and muscle strength.

Chen et al. [24] conducted a study in which he included patients from August 2017 to November 2020 who had either postoperative or curative IMRT for HNC. Between March 2021 and January 2022, the data analysis was completed. Utilizing patient-reported standard of existence and both subjective and objective taste functions, outcome measures were established. The findings showed that taste dysfunction (TD) persisted in the most of patients both during and three months following radiation therapy. A small number of people developed chronic TD. Patients with HNC getting intensity-modulated radiation therapy (IMRT) showed a correlation between TD and a high oral cavity dosage. After IMRT, reducing the oral cavity dose may encourage early taste function recovery [24].

Another study by Mathlin et al. [27] carried out a study involving 61 participants who completed the MDASI-HN questionnaire in a single department while undergoing radical radiotherapy or chemo-radiotherapy for HNC during weeks 1 and 4. The participants who experienced dysgeusia in week 4 also answered additional questions about the foods they could taste and how they handled taste changes. According to the findings, individuals undertaking radiotherapy for any type of HNC should be informed of the extremely high chance of taste changes as well as the duration of this side effect. Patients who experience changes in taste should be told that a softer food that requires less chewing will be more palatable [27].

In 2021, a thorough extensive research was carried to find relevant publications, PubMed, Medline, and EMBASE were consulted for information on taste, RT, and HNC. This research shown that taste impairment after radiation therapy is frequent and adversely impacts patients' dietary habits and overall standard of existence. Treatment plan choices like the RT modality selected, the dosage distributed throughout the gustatory field, and the use of adjuncts like bite blocks, may prove advantageous. But the proof is scant. Large prospective cohort studies or randomized studies with adequate confounding correction are desperately needed [28].

A questionnaire-based study was conducted by MD Anderson et al. in 2021, and 79 individuals were enlisted. The study was open to HNC free survivors who went through the course of therapy over six months earlier. MDASI-HN was finished by the participants. Patients who were 65 years or older at the moment of treatment for OPC with final radiotherapy were considered. According to the data, the majority of older oropharyngeal cancer patients only had 6 mild-to-moderate intensity symptoms, and they had a wide range of freedom from universal symptoms after a mean of almost four years from the conclusion of therapy. However, 38% of those tested positive for a minimum of one significant symptom. A number of patients reported moderate-to-severe xerostomia, difficulty tasting food, and dysphagia-related symptoms; nonetheless, attempts should be undertaken to improve the present small (9%) fraction of free of symptoms survivors [24].

Another study by McLaughlin. [28], involved 92 participants. Using high, medium, and low concentrations of sweet, salty, sour, and bitter tasting solutions, taste discrimination was evaluated. According to the study's findings, taste dysfunction persisted as an issue for all types of HNC therapies, regardless of the cancer's location or stage. On the taste test, participants who claimed to have lost one or more particular taste modalities did poorly. Participants were unable to correctly identify which taste was the most compromised [29].

Murtaza et al. [30] provided a summary of the systems behind taste perception and how they are affected by cancer in their review study. We emphasize how chemotherapy and radiation therapy affect taste physiology. In participants with advanced cancer sites, we also offered information on how to restore taste sharpness using medication, dietary changes, and various preventive techniques.Following the assessment, it was already established that the HNC patient receiving radiation therapy had experienced a significant change in taste. While radiotherapy is a necessary, long-term treatment, it is not without its consequences. The taste change that already exists is made worse by this radiation. On the other hand, physiotherapy may help to improve range of motion, muscle strength, and general quality of life, and it may also result in less severe taste changes when administered in conjunction with radiation therapy. One effective form of treatment is taste improvement training. Priority should be given to therapies that are reversible, inexpensive, and easily available. This study has filled up this information gap and improved an existing body of

evidence demonstrating the value of the taste enhancement training program as an additional resource for enhancing taste improvements in HNC patients.

The study had a few limitations, including a small sample size, which prevented the findings from being generalized to other forms of cancer. It was limited to a certain geographic area. The study's timeline was likewise carefully maintained. We recommend that the next group employ a bigger sample size and that it includes all sorts of procedures, including the total glossectomy advised for HNC. An individual can also be selected from amongst cancer treatment centers for a greater number of patients.

Healthcare professionals can detect problems, inadequacies, or restrictions in movement that may result after surgery, radiation therapy, or chemotherapy by assessing sensation, strength, ROM, and QoL. As a result, they can carry out focused treatment options to enhance individuals' sensation, strength, mobility, and general functional autonomy, such as physical therapy or rehabilitation activities. In spite of challenges associated to cancer, this all-encompassing approach fosters patient resilience and well-being.

The study concluded that oral somatosensory training program had shown a significant positive response in improving oral somatosensory dysfunction as well as taste and sensory perception, ROM, muscle strength and their daily activities among HNC survivors.

Author Contribution Statement

The authors confirm their contribution to the paper as follows: study conceptualization and design, SB Shinde and AA Vaidya; organization and collection of data, G Anand , SK Patil AA Vaidya; analysis and interpretation of results, PP Jain, RV Shinde, AA Vaidya; draft manuscript preparation, SB Shinde, AA Vaidya and PP Jain; and proofreading and editing of the manuscript, SB Shinde, AA Vaidya and PP Jain. All authors reviewed, agreed, and approved the final version of the manuscript.

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Scientific Approval

The study protocol was approved by protocol committee of Krishna Vishwa Vidyapeeth (Deemed to be University).

Ethics Committee Approval

The study protocol was approved by Institutional Ethics Committee of Krishna Vishwa Vidyapeeth (Deemed to be University), Karad (Protocol Number-183/2021-2022).

Conflicts of interests

Nil.

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