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Postlaryngectomy Olfactory Rehabilitation and Swimming

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A B S T R A C T

The aim of the study was to determine the influence of swimming on postlaryngectomy olfactory rehabilitation. This prospective open interventional trial at a tertiary academic hospital included 100 laryngectomised patients; 17 were swimmers and 83 were nonswimmers. Participants practiced the polite yawning technique (PYT) for postlaryngectomy olfactory rehabilitation. Rhinomanometry was used to measure air quantity in the right and left nostrils, respectively; to test sense of smell, we applied the smell diskettes olfaction test (SDOT). Swimmers used swimming aids and swam only in a pool accompanied by another person trained in the rescue and resuscitation of a laryngectomee. Measures were made at three time points. Following PYT initiation, the number of accurately guessed odours was higher among swimmers (SDOT1 = 5.29, SDOT2 = 6.40, SDOT3 = 6.76) than nonswimmers (SDOT1 = 3.73, SDOT2 = 5.48, SDOT3 = 5.60) as were airflows through the left (swimmers: FL1 = 40.82, FL2 = 137.71, FL3 = 172.80; nonswimmers: FL1= 13.05, FL2 = 104.63, FL3 = 113.00) and right nostrils (swimmers: FR1 = 46.82, FR2 = 115.41, FR3 = 145.40; nonswimmers: FR1 = 13.70, FR2 = 92.77, FR3 = 106.43). The number of odours identified by laryngectomised patients increased with the volume of nasal airflow, but this number and the efficiency of olfactory rehabilitation were higher in swimmers compared to nonswimmers. Swimming with a swimming aid improved the quality of life after surgery and may facilitate resocialisation of laryngectomised patients.

***Key words**: laryngectomees, olfactory rehabilitation, swimming*

Introduction

Laryngectomy can cause many problems, such as the need to cope with a stoma, the adjustment to tracheostomal breathing, formation of a voice, and loss of smell. The resulting loss of nasal breathing in laryngectomised patients causes the cessation of airflow, preventing stimulation of the olfactory epithelium[1,2]. The current clinical consensus is that the reduced nasal airflow underlies postlaryngectomy hyposmia and anosmia[3]. The possibility of olfactory rehabilitation is an important factor in postoperative treatment, and positive results are very stimulating for patients. Once speech and sense of smell come back, confidence grows, and an otherwise healthy patient can return to previously enjoyed activities and hobbies[4].

At first sight, swimming would appear to be a potentially dangerous activity for a laryngectomy patient, but with various swimming aids developed especially for this group, swimming has proved effective, safe, reliable and therapeutic[5]. With the use of different swimming aids, airflow again passes through the nostrils, preventing degenerative changes of the olfactory mucosa. This paper describes differences in airflow and preservation of sense of smell between swimmers and nonswimmers during and after postlaryngectomy olfactory rehabilitation.

Materials and Methods

Participants

A prospective interventional study was performed among the members of the Laryngectomised Patients Club, which is sponsored by the Clinic of Otorhinola-

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ryngology, Head and Neck Surgery, University Hospital Centre (KBC) Rijeka, during a 3-month period. The study involved all members who attended a set of lectures on the importance of olfactory rehabilitation using the polite yawning technique (PYT) and in whom no significant nasal airway obstruction was detected during endoscopic examination.

PYT involves having the patient execute a yawn, but with the lips completely closed while lowering the tongue, soft palate, and jaw[6,7]. For maximum effect, the patient repeats the movement several times in quick succession. Participants in this study received an explanation of PYT in the course of group meetings, during a 10-minute instructional session. Each patient also received 5 minutes of individualised instruction to ensure a full understanding of the technique. After these trainings, participants then performed the technique on their own for two weeks; if this time was not adequate for complete rehabilitation, patients did the PYT exercises for 2.5 months more.

Measurements of airflow and olfactory detection were made at three time points: just after the initial training (all patients); after the first two-week home-exercises period (all patients); and at the end of the additional 2.5-month period of continued exercises for the subgroup of patients who needed continued rehabilitation (i.e., at the 3-month point after PYT initiation).

For airflow testing, the volume was measured at the lowest possible pressure of 75 Pa because higher pressures were not tenable for most of the patient group. For the olfactory measurements, which took place at the same time as the rhinomanometric testing, patients with smell diskettes olfaction test (SDOT) scores of four to six (see below) were continued for the 2.5 further months of therapy. Patients who had scores of three or less were inferred to either be nonadherent or have a continued impaired sense of smell. Participants were considered rehabilitated if they scored 7 or 8 on the SDOT[8].

Rhinomanometry

This objective measure of nasal airflow, resistance, and pressure involves a rhinomanometric monitor (Rhinomanometer 300, Atmos, Lenzkirch, Germany) that records the curves and volume of air inhaled through the nostrils. Its rapid feedback provides information about the pressure differential between the nasal vestibule and the choane. Patients were instructed to perform PYT during the measurements, using a technique very similar to the standard[10,11], which allowed evaluation of how PYT influenced airflow rate.

Olfactometry

The SDOT test involves a questionnaire and eight diskettes, each with a different odour (coffee, chocolate, fish, grass, peach, pineapple, rose, and vanilla) at concentrations far higher than the typical threshold values for olfaction. The test is a fast and effective way to evaluate olfactory function. The questionnaire is multiple choice, giving one point for each correct answer. Scores of 7 or the maximum of 8 indicate normal olfaction (probability 99.75%), but scores of 6 or less indicate hyposmia or anosmia, and the possibility of someone with anosmia randomly passing the test is 0.26%[12].

Swimming

At the end of three months, the patients were divided into two groups: the swimmers (n = 17) and the non-swimmers (n = 83). The swimmers were members of the Laryngectomy Swimming Club and in average swam 3 hours a week. Normal swimming is possible after total laryngectomy in a well-motivated and previously experienced swimmer with simple equipment. These swimming aids consist essentially of an extension tube plugged firmly and securely into the tracheal stoma, forming a water-tight seal while the other end of the tube is flattened and put between the lips (Figures 1 and 2). During inspiration, the airflow goes through the nose, into the mouth, and through the tube in the trachea and the lungs. The laryngectomee should never swim alone, and it is strongly advised that attending swimmers or family should be trained in the rescue and resuscitation of a laryngectomee[1,9].

Fig. 1. Members of the Laryngectomy Swimming Club in a pool.

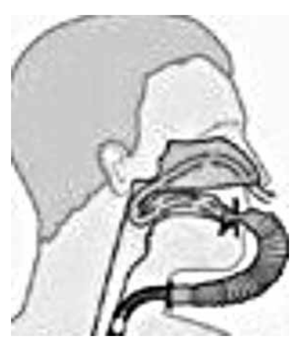

Fig. 2. A schematic drawing of a swimming device.

Ethics and consent

All participants gave written informed consent for the study, which was approved by the Medical-Ethical Protocol Institutional Review Board of KBC Rijeka. The measurement and rehabilitation protocols and swimming were not expected to pose any dangers for the participants.

Statistical analysis

Because of the huge discrepancy in number between swimmers and nonswimmers, with a smaller swimmers group, we used nonparametric statistics. To calculate the difference between the two groups, the Mann–Whitney test was used. The differences among the three consecutive measurements within each group were analysed with the Friedman test while those between the two consecutive measurements were analysed with the Wilcoxon test. To calculate the correlation between the variables, Spearman's correlation coefficient was used. Probability (p) values of less than 0.05 were regarded as statistically significant. The software was SPSS 16.0 for Windows (SPSS Inc, Chicago, Illinois).

Results

Initially, 106 laryngectomees participated in the study; however, six were excluded because of severe nasal obstruction. A total of 100 laryngectomees thus were available for statistical analysis. The swimming group consisted of 17 participants (16 men and 1 woman), while the nonswimming group had 83 participants (73 men and 10 women). The mean age in the first group was 63.92 ± 7.42 years (range, 42–86 years); for the second group, it was 64.61 ± 9.56 years (range, 35–88 years).

Olfactometry results

The swimming group achieved higher SDOT scores than the nonswimming group at all three measurements, but in both groups, SDOT scores increased with each subsequent measurement (Table 1). In the swimming group, the SDOT score in the third measurement (SDOT3) was significantly higher than in the first measurement (SDOT1) (Wilcoxon signed-rank test, $p = 0.002$); however, SDOT1 scores and the SDOT scores in the second measurement (SDOT2) (Wilcoxon signed rank test, $p = 0.066$) and SDOT2 and SDOT3 (Wilcoxon signed ranks test, $p = 0.102$) did not differ significantly. In the nonswimming group, SDOT was significantly higher in each successive measurement compared to the previous measurement (Wilcoxon signed-rank test, all $p < 0.001$).

Rhinomanometric results

The results indicated a significant difference among the three separate airflow measurements [right nostril airflow values obtained in the first measurement (FR1), left nostril airflow values obtained in the first (FL1), and third measurements (FL3)], with the swimming group achieving higher scores than the nonswimming group. Individual measurements in the swimming group did not differ significantly, but they did among nonswimmers (Table 2). In the nonswimming group, the airflow rate in

TABLE 1
SWIMMERS AND NONSWIMMERS: SDOT SCORES AT THREE TIME POINTS

Measurement	Swimmers		Nonswimmers		Mann-Whitney p
	$\overline{X}$	SD	$\overline{X}$	SD	
SDOT1	5.29	1.79	3.73	1.76	p < 0.001
SDOT2	6.40	1.09	5.48	1.53	p = 0.002
SDOT3	6.76	0.89	5.60	0.83	p = 0.050
Friedman test – p	p = 0.037		p < 0.001		

SDOT – smell diskettes olfaction test, $\overline{X}$ – mean, SD – standard deviation

TABLE 2
SWIMMERS AND NONSWIMMERS' AIRFLOW RATES AT THREE TIME POINTS

Measurement	Swimmers		Nonswimmers		Mann-Whitney p
	$\overline{X}$	SD	$\overline{X}$	SD	
FR1	46.82	62.77	13.70	37.99	p = 0.004
FR2	115.41	53.67	92.77	70.09	p = 0.128
FR3	145.40	37.91	106.43	50.94	p = 0.073
Friedman test – p	p = 0.504		p < 0.001		
FL 1	40.82	63.39	13.05	39.52	p = 0.007
FL 2	137.71	77.25	104.63	77.61	p = 0.124
FL 3	172.80	58.22	113.00	47.58	p = 0.026
Friedman test – p	p = 0.247		p < 0.001		

FR – airflow rate of the right nostril, FL – airflow rate of the left nostril, $\overline{X}$ – mean, SD – standard deviation the right nostril increased with each measurement (Wilcoxon signed-rank test, all $p < 0.001$); airflow rate in the left nostril in FL2 and FL3 were significantly higher than FL1 (Wilcoxon signed-rank test, both $p < 0.001$). FL2 and FL3 did not differ (Wilcoxon signed-rank test, $p = 0.059$).

Correlation between airflow and SDOT in the nonswimming group

The relationship between SDOT and rhinomanometry measurements was analysed. A significantly positive correlation was obtained between SDOT1 and right nostril ($r_s = 0.317$; $p < 0.01$) and left nostril airflow values in the first measurement ($r_s = 0.309$; $p < 0.01$). SDOT2 was significantly positively correlated with left nostril ($r_s = 0.423$; $p < 0.01$) and right nostril airflow values obtained in the second measurement ($r_s = 0.501$; $p < 0.01$) and with left nostril airflow values obtained in the first measurement ($r_s = 0.228$; $p < 0.05$). In addition, SDOT3 was significantly positively correlated with left nostril ($r_s = 0.385$; $p < 0.01$) and right nostril airflow values obtained in the second measurement (r_s = 0408.; $p < 0.01$) and right nostril airflow values obtained in the third measurement ($r_s = 0.459$; $p < 0.01$). Consequently, when the values of rhinomanometry were higher, the patients had better scores in the smell tests, and vice versa.

Correlation between airflow and SDOT in the swimming group

The third rhinomanometric measurement in the left nostril in the swimming group was significantly negatively correlated with SDOT1 ($r_s = –0.894$; $p < 0.05$) and SDOT2 ($r_s = –0.894$; $p < 0.05$) while the second rhinomanometric measurement in the left nostril was significantly negatively correlated with SDOT3 ($r_s = –0.894$; $p < 0.05$). Thus, as airflow rates were higher, the number of identified odours was lower. Results revealed no other significance between SDOT and rhinomanometry measurements (Table 3).

Discussion

Normal swimming is possible after total laryngectomy with simple equipment, but the presence of a swimming aid and increase in respiratory dead space make the effort of swimming more intense and usually are the limiting factors in the duration for any one individual swimming period[1]. In a fit, well-motivated, previously experienced swimmer, the ability to swim has proved to be a most rewarding and satisfying post-operatively experience[5].

Starting from the assumption that establishing nasal airflow is a prerequisite for olfactory rehabilitation and knowing that swimming with swimming aids re-establishes nasal airflow, we focused our research on estimating influence of swimming on postlaryngectomy olfactory rehabilitation. In a review of the available literature, we found only one case report by Landis et al.[14], in which patient olfaction improved from hyposmia without the larynx bypass to normosomia with the swimming aid, supporting the suggestion that postlaryngectomy hyposmia arises from a nonfunctioning nose rather than from postsurgical neuronal modification.

Several psychological studies have shown that warm water or air can induce a neurovegetative reflex when they come in contact with the nasal mucous membrane. The induced reflex has a direct effect on vascular constriction, which in turn leads to a decrease in nasal resistance. These outcomes are the result of physical activity, to meet the increased demand for oxidation blood flows from the intestinal, tracheal–bronchial, and nasal mucous membranes to brain, heart, muscles, and skin. This blood flow accounts for the reduced nasal resistance (the resistance returns to its original values within 15–30 minutes after the activity). The changes in the nasal flow also trigger the alary muscle within the nose. Its contractions increase nasal compliance, impeding an inspiratory collapse of the nasal valve[15]. In an animal model, Delp et al.[16] discovered that the blood flow to the rhinencephalon and olfactory bulbs, at the very core of the olfactory system, was not elevated during physical activity. In fact,

TABLE 3
CORRELATION BETWEEN AIRFLOW AND SDOT SCORES IN THE SWIMMING GROUP AT THREE TIME POINTS

Spearman's rho		FR1	FL1	FR2	FL2	FR3	FL3
SDOT1	Correlation coefficient	0.178	0.413	0.040	–0.223	0.783	–0.894
	Sig. (2-talied)	0.494	0.099	0.879	0.390	0.118	0.041
	N	17	17	17	17	5	5
SDOT2	Correlation coefficient	–0.008	0.269	–0.175	0.027	0.783	–0.894
	Sig. (2-talied)	0.976	0.296	0.500	0.917	0.118	0.041
	N	17	17	17	17	5	5
SDOT3	Correlation coefficient	–0.125	0.395	0.447	–0.894	0.224	–0.335
	Sig. (2-talied)	0.841	0.510	0.450	0.041	0.718	0.581
	N	5	5	5	5	5	5

SDOT – smell diskettes olfaction test, FR – airflow rate of the right nostril, FL – airflow rate of the left nostril vascular resistance in the rhinencephalon was heightened. These findings seem to corroborate the hypothesis that olfactory neural activities are not elevated during physical exertion.

The effects of the reduced blood flow on olfactory perception might be compensated by the increase of olfactory molecules that reach the mucosa as a result of reported shrinkage of the nasal mucous membrane[17]. In the case of laryngectomised swimmers, the constant flow of air through the nose might prevent degenerative changes to the mucosa[18].

Swimming is recognised as an effective health-promotion measure. However, recent data suggest that it may also sometimes have detrimental effects on the respiratory system because of airway epithelial damage and increased nasal and lung permeability caused by the exposure to chlorine subproducts in indoor swimming pools in association with airway inflammatory and remodelling processes[19]. Ottaviano et al.[20] showed that regular swimmers have a significantly lower olfactory acuity than nonswimmers because of training in chlorinated water for 4.5 hours a week, what could be explanation for a negative correlation between SDOT and rhinomanometry in the swimming group.

The results of our study demonstrate that the number of identified odours is higher in swimmers and in nonswimmers as airflow rates increase. Nevertheless, the number of identified odours and efficiency of olfactory rehabilitation are higher in swimmers than in nonswimmers. We also have to consider that swimmers, as more sportive than nonswimmers, are higher motivated and in better general health to perform PYT and olfactory rehabilitation. Keeping in mind that swimmers had been exposed to chlorine subproducts during their training, we can conclude that the results obtained are generally encouraging. The number of swimmers was relatively low, letting us infer that in a larger sample, differences between swimmers and nonswimmers would be more prominent.

Conclusion

Swimming with swimming aids increases nasal airflow and prevents degeneration of olfactory mucosa. In this way, postlaryngectomy olfactory rehabilitation and the quality of life after surgery can be improved, and resocialisation of laryngectomised patients may be facilitated. Overall, these findings confirm the hypothesis that sense of smell is rehabilitated once the nasal airflow is re-established.

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OLFAKTORNA REHABILITACIJA NAKON TOTALNE LARINGEKTOMIJE I PLIVANJE

S A Ž E T A K

Cilj istraživanja bio je utvrditi utjecaj plivanja na olfaktornu rehabilitaciju nakon totalne laringektomije. U ovom prospektivnom intervencijskom istraživanju provedenom u sveučilišnoj bolnici uključeno je 100 laringektomiranih bolesnika, 17 ih je plivalo dok 83 nije. Za olfaktornu rehabilitaciju po totalnoj laringektomiji korištena je Polite Yawning tehnika. Rinomanometrijom se mjerio protok zraka kroz lijevu i desnu nosnicu, dok se za ispitivanje osjeta mirisa koristio Smell Diskettes Olfaction Test (SDOT). Plivači su imali pomagala za plivanje i plivali su isključivo u bazenu u pratnji druge osobe osposobljene za spašavanje i reanimaciju laringektomiranih osoba. Mjerenja su ponavljana u tri različita vremenska perioda. Nakon savladavanja PYT, broj točno pogođenih mirisa bio je veći među plivačima (SDOT1 = 5.29, SDOT2 = 6.40, SDOT3 = 6.76) nego neplivačima (SDOT1 = 3.73, SDOT2 = 5.48, SDOT3 = 5.60) kao što su bili i protoci zraka kroz lijevu (plivači: FL1 = 40.82, FL2 = 137.71, FL3 = 172.80; neplivači FL1 = 13.05, FL2 = 104.63, FL3 = 113.00) i desnu nosnicu (plivači: FR1 = 46.82, FR2 = 115.41, FR3 = 145.40); neplivači: FR1 = 13.70, FR2 = 92.77, FR3 = 106.43). Broj identificiranih mirisa povećavao se kao je rastao protok zraka kroz nos, s tim da je broj i učinkovitost olfaktorne rehabilitacije bila viša u plivača u odnosu na neplivače. Plivanje pomoću pomagala može poboljšati kvalitetu života nakon operacije i može olakšati resocijalizaciju laringektomiranih osoba.