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Original Article

Effects of Regular Aerobic with Nasal Breathing Exercise Training on Olfactory Rehabilitation in Asthmatic Patients with Chronic Rhino Sinusitis

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ABSTRACT

Background: Chronic rhinosinusitis (CRS) is the most common cause of smell loss and has a strong association with asthma. Breathing exercise training has been known to be an effective treatment for decreasing asthma symptoms. However, its effect on the olfactory disorder in asthmatic patients with CRS is unknown. This research aimed to investigate the effects of regular aerobic with nasal breathing exercise training on olfactory rehabilitation in asthmatic patients with CRS.
Methods: In this quasi-experimental study, thirty-five inactive asthmatic women with CRS and olfaction disorder (mean age=34.7±7.5 years) were selected and grouped into experimental (n=18) and control (n=17) groups. The experimental group participated in an aerobic and breathing exercise program (60 min/day, three days a week), and the control group refrained from participating in regular exercise for 12 weeks. Self-rated olfactory acuity and function questionnaires were used to assess changes in exercise-induced olfactory acuity and function.
Results: After 12 weeks, the exercise group improved smell function (P=0.002) and exhibited significantly increased acuity in smelling the odor of gas (P=0.019) compared with the control group. Body mass index (BMI) decreased (P=0.019) and forced expiratory volume in 1 second (FEV1) increased (P=0.002) significantly in the exercise group. There was a negative relationship between mean change in BMI and mean change in acuity in smelling the odor of gas (r=-0.381, P=0.024).
Conclusion: According to the self-report olfactory acuity and function questionnaires, the improvement in the smell function of asthmatic patients with chronic sinusitis after 12 weeks of regular aerobic with nasal breathing exercise was promising and should be studied further.

Introduction

Olfactory dysfunction is prevalent (30% - 80%) in patients with chronic rhinosinusitis (CRS), a disease that affects 12.5% of the adult population [1]. CRS is the most common cause of smell loss [2] and has a strong association with asthma. The evidence indicates a high prevalence of CRS in asthmatic patients [3]. It further indicates that patients with CRS have lower forced expiratory volume in the first second (FEV1) compared with healthy people [4]. According to the results of a study by Caglar et al., odor threshold value, discrimination, and identification were lower in the patient group with FEV1<80% compared with the healthy control group [5].

Despite the fact that olfactory dysfunction has a significant impact on the quality of life of patients with CRS and asthma, it is often overlooked by patients and doctors and its clinical management and treatment are still limited [6]. The treatment of posttraumatic olfactory dysfunction with corticosteroids and regular, structured exposure to odors through olfactory training (OT) [7]

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as well as olfactory rehabilitation after endoscopic sinus surgery in patients with chronic sinusitis and nasal polyps have been studied [8], but no research was found that used exercise therapy to improve olfactory function in patients with CRS. Having an active lifestyle or changing the respiratory pattern at maximal work may be an effective way to improve a patient's olfactory disorder. The pattern of nasal breathing reduces night-time episodes and the severity of exercise-induced asthma (EIA) provoked in asthmatic patients [9]. Repeated exercise with nose breathing during more training sessions may have other beneficial effects, such as improving the olfaction function in asthmatic patients with CRS. The results of previous studies have shown that regular exercise training retains the olfactory function in older adults [10] and in individuals with Parkinson's [11]. However, no study has examined the effect of regular aerobic and respiratory exercises on the olfactory function of CRS patients. Zhang et al. reported that various types of physical activity like tai chi and running prevent and delay olfactory deterioration in older adults [12]. Arshamian et al. indicated that nasal breathing affects odor function more than mouth breathing [13], and Morales et al. reported that the nasal airflow-inducing technique enables an essential recovery of olfaction and improvement of taste after total laryngectomy [14]. Considering the hypothesis that regular exercise and nasal breathing may be an effective, low cost, and available way to improve olfactory function lacking potential side effects, the present study aimed to investigate the effects of regular aerobic and breathing exercise training with nasal breathing on self-rated olfactory acuity and function in asthmatic patients with CRS.

Methods

In this quasi-experimental research conducted between February 4 and October 11, 2016, asthmatic women with a diagnosis of CRS were introduced by the asthma specialists of Sahand Clinic in Urmia, Iran, and were assessed for eligibility. In total, thirty-five eligible patients participated in this study.

Eligibility criteria for inclusion were having an age between 20 and 40 years and a history of olfactory disorder for more than one year. Exclusion criteria were pregnancy, major cardiovascular illness, renal, metabolic, or other pulmonary problems, accident or sinus surgery, very bad nasal patency, malignant tumors, multiple sclerosis, smoking, regular diet or exercise programs for six months prior to the study, and changing the treatment during the study.

The demographic and clinical characteristics of patients such as age, asthma duration (yrs), and olfactory loss duration (yrs) were approved. All aspects of the use of human subjects in this study were approved by the Urmia University of Medical Sciences Ethics Committee (ir.umsu.rec.1395.81). Before the exercise, written consent was provided by patients.

Sample size was determined according to the article by Rosenfeldt et al. This published study considered the effect of an aerobic exercise intervention on olfaction function in 38 individuals. With the difference between mean changes of olfaction in the exercise and control groups (2.4) and its standard deviation (2.3) [11], using the following formula with 80% power using a cutoff for statistical significance of 0.05 [15], and considering approximately 20% of the drop, 17 participants were required in each group; a total of 35 participants were included in this study.

$$\text{Standardized difference} = \frac{\text{Target difference}}{\text{Standard deviation}} = d$$

$$n = \frac{2}{d^2} \times C_{0.05,80\%} \qquad C_{0.05,80\%} = 7.9$$

$$\frac{2.4}{2.3} = 1.04 = d$$

$$n = \frac{2}{1.04^2} \times 7.9 = 14.62$$

Samples were randomly divided into experimental (n=18: receiving specific exercise training) and control groups (n=17: normal daily activities).

Aerobic Exercise Training

Exercise in the present study was designed by the researcher based on the American College Sports Medicine (ACSM) guidelines [16] and the results of previous studies [11-13].

The exercise group trained (three days/week/evening) for 12 weeks. Each training session began with 15 minutes of warm-up, continued with a 30-minute walk/run on a treadmill with 60-80% of HR_{max}, and a final 15 minutes of breathing exercises. Before the start of training, subjects were trained on how to work with treadmills and safety. Training began with 60% of maximum heart rate in the first two weeks and gradual increases in subsequent meetings (Table 1). Control of exercise intensity (based on heart rate) was performed by Polar heart rate monitors. In this program, the ACSM guidelines were used to limit any problems such as exercise-induced asthma (EIA). Patients were encouraged to warm up long-term, drink plenty of water before and after the exercise session, and inhale through the nose and exhale through the mouth as much as possible when exercising [9]. The control group refrained from participating in regular exercise for 12 weeks of the study protocol.

Aerobic and Breathing Exercises Training

Exercises employed nasal breathing and sitting comfortably with good posture, which are described in Table 1 (exercises number 2 to 6) and are shown in Figure 1.

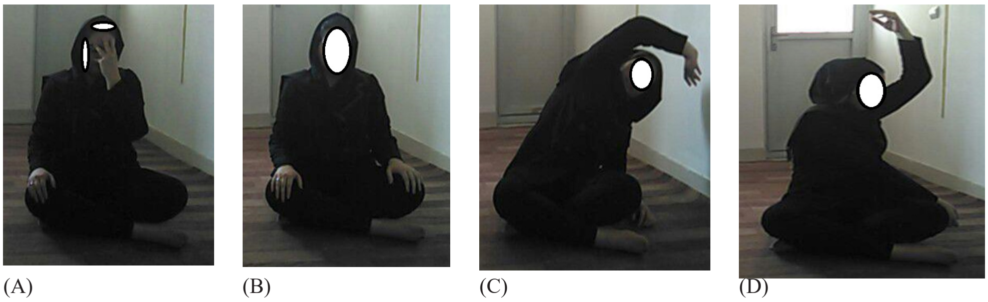
Self-Reported Olfactory Acuity

Due to the limitation of olfactory test clinics and standard olfactory evaluation tests, we were compelled to use questionnaires to gain information about the patients' olfactory function and acuity.

The self-administered questionnaire on odor as an easy method of estimating olfaction has been used and approved by other studies [17, 18]. In the present study, the olfactory acuity questionnaire described by Santos et al. [17] was used (Table 2).

Table 1: Aerobic and breathing exercises training in the experimental group

Exercise	Performance
Number 1: 30-minute walking/running on a treadmill, inhaling through the nose and exhaling through the mouth. Each session of training began with 15 minutes of walking on the treadmill for warm-up.	First two weeks: 60% of HRmax Third to sixth week: 65% of HRmax Seventh and eighth weeks: 70% of HRmax Ninth and tenth weeks:75% of HRmax Eleventh to twelfth week: 80% of HRmax
Number 2: Eyes closed, the left hand over the left knee, right nostril closed with the right thumb, inhaling slowly through the left nostril, the remaining the fingers placed on the forehead, exhaling slowly through the mouth (Figure 1, A).	First three weeks: five repeats Second three weeks: eight repeats Last weeks: ten repeats
Number 3: Exercise 1 runs with the change of the hand's positions (Figure 1, A).	First three weeks: five repeats Second three weeks: eight repeats Last weeks: ten repeats
Number 4: Hands on knees, inhaling slowly through the nose, exhaling slowly through the mouth (Figure 1, B).	First three weeks: five repeats Second three weeks: eight repeats Last weeks: ten repeats
Number 5: Deep nasal breathing, filling chest, keep inhaling, exhaling slowly through the mouth (Figure 1, B).	First three weeks: keep inhaling for three seconds Second three weeks: keep inhaling for five seconds Last weeks: keep inhaling for eight seconds
Number 6: While stretching or rotating the body, inhaling slowly through the nose, exhaling slowly through the mouth during body returns (Figure 1, C, D).	First three weeks: repeat two times for each side of the body Second three weeks: repeat three times for each side of the body Last weeks: repeat four times for each side of the body



(A) (B) (C) (D)

Figure 1: Breathing exercises training in the experimental group

Table 2: Questionnaire about olfactory acuity

Question	Responses	Scores
How do you consider your olfaction at this moment?	Poor	1
	Fair	2
	Good	3
	Very good	4
How do you consider your taste at this moment?	Poor	1
	Fair	2
	Good	3
	Very good	4
How often can you smell perfume?	Never	1
	Sometimes	2
	Usually	3
	Always	4
How often can you smell food?	Never	1
	Sometimes	2
	Usually	3
	Always	4
How often can you smell the odor of gas leaking?	Never	1
	Sometimes	2
	Usually	3
	Always	4
How often can you smell smoke?	Never	1
	Sometimes	2
	Usually	3
	Always	4
Do you have any difficulties in your daily life due to alterations in your perception of odors?	I have no difficulty.	1
	I have few difficulties.	2
	I have some difficulties.	3
	I have many difficulties.	4

Self-Reported Olfactory Function

The self-reported olfactory function questionnaire used to evaluate patients who reported their olfactory function at the end of the protocol was designed based on research by Rawal et al. [19]. The researcher asked patients to use a seven-point scale to rate their smell function at the time of the study (very poor to excellent), compared to before the exercise protocol, and to rate the flavor of food at the time of the study compared to before the exercise protocol (extremely weaker to extremely stronger). The self-reported olfactory acuity and function questions used in the present study were translated into Persian by native translators. Difficulties of translation and the given average score by translators according to a 100-point Visual Analogue Scale (VAS) from zero (easy translation) to 100 (difficult translation) was below 30. The translated Persian text was reverse translated to English to compare the translations. In the qualitative review of the questionnaire, the researcher asked experts to provide the necessary feedback on the questionnaire. The translation quality (sentences are clear, simple and understandable words used, use of specialized and artificial terms avoided) was confirmed by two other translators and a group of experts. Professional otolaryngologists, pulmonologists, and exercise physiologists assessed the self-rated olfactory acuity and function survey for content validity, instrument construction, and appropriateness. To determine content validity, the content validity index (CVI) was calculated. Items with CVI ≥ 0.8 were considered to have good content validity. The reliability of the questionnaires was assessed by Cronbach's alpha coefficient. The Cronbach's alpha for the self-reported olfactory acuity test was 0.77, while the self-reported olfactory function test was 0.75.

FEV1 Measurement

The FEV1 was evaluated using a spirometer (model ST-95 Fukuda, Sanjio, Spiroanalayzer, Japan) according to the standards published by the American Thoracic Society (ATS) [20].

BMI Measurement

BMI was calculated using weight and height (Kg/m2). Body weight and height were measured with a scale and a stadiometer (Seca 755, Germany), respectively, before and after the exercise protocol.

Statistical Analysis

The normal distribution was checked using the Kolmogorov-Smirnov test. Accordingly, baseline characteristics such as age, asthma duration, olfactory loss duration, BMI, and FEV1 had a normal distribution. Thus, an unpaired t-test was used to compare the baseline characteristics between control and experimental groups, and ANCOVA, with the baseline value as a covariate, was used to compare the differences between the groups. Ordinal variables with Likert scoring did not have a normal distribution. The Mann-Whitney U test used to compare self-rated olfactory acuity and function differences between two groups. The relationship between mean change in BMI, FEV1, and mean change in smell function was measured with Spearman's correlation. Data is shown as mean±SD. A *p*-value less than 0.05 was considered significant. The SPSS statistical software program (version 23) was used for all analyses.

Results

The characteristics of the study groups are shown in Table 3. There were no differences between the groups at baseline (P>0.05). After training, BMI levels decreased (F (1, 33)=6.070, P=0.019), and FEV1 increased (F (1, 33)=15.072, P=0.001) significantly in the experimental group compared to the control (P<0.05).

The results of the self-rated olfactory acuity questionnaire pre- and post-exercise training in the experimental and control group are shown in Table 4. The Mann-Whitney U test revealed a significant difference between olfaction and smelling the odor of gas between the experimental and control groups (P<0.05) (Table 4). Before exercise training, 8 (44%) and 10 (56%) of the experimental group participants considered their olfaction poor and fair,

Table 3: Clinical characteristics and Body mass index (BMI), forced expiratory volume in 1 second (FEV1) changes after exercise training in patients

	Experimental		Control		P*	P**
	Pre- (mean±SD)	Post- (mean±SD)	Pre- (mean±SD)	Post- (mean±SD)		
Age	32.9±7.5		36.7±8.2		0.363	
Asthma duration(yrs)	8.9±4.5		9.4±5		0.819	
Olfactory loss duration(yrs)	5.2±3.7		6.3±3.1		0.519	
BMI	29.9±4.2	28.8±4.3	28.9±4.1	29.4±4.2	0.342	0.019**
FEV1	75.5±10.1	84.4±11.6	71.4±14.3	69.2±15.1	0.330	0.001**

*Unpaired t-test to compare the baseline characteristics between groups; ** ANCOVA to compare the differences between the groups after protocol; Significance of change at the level of 0.05. BMI: Body mass index; FEV1: Forced expiratory volume in 1 second

Table 4: Results of self-rated olfactory acuity questionnaire before and after nasal breathing exercises in experimental and control groups

Mean score in consideration of	Experimental		Control		Mann-Whitney U	P
	Before	After	Before	After		
Olfaction	1.5±0.51	2.2±0.81	1.5 ±0.51	1.6±0.49	91.50	0.030*
Taste	1.8±0.43	1.9±0.42	1.8±0.75	1.7±0.47	119.0	0.168
Smell of perfume	1.9±1.1	2.2±0.78	1.8±0.43	1.8±0.52	117.0	0.197
Smell of food	1.8±0.67	2.1±0.58	2.3±0.77	2.1±0.60	152.0	1.000
The smell of gas	1.9 ±1.1	2.3±0.84	1.6±0.62	1.7±0.58	90.00	0.019*
The smell of smoke	2.1±1.3	2.7±1.1	2.3±0.49	2.4±0.51	128.5	0.403
*Difficulties in daily life due to changes in the perception of odors	3.6±0.50	3.0±0.54	3.4±0.61	3/5±0/74	97.50	0.042*

Four-point scales: minimum score to poor sense=1 and maximum score to stronger sense=4; * Have no difficulty=1, have many difficulties=4; Mann-Whitney U to compare the differences between the groups after the protocol

Table 5: Comparison of self-rated olfactory function mean scores in experimental and control groups after the protocol

Mean score in consideration of	Experimental	Control	Mann-Whitney U	P
Smell at time of study	4.17±1.3	3.3±1.1	93.0	0.042*
Smell at time of study compared to prior to the exercise protocol	4.6±0.69	3.7±0.66	63.0	0.002*
Flavor of food at the time of study compared to the pre-exercise protocol	4.0±0.77	3.6±0.86	119.0	0.226

Seven-point scale: very poor=1 to excellent=7; *Mann-Whitney U, Significance of change at the level of 0.05

respectively. After exercise training, 5 (28%) patients reported improvement to a good level, 1 (5%) reported a very good level, 3 (170%) considered it poor, and 9 (50%) considered it fair. Only one patient reported her taste as good, and none of the experimental participants considered their taste as very good after exercise training. The ability to smell perfume, smoke, and food didn't change ($P<0.05$), but the ability to smell the odor of gas improved ($P=0.019$) and the difficulties in daily life due to changes in the perception of odors decrease in the experimental group after exercise training ($P=0.042$) (Table 4).

After 12 weeks of exercise training, based on the results of the self-reported olfactory function questionnaire, the score of self-rated smell was better in the exercise group than in the control (4.6 vs. 3.7, respectively) ($P=0.002$). Exercise training had a significant effect on the sense of smell in patients ($P=0.042$); however, sensitivity to food flavor was slightly and not significantly better in the exercise group (Table 5).

The results of other measurements indicated that the only negative correlation was between mean change in BMI and mean change in acuity in smelling the odor of gas ($r=-0.381$, $P=0.024$), and no significant relationship was observed between FEV1 and self-rated olfactory acuity or function ($P>0.05$).

Discussion

In the present study, the effect of nasal breathing during aerobic exercise training on olfactory recovery was promising in asthmatic women with CRS. Exercise training was also able to induce a decrease in body mass index and an increase in FEV_1 (Table 3). These results are in line with previous findings that found a significant effect of breathing aerobic exercise training on decreases in BMI [21] and increases in FEV_1 [22] and suggest that breathing exercise training may be beneficial for asthmatic patients with CRS. The effect of aerobic nasal breathing exercises on olfactory dysfunction, however, has not been well studied. Some studies have shown the beneficial effects of nasal breathing exercises on reducing night-time episodes, asthma symptoms [9], and allergic rhinitis symptoms [23]. There is also convincing evidence of the effect of breathing exercises on psychological and general health and on reducing rescue medication usage [9], improvement of lung function (FEV_1) [24], improved exercise capacity, and asthma clinical control in asthmatic patients [25]. The results also showed that regular exercise can preserve a sense of smell in older adults [10] and individuals with Parkinson's disease [11].

Although the mentioned studies have found an association between exercise and better olfaction, the cause-and-effect association between olfaction and exercise remains unknown. It is possible that exercise affects either general health or brain function [10], obesity [21], nasal volume [26], and upper respiratory tract infection [27] and may facilitate neuroplasticity of the olfaction system [11]. The effect of exercise in the prevention of acute respiratory infection [28] and nasal inflammation [29] has been shown. Inflammatory changes within the olfactory mucosa may be the cause of olfactory deficits in patients with chronic sinusitis [30].

Studies have found an association between olfactory impairment and neurodegenerative disease [31]. Evidence also indicates a correlation between human olfactory function and nasal volumetric measurements [32]. Yon DK et al. reported an association between serum lipid levels and peripheral olfactory function, allergic rhinitis, and nasal symptoms [33].

Exercise enhances neurogenesis and cognitive function and lowers the risk of cognitive impairment [10]. Additionally, studies have shown that physical exercise increases nasal volume and has a vasoconstrictor effect over nasal mucosa, which may also affect olfaction [26]. The findings indicated that exercise increases the nasal airway patency by discharging the sympathetic nerve and can also decrease the thickness of the mucosa [34].

Therefore, nasal breathing exercise training may have a beneficial effect on olfactory improvement by changing in brain function, inflammation, blood lipids, or other conductive or sensorineural factors. It appears that in this study, twelve weeks of regular treadmill aerobic exercise with an intensity of 60% to 80% MHR improved the olfactory system by decreasing BMI. Meta-analyses suggest that higher BMI and weight are associated with olfactory dysfunction [35, 36]. In the current study, there was a significant decrease in patient BMI after exercise training. The results of previous studies have also shown the effect of a 20- to 30-minute aerobic treadmill-based training program with an intensity of 60-70% MHR [37] on weight loss in obese subjects.

T novel study is the first to investigate the effects of aerobic nasal breathing exercise training on olfaction disorders in asthmatic patients with CRS. This study also investigated changes in obesity and respiratory function (FEV1) after exercise and the relationship between such changes and self-rated olfactory function. Based on the results, it can be concluded that the training program of the present study can be a useful, simple, and low-cost treatment aid for asthmatic patients with CRS. In short, the increases in self-rated olfactory acuity and function scores in the experimental group compared with the control group illustrate the beneficial effects of the nasal breathing training on olfaction disorder.

The current study has some limitations. The sample size was small because of the limited availability of asthmatic women with CRS and olfactory disorder who were interested in an exercise program; because of inaccessibility to advanced tools and methods, olfactory evaluation was based on self-reports. Though the use of self-report questionnaires by past studies [17, 19] can be of value for the present study, the satisfaction of patients with the improvement in their sense of smell gives us hope and feedback that indicates aerobic nasal breathing exercise training is an effective factor in improving olfaction. Future more extensive studies are suggested for more robust results in this area.

Conclusion

According to self-report olfactory acuity and function questionnaires, the improvement in the smell function of asthmatic patients with chronic sinusitis was promising and should be studied further. This is a new study that showed that nasal breathing during an intensive activity (80%MHR) in asthmatic patients with CRS who mainly breathe through their mouths can be useful in modulating olfactory performance.

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Conflict of Interest: None declared.

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