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RESEARCH ARTICLE

Functional Nasal Breathing Rehabilitation: Effectiveness and Feasibility of an Online Integrative Breathing Therapy Protocol

Rosalba Courtney D.O., Ph.D.,[1] Roger Engel, D.C., D.O., Ph.D.,[2] Sandra Grace, B.A., Dip.Ed., M.Sc., Ph.D.,[1] Anna Potts, B.Sc., M.Ost.Med.,[1] Brooke Riordan, B.Sc., M.Ost. Med.,[1] Kaitlyn Ireland, B.Sc., M.Ost.Med.,[1] Courtney Osbourne, B.Sc., M.Ost.Med.,[1] Avinash Sukhtankar, B.Sc., M.Ost.Med.[1]

[1]*Southern Cross University*
[2]*Macquarie University*

Purpose: Nasal disuse and mouth breathing are associated with negative structural, functional, postural, occlusal, and behavioural changes. While there is some research to suggest that nasal breathing exercises can reduce mouth breathing, clinical protocols have not been extensively investigated. The purpose of this research was to determine the feasibility and effectiveness of a nasal breathing rehabilitation protocol based on Integrative Breathing Therapy principles called Functional Nasal Breathing Rehabilitation (FNBR).

Methods: Twenty-three participants with symptoms of nasal obstruction and self-reported mouth breathing completed the 4-week online FNBR training. Outcome measures included the Nasal Obstruction Symptom Evaluation (NOSE) scale, a numeric rating scale (NRS) for nasal breathing difficulty and obstruction, allergy symptoms, self-reported daytime and nighttime mouth breathing, and a composite questionnaire called the Self-reported Nasal Breathing Difficulty Questionnaire (SRNBQ) to compare symptoms of nasal obstruction, allergy and reported mouth breathing pre- and post-trial. A content analysis was performed on qualitative data collected during weekly online interviews.

Results: There were statistically significant improvements in the SRNBQ total score (p = .002), NOSE scale (p = .006), NRS score (p = .008), and mouth breathing daytime and night-time (MBDS) score (p = .024), but not in allergy symptoms. Participants were highly adherent with the techniques, with 91% of the participants completing formal breathing practice more than four times a week and 96% reporting that they used the practices informally in daily life mostly or all of the time.

Conclusion: Functional Nasal Breathing Rehabilitation appears to be a feasible and effective modality for reducing mouth breathing and improving nasal obstruction symptoms in patients with subjective signs of nasal obstruction.

Keywords: *nasal breathing, functional nasal rehabilitation, breathing training, breathing exercises, integrative breathing therapy*

INTRODUCTION

The adverse effects of mouth breathing have immediate as well as cumulative effects on diverse body systems beginning with the respiratory system but also potentially affecting the brain and nervous system, sleep and oral health while also increasing the predisposition to craniofacial and postural deformity, malocclusion and oral motor dysfunction (Triana et al., 2016).The nose is the gateway to the whole breathing system and nasal breathing assists in the protection and regulation of the upper and lower respiratory tracts and optimization of ventilation and breathing patterns. The ability of the nose to filter, warm and humidify inhaled air helps to protect the lungs and airway from pathogens, allergens and particulate matter, and helps to prevent the inflammatory changes and increased bronchoconstriction that can result from inhalation of excessively cold and dry air into the lungs (Bjermer, 1999; Hallani et al., 2008a; Morton et al., 1995). Nasal breathing also promotes ideal morphology and muscle function of the upper airway and helps to regulate ventilatory drive, breathing patterns, and oxygen uptake from the lungs (Hsu et al., 2021; Lundberg et al., 1999; Morton et al., 1995; Zwillich, 1983). The increased nitric oxide production and concentration within the respiratory tract, which occurs as a result of nasal breathing, has immuno-regulatory, bronchodilating and vasodilating effects that result in improved infection control and improved pulmonary hemodynamics and oxygen uptake from alveoli (Germann et al., 1998; Lundberg et al., 1999; Lundberg, 1996). These respiratory and airway effects of nasal breathing provide a rationale for why they should play a role in the management of

Correspondence: Rosalba Courtney D.O., Ph.D., 11 Binburra Ave, Avalon, NSW, Australia
Email: rosalba.courtney@gmail.com

ORCID: https://orcid.org/0000-0001-7978-0908 (RB)
https://orcid.org/0000-0001-6021-0497 (RE)
https://orcid.org/0000-0002-0300-4088 (SG)

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respiratory conditions such as asthma, respiratory infections, and sleep apnea (Fitzpatrick et al., 2003; Hallani et al., 2008a; Lee et al., 2015; Martel et al., 2020; Meurice et al., 1996; Tanaka et al., 1988; Turkalj et al., 2016).

Numerous studies have shown links between mouth breathing and nasal disuse with adverse changes in both structural development of the craniofacial region, body posture and muscle function of the orofacial complex (Chambi-Rocha et al., 2018; Torre et al., 2018; Triana et al., 2016). The craniofacial changes that can result from mouth breathing have the potential to reduce the size of the intraoral space and pharyngeal airway (McNamara, 1981). The reduction in intraoral space resulting from narrowing of the upper and lower palate means that the space may not be sufficient to accommodate the tongue, which can then obstruct the pharyngeal airway (Torre et al., 2018).

The incidence of chronic or excessive mouth breathing in adults is not well reported; however, it appears to occur in adults with and without nasal obstruction and therefore might be linked to functional sensory and motor issues as well as to psychological factors (Koutsourelakis et al., 2006). Treatment of anatomical or pathological causes of nasal disuse are not always successful and some individuals continue to experience a sense of nasal insufficiency and continue to breathe orally despite multiple medical and surgical procedures (Bartley, 2006; Manji et al., 2018). There is also some evidence that enlargement of the nasal cavity through orthodontic treatment does not guarantee a resolution of oral breathing (Levrini et al., 2014).

There may be a number of causes for perpetuating mouth breathing in nasal disuse. A subjective sense of nasal insufficiency that is not well correlated to the extent of nasal obstruction has been linked to a range of functional factors including subjective perception of nasal load, anxiety, poor activity of nasal dilator muscles, dysfunctional breathing and hyperventilation (Bartley, 2006; Hallani et al. 2008b; Mangin et al., 2017; Strohl et al., 1982). Nasal muscle dysfunction in conjunction with oral and pharyngeal dysfunction, postural abnormalities and breathing pattern dysfunction all contribute to the perpetuation of oral breathing (Levrini et al., 2014). Nasal disuse in habitual mouth breathers combined with various levels of nasal obstruction can lead to changes in local nasal dilator muscle activity that influence sensory perception and impact nasal resistance (Levrini et al., 2014; Strohl et al., 1982). During oral breathing there is a lack of the oscillatory mechanical pressures that help maintain hydration, mucociliary clearance, local innate immune defense and mucosal homeostasis (Button et al., 2008; Maniscalco et al., 2013).

Clinical protocols to improve nasal breathing have used a range of different approaches and techniques. These often begin with simple encouragement of nasal breathing (Marchesan et al., 1996). Advice given to patients to make a dedicated and persistent effort to maintain nasal breathing might in some cases help to break the cycle that perpetuates nasal obstruction by improving mucosal homeostasis and the regulation of innate immune pathways (Gelardi et al., 2012; Lane, 2009). Other protocols include general breathing training aimed at optimizing breathing patterns and reducing hyperventilation (Bartley, 2006), with some using localized nasal muscle training, humming, nasal hygiene instructions and oronasal exercises such as breath holding either as stand-alone techniques or in conjunction with general breathing training (Eby, 2006; Levrini et al., 2014; Vaiman et al., 2005). These studies provided the foundations for further development of clinical protocols for nasal rehabilitation.

Integrative Breathing Therapy (IBT) is an approach to breathing retraining and breathing therapy based on a multidimensional model of breathing. This model emphasizes the importance of addressing the biochemical, biomechanical and psychophysiological aspects of breathing by approaching breathing from a systems perspective, and treating the nose as part of a unified breathing system (Courtney, 2016). A structured Functional Nasal Breathing Retraining (FNBR) protocol, suitable for online delivery, was developed based on IBT principles. It includes selected previously-used nasal rehabilitation techniques with demonstrated effectiveness integrated with breathing pattern training, olfaction training, and mind-body techniques for nasal-limbic integration. It was designed to improve nasal breathing by reducing symptoms of nasal obstruction and the incidence of mouth breathing.

The primary aim of this study was to gather preliminary data on the effectiveness of the FNBR protocol for people with symptoms of nasal obstruction and self-reported mouth breathing. The secondary aim was to assess the feasibility of the online delivery of the theoretical and practical components of the FNBR protocol and to learn about the experiences of people participating in the training program.

METHOD

Participants

Participants who self-identified as having difficulties maintaining nasal breathing were recruited by flyers distributed via social media, through researchers' professional networks and Southern Cross University health clinics. Participants were required to be older than 20 years

of age, English speaking, located in Australia or New Zealand, and able to breathe through their nose exclusively for 3 minutes or longer. The 3-minute lip taping nasal breathing test is an assessment used to identify people with subjective nasal breathing difficulty (Zaghi et al., 2020). Participants who were unable to complete the 3-minute taping test are more likely to have severe nasal obstruction and were excluded from the study and referred to their general practitioner for further assessment.

In addition, participants were excluded if they met any of the following criteria:

- Currently pregnant
- Reported experiencing severe seasonal allergic rhinitis
- History of a craniofacial disorder syndrome (e.g., Down, Treacher, Collins, Crouzon, or Apert syndromes)
- History of tracheostomy dependence
- Prior history of laryngeal, sub-glottic or pulmonary airway stenosis or surgery

Protocol

Participants were enrolled in the study once eligibility and informed consent were confirmed. Initial interviews were conducted individually online via a video conferencing platform (Zoom) including questions about nasal and respiratory health, medication history, and diagnosis of nasal pathology by an otorhinolaryngologist.

The online FNBR protocol was developed based on IBT principles and clinical experience. The protocol was presented by the lead author (RC) over four weekly sessions and was delivered online via a video conferencing platform (Zoom). It included theory-based education, demonstrations of the nasal breathing rehabilitation techniques, and explanations of home practice requirements for formal and informal practice. The structure of the protocol is outlined in Table 1.

The practical elements of the protocol included techniques such as humming (Eby, 2006), smell training (Hilgers et al., 2002), nasal muscle training (Vaiman et al., 2005) and breath holding (Hasegawa et al., 1978). These techniques were combined into a structured protocol that also included novel techniques such as the nose opening smile (NOS) (Appendix A), mindfulness of nasal breathing, as well as instructions on humming and nasal muscle training variations.

Individual weekly online interviews were conducted over the 4 weeks of training to allow participants to ask questions regarding the techniques. At the conclusion of the 4-week trial, participants were advised to continue with their practice during Week 5. Final interviews were conducted in Week 6 when the final SRNBQ was completed. Participants were asked about their understanding of the techniques, how often they practiced and about any changes in their nasal breathing.

Sample size

This project used a convenience sample of participants from Australia and New Zealand. The minimum sample size of 20 was calculated using the minimal clinical important difference (MCID) for the Nasal Obstruction Symptom Evaluation (NOSE) scale (Ziai et al., 2017) (24 points; SD = 13), as determined by previous research (Kandathil et al., 2019).

Outcome Measures

Primary validated outcome measures included the NOSE and numeric rating scales (NRS) to determine subjective nasal breathing difficulty. The NOSE scale is a validated assessment tool of nasal obstruction symptoms (Ziai et al., 2017). It contains 5 items, each scored from 0 (no symptoms) to 4 (most severe symptoms) with a total score of 20. The NRS was used to assess subjective nasal breathing obstruction and difficulty (Haye et al., 2018). Participants self-report their sense of nasal breathing difficulty/obstruction on a scale ranging from 0 – 10 [0 = no difficulty/obstruction, 10 = worst sense of difficulty/obstruction].

The NOSE and NRS scores are also included as subscales in the Self-Reported Nasal Difficulty Breathing Questionnaire (SRNBQ) along with subscales for mouth breathing during the day and night (MBDS) and nasal allergy symptoms (NAS). The SRNBQ is an unvalidated scale that was constructed by combining these subscales to simultaneously gather information about subjective nasal breathing difficulty symptoms, nasal allergy symptoms and mouth breathing behavior for convenience. It has been used clinically alongside the FNBR protocol but has not undergone psychometric testing and is not validated. It has a total possible score of 48 (see Appendix B).

Secondary outcome measures included adherence with formal and informal practice ("How often were you able to do your formal nasal breathing practice?" [0 = not at all, 1 = less than 4 times a week, 2 = more than 4 times a week, 3 = daily], and "How often were you able to use informal practice techniques to maintain nasal breathing during the week?" [0 = not at all, 1 = sometimes, 2 = mostly and 3 = all the time]), and incidence of respiratory infections or acute allergic reactions ("Were you able to understand last week's lesson – the explanation of the techniques and practical techniques?" [0 = not at all, 1 = some of it, 2 = most

Table 1. Functional Nasal Breathing Rehabilitation (FNBR) protocol

Week	Theory	Techniques	Home Practice
1	Learn why nasal breathing matters. Understand nasal disuse. Principles of nasal rehabilitation.	Exhalation breath hold. Humming basics Humming variations: • Sinus vibration • Unilateral nasal humming	**Formal practice** (15 minutes per day) Breath holds followed by 3-minute sets of humming basics and variations. Repeated 4x. **Informal practice** Random-use breath holds and humming to clear nose as needed
2	Learn about how nasal muscles, posture, tongue position and diaphragmatic breathing affect nasal breathing ability**.**	Exhalation breath holds Nose push outs NOS basics NOS with low slow breathing	**Formal practice** (15 minutes per day) Breath holds followed by 3-minute sets of any humming or NOS basics and variations. Repeated 4x. **Informal practice** Random use breath holds, NOS, humming to clear nose as needed
3	How mindfulness trains neuroplasticity. How nasal breathing, smelling and alternate nostril breathing affects the brain and nervous system.	Exhalation breath holds NOS variations: • smelling NOS • alternate nostril NOS • mindful NOS	**Formal practice** (15 minutes per day) Breath holds followed by 3-minute sets of any humming or NOS basics and variations. Repeated 4x. **Informal practice** Random use breath holds, NOS, humming to clear nose as needed
4	Review theory	Review practice of all techniques	**Formal practice** (15 minutes per day) Breath holds followed by 3-minute sets of any humming or NOS basics and variations. Repeated 4x. **Informal practice** Random use breath holds, NOS, humming to clear nose as needed

of it, 3 = completely]. Participants were also asked about their understanding of techniques. The final interview included questions on how participants found the online learning experience, if they would continue with their practice, and if they would recommend it to others.

Data Analysis

Statistical analysis was carried out using Microsoft Excel for Microsoft 365 MSO (16.0.13801.20840) 64 bit (Microsoft Corporation, Redmond WA). The statistical test used was a paired t-test. A p-value lower than 0.05 was considered to be statistically significant; Bonferroni correction was not applied due to the exploratory nature of this study. The change in NOSE scale score, NRS score, SRNBQ score, mouth breathing daytime and during sleep score (MBDS), and nasal allergy symptoms (NAS) score were calculated pre- and post-intervention.

Qualitative research methods using content analysis were performed on the transcribed interview data from 23 participants. Content analysis focuses on similarities and differences in the text (Graneheim et al., 2017). It allows for both descriptive and interpretive analysis (Kleinheksel et al., 2020). Two researchers (AP and KI) independently analyzed the data to identify codes and patterns (themes) in the data. The research team met on two occasions to discuss and refine themes and to ensure trustworthiness of the analysis.

Ethics

The research was approved by the Human Research Ethics Committee at Southern Cross University, approval number 2022/022.

RESULTS

Twenty-four participants were enrolled in the study, 5 male and 19 female. All participants were over the age of 20. Twenty-three participants completed the protocol; one participant dropped out due to worsening of symptoms of an unrelated disease. The paired *t*-test results on outcome measures for all participants showed significant improvement in SRNBQ (p = .002), NOSE scale score (p = .006), NRS score (p = .008), and MBDS score (p = .024) (see Table 2). There were no significant changes reported in the NAS scores for all participants.

Throughout the four weeks of coaching sessions, participants reported understanding the theoretical and practical information in the online training sessions. On average, 91% of the participants did the formal breathing practice more than four times a week (see Table 3). During the protocol, 96% of participants did informal breathing practices mostly or all the time (see Table 4).

Table 2. Changes in outcome measures after the Functional Nasal Breathing Rehabilitation program according to paired-t tests

Outcome Measure	*t* (*df* = 44)	*p*
SRNBQ	2.967	.002**
NOSE	2.597	.006**
NRS	2.507	.008**
MBDS	2.032	.024*
NAS score	1.270	.105

Note. SRNBQ = Self-reported nasal breathing questionnaire; NOSE = Nasal Obstruction Symptom Evaluation; NRS = numeric rating scale for nasal breathing difficulty/obstruction; MBDS =: Mouth breathing daytime and during sleep; NAS = Nasal allergy symptoms. *p < .05, **p < .01

Table 3. Adherence with formal breathing practice

Description	Participants (N)	Percentages (%)
Not at all	0	0.0
Less than 4 times/week	2	8.7
More than 4 times/week	5	21.7
Daily	16	69.5

Table 4. Adherence with informal breathing practice

Description	Participants (N)	Percentage (%)
Not at all	0	0.0
Sometimes	1	4.4
Mostly	19	82.6
All the time	3	13.0

The total number of participants was insufficient to perform statistical tests evaluating differences in symptoms reduction according to effects of training frequency.

THEMES

In the weekly interviews, participants shared their positive and negative experiences and subjective impressions of the program. These qualitative data were gathered to assist with evaluating the feasibility of this protocol. After discussion of these data, researchers agreed that four key themes emerged from the analysis: improvements, challenges, facilitators, and preferences. Table 5 shows themes according to number of participants and frequency of mention with sample statements.

Improvements

The majority of participants reported an increase of nasal breathing awareness during the trial and as the trial progressed, and many participants reported an improvement in their nasal breathing intensity, depth, and frequency. Many of the participants who reported colds and allergies found that techniques such as breathholding, NOS and humming variations decreased their symptoms and made them feel a lot clearer overall.

Other improvements included sleeping better and snoring less. A few participants discovered improvements in mood, energy and mentality. They also reported feeling more relaxed and less emotional.

Table 5. Themes according to number of participants and frequency of mention

Themes	Number of participants	Frequency of mention	Sample statements
Improvements	21	77	I am surprised how well it worked actually, like it's all clear now. No problems at all. Mind blowing actually. The nose – it's probably the best it's been ever that I can remember. It's all open and clear at the moment which is nice. (P21*)* My partner thinks my snoring has gotten a bit better. (P3) I did find I sleep better, not waking up as much. I'm a really bad sleeper and have been all my life. (P4)
Challenges	18	91	I think there was probably a slight element of asthma sitting underneath it that was making it feel like I didn't want to hold my breath as long. (P28) I've been finding it challenging. It still brings up some emotional resistance. (P37) If I'm active, I find it very much harder to maintain the nasal breathing or if I'm stressed. I seem to revert back to mouth breathing more easily. (P37)
Facilitators	6	36	My awareness has increased which has helped. Gets easier the more you practice. (P11) The deep breathing associated with the practice is really helpful. It settles me. I feel more relaxed. It improves my breath-hold result. (P37) Fifteen minutes a day is pretty hard but my colleague and I have been keeping each other accountable by ringing each other at night time and doing it together, so that's been really good. (P18) Understanding the anatomy was really helpful. (P28) I had one morning this week where one side was temporarily blocked, but I really persevered with the breath holding and then alternating humming and got it going again. (P2)
Preferences	21	40	I catch myself informally trying to do the nose opening smile and I really enjoyed the smelling one so now I always have the scented oil close by in the kitchen or living room. (P25) Humming on higher notes is more preferable. (P37) I like the meditative ones. They're more my style. (P42)

Challenges

Although most participants reported an improvement in breathholding as the trial progressed, many found the breathhold techniques challenging when they first began using them.

Participants found that cold weather affected their symptoms and informal nasal breathing practice. The trial was conducted during the winter months in Australia and New Zealand with more than half of the participants feeling unwell during the trial and noted that the cold or rainy weather was affecting their nasal breathing. They experienced symptoms of a common cold, allergic rhinitis, asthma, stress, and fatigue.

Mask wearing (due to COVID-19 pandemic regulations) was reported as a common challenge for maintaining nasal breathing. Occasionally a regression in nasal breathing ability was reported and this was attributed to illness or allergy.

There were also some emotional challenges that were reported where the techniques would bring up feelings of anxiousness for a few of the participants. There were also some who found it difficult to nasal breath during exertion.

Facilitators

Improved breathing awareness and better recognition of mouth breathing behavior were recognized as factors that facilitated practice of the techniques. Greater frequency of practice was also reported to improve results. A number of participants practiced twice a day and said they found a noticeable difference in their nasal breathing progression. Having a practice partner also encouraged adherence to the practice routine. A few of the participants practiced with each other online and said that it made it easier for them to do their daily formal practice.

Other factors that facilitated the nasal breathing practice included the weekly online training and coaching sessions and understanding the nasal anatomy and the mechanisms underpinning the techniques which were part of the weekly training sessions. Those who experienced cold or allergy symptoms reported that the breathhold and humming techniques helped alleviate their symptoms.

Preferences

Formal practice was favored by some, however, many of the participants preferred the informal practice, mainly due to lack of routine, time or convenience. Technique preference was varied among the group, with a preference to humming, breathholds and the NOS. A number of participants favored the NOS while smelling a scent. Some said they liked the meditative techniques of the practice.

All participants mentioned they would continue their practice; however, informal practice was generally favored due to time constraints and convenience such as performing techniques while driving. All participants said they would recommend the protocol to people who had nasal issues or asthma.

The online learning experience was well received with most participants highlighting convenience and ease of technology. Many participants stated they were already familiar with the online learning format due to the prevalence of online courses. The group learning environment was generally well received, however two participants mentioned they would be more inclined to attend one-on-one sessions with the added benefits of privacy and comfort.

DISCUSSION

The aim of this study was to identify the effectiveness and feasibility of a nasal breathing rehabilitation protocol in people reporting symptoms of nasal obstruction and self-reported mouth breathing. The protocol used in the study was delivered online over 4 weeks by a single instructor. It included comprehensive theoretical and practical components that focused on techniques that addressed a range of nasal and breathing functions. Participants were advised to do a formal daily practice sequence of a range of techniques and were then asked to apply the techniques informally during the day in an attempt to control symptoms and help maintain nasal breathing.

Participants reported significant improvements in their ability to breathe nasally during the day and night following this online program as well as a reduction in nasal symptoms. However, participants reported no significant improvements in nasal allergy symptoms. This suggests that while functional nasal breathing rehabilitation improves general nasal breathing ability and reduces discomfort associated with nasal obstruction, it does not specifically relieve nasal allergy symptoms such as sneezing, itching and runny nose. Our findings differ from those in other studies where nasal breathing exercises did reduce symptoms of allergic rhinitis. It is possible that duration of practice may be a factor where implementation of these techniques over a longer period resulted in improvements in nasal allergy symptoms (Nair, 2012).

The reduction in nasal symptoms and improved ability to breathe nasally are consistent with anecdotal reports and previous research on other protocols with some similarities to the FNBR program used here (Bartley, 2006; Eby, 2006; Vaiman et al., 2005; Villa et al., 2015). In Bartley's (2006) case series, patients who were non-responsive to multiple surgical and medical interventions improved after undertaking a course of physiotherapist-led breathing retraining. In a study of children with residual obstructive sleep apnea (OSA) after adenotonsillectomy, a comprehensive program of breathing and local rehabilitation of nasal and oral functions resulted in reduced mouth breathing and statistically significant improvement in OSA (Villa et al., 2015). In a single case study, daily practice of humming, one of the nasal techniques included in the FNBR, greatly reduced nasal obstruction in a patient with sinonasal disease (Eby, 2006). Breathholding, another technique included in our protocol and other breathing training approaches such as the Buteyko method, have been shown to decrease nasal resistance (Hasegawa et al., 1978).

As this study focused on improving nasal functions and reducing subjective symptoms of nasal obstruction, objective changes in nasal patency or mucosal health are not known. However, subjective improvement is an important step in breaking the cycle of nasal disuse, particularly given the poor correlation between nasal passage size and

subjective nasal breathing difficulty (Bartley, 2006; Lee et al., 2015; Levrini et al., 2014).

A secondary aim of the study was to explore the patient experience during the online program and to assess its feasibility as a clinical nasal rehabilitation intervention. Participants predominately reported positive effects regarding breathing awareness, nasal breathing ability and ability to relieve symptoms with the techniques. They also described improvements in mood, sleep, and snoring with one participant reporting that the techniques triggered emotional stress.

Maintaining consistency of the practice was reported as a challenge for some participants. Nevertheless, a high adherence rate was demonstrated with the vast majority of participants completing their formal breathing practice more than 4 times a week. Success of a protocol is often reliant on participation and adherence. In our study, there was a high level of participation which may be attributed to the weekly private online interviews and coaching sessions. Participants also reported the protocol was easy to follow and enjoyable. We believe these factors contributed to the high level of adherence. Furthermore, informal practices may also have contributed to controlling symptoms and breaking the cycle of nasal disuse.

In this trial we introduced a custom-designed composite subjective questionnaire, the SRNBQ which provided a total score made up of its component subscales, i.e., the NOSE scale, the NRS, mouth breathing behaviors in the day and during sleep (MBDS), and nasal allergy symptoms (NAS). The SRNBQ, which provided a more comprehensive evaluation of symptoms and breathing behaviors than any of the subscales, was developed as a pragmatic clinical tool to be used alongside the FNBR. This questionnaire is unvalidated but might be convenient in clinical situations. However, psychometric testing is needed to further develop and refine this questionnaire and to assess its utility and validity before its use can be recommended.

An unexpected element during the current study was that some participants were required to wear a face mask due to COVID-19 pandemic restrictions. This may have had an impact on their nasal breathing ability. In addition, the study was conducted during winter which may have had an impact on a patient's level of nasal allergy symptoms. Despite these factors, participants still reported symptom reduction and improved ability to breathe nasally.

Given the adverse effects of mouth breathing and the benefits of nasal breathing, a protocol such as this may be particularly useful for patients who have not had an optimal response to medical or surgical intervention and who continue to suffer from symptoms of nasal obstruction or continue to mouth breathe. It may be appropriate to adopt this approach before undertaking more invasive procedures. Ideal treatment for some patients may lie in collaboration between medical, dental and allied health practitioners to treat oral, nasal and breathing function.

This approach may also benefit patients with a degree of empty-nose syndrome (Mangin et al., 2017, Manji et al., 2018) or conditions assisted by improved nasal function such as sleep apnea, Eustachian tube disorders, asthma, and allergies. The mind-body style of nasal breathing used in the FNBR, where focused attention to nasal sensations is combined with relaxation, may also be worth exploring for its ability to desensitize patients with multiple chemical sensitivities or vasomotor rhinitis. An individualized approach that assesses and treats dysfunctional breathing, addresses pathology and underlying causes of mouth breathing is ideal, even though a group and online approach such as this has value for its convenience.

Nasal breathing can influence patterns of neural activity in the brain, potentially spreading the benefits of nasal breathing beyond the respiratory system in ways that influence cognitive abilities and emotional state. Nasal breathing rehabilitation might also have benefits for cognitive function and emotional regulation. When breathing is nasal rather than oral, there is more widespread activation of brain regions and greater synchronization or entrainment of breathing and brain rhythms (Tort et al., 2018; Zelano et al., 2016). Coordinated neural activity in the limbic system and across distant brain regions regulates neural rhythms involved in memory and learning and improves aspects of cognition and memory (Zelano et al., 2016). This entrainment of neural activity with breathing has the potential to modulate emotional and cognitive processes including those linked with fear and anxiety (Dupin et al., 2019).

Limitations

Limitations of the study include the small sample size with no randomization, blinding or control group. Due to COVID-19 restrictions regulating face-to-face contact, no objective measures were able to be collected. Furthermore, patients were not diagnosed by an otolaryngologist prior to completing the protocol; therefore, assessors were not aware of existing pathologies and the degree of any pathology if present. Finally, the SRNBQ comprises the other four outcome measures, and corrections for multiple testing was not applied. Therefore, statistical results from each measure should be interpreted with caution.

Future directions

Future research with a larger sample size and a control group is needed to provide more definitive evidence of effectiveness of this approach and to further explore the impact of training frequency to establish minimum practice requirements. Future studies could also assess the characteristics of responders and evaluate objective as well as subjective changes. In addition, the SRNBQ needs to undergo psychometric testing to establish its utility and validity as a clinical assessment tool and outcome measure.

CONCLUSION

Functional Nasal Breathing Rehabilitation appears to be a feasible and effective modality for reducing mouth breathing and improving nasal obstruction symptoms in patients with subjective signs of nasal obstruction. Content analysis of participants' comments indicated that the theory was understandable and the practical techniques were enjoyable, useful and effective.

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APPENDIX A

The Nose Opening Smile (NOS)

1. **Posture and tongue position** – Sit with your spine straight and your head over your shoulders (chin slightly back).

2. **Connect with sensations** – Connect with the sensation of the tongue in the roof of the mouth. Feel the sensations in your nose; feel the difference between the inhale and the exhale.

3. **Savor, imagine and enjoy** – Use your memory and imagination to invoke the feeling of smelling something pleasant, delicious, enjoyable. Or just enjoy the feeling of the air in your nostrils. Practice dilating and expanding your nostrils as you gently inhale, smile and relax.

4. **Smile to open your nose** – Open your nostrils with flaring motions, use the smile and rise of your eyebrows to assist you. Relax and breathe slowly as you do this.

5. **Whole body breathing** – Sense and direct your breath to move into the lower rib cage and belly, widening your rib cage and letting the belly move outward on the inhale.

APPENDIX B

Self-Reported Nasal Breathing Difficulty Questionnaire (SRNBQ)

1. Mouth Breathing During Daytime and During Sleep

Time	Never 0	Sometimes 1	Mostly 2	Always 3
Daytime				
Nighttime				

2. Numeric Rating Scale for Nasal Breathing Difficulty (0 = no difficulty, 10 = maximally difficult)

0	1	2	3	4	5	6	7	8	9	10

3. Nasal Allergy Symptoms

Symptom	Not a problem 0	Mild problem 1	Moderate problem 2	Fairly bad problem 3	Severe problem 4
Sneezing					
Itching					
Runny Nose					

4. Nasal Obstruction Symptom Evaluation (NOSE) Scale

Symptom	Not a problem 0	Mild problem 1	Moderate problem 2	Fairly bad problem 3	Severe problem 4
Nasal Stuffiness					
Nasal blockage or obstruction					
Trouble breathing through my nose					
Trouble Sleeping					
Unable to get enough air through my nose during exercise or exertion					

APPENDIX B (continued)

Development of the Self-Reported Nasal Breathing Difficulty Questionnaire (SRNBQ)

Currently validated subjective scales of nasal breathing difficulty such as the NOSE scale and Numeric Rating Scale do not enquire about daytime or nighttime mouth breathing nor specifically about common nasal allergy symptoms.

The SRNBQ was compiled by the first author (RC) in her clinical practice as a convenient way of simultaneously gathering information about nasal and allergy symptoms and mouth breathing behaviors.

The SRNBQ contains four sections that can be treated as subscales. Section 2 (Numeric Rating Scale for perceived nasal obstruction) and Section 4 (NOSE scale for reporting symptoms associated with nasal obstruction) are both validated and commonly used in research and clinical practice (Haye et al., 2018, Ziai et al., 2017). Sections 1 and 3 have not been validated. However, the group of three common allergy symptoms listed in Section 3 has been shown to be responsive to nasal breathing exercises (Nair 2012).

The SRNBQ has not undergone psychometric analysis and further research is needed to explore the structural relationships, utility and validity of this questionnaire.