Original Article

Does the Use of a Handheld Fan Improve Chronic Dyspnea? A Randomized, Controlled, Crossover Trial

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Abstract

Context. Dyspnea is a disabling distressing symptom that is common in advanced disease affecting millions of people worldwide. Current palliative strategies are partially effective in managing this symptom; facial cooling has been shown to reduce the sensation of breathlessness when induced in volunteers but has not been formally investigated in dyspnea associated with disease.

Objective. The objective of this study was to investigate whether a handheld fan reduces the sensation of breathlessness in such patients, enhancing palliative approaches.

Methods. The effectiveness of a handheld fan (blowing air across the nose and mouth) in reducing the sensation of breathlessness was assessed in patients with advanced disease. Fifty participants were randomized to use a handheld fan for five minutes directed to their face or leg first and then crossed over to the other treatment. The primary outcome measure was a decrease of greater than 1 cm in breathlessness recorded on a 10 cm visual analog scale (VAS).

Results. There was a significant difference in the VAS scores between the two treatments, with a reduction in breathlessness when the fan was directed to the face ($P = 0.003$).

Conclusion. This study supports the hypothesis that a handheld fan directed to the face reduces the sensation of breathlessness. The fan was acceptable to participants: it is inexpensive, portable, enhances self-efficacy, and available internationally. It should be recommended as part of a palliative management

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strategy for reducing breathlessness associated with advanced disease. J Pain Symptom Manage 2010;39:831–838.

Key Words
Dyspnea, handheld fan, palliation

Introduction

Dyspnea, the unpleasant sensation of difficulty in breathing, is a common, disabling, and distressing symptom and is difficult to palliate effectively. There is little evidence to guide management.[1,2] Ninety-four percent of patients with chronic lung disease, 50% of patients with heart disease, and, in the last year of life, 90% of patients with lung cancer experience dyspnea.[3,4] The prevalence of dyspnea is increasing as the management of conditions such as heart failure, chronic obstructive pulmonary disease (COPD), and cancer has improved. These treatments delay, rather than prevent, the onset of dyspnea, and patients survive with advanced chronic disease, resulting in an increased health and economic burden.[5]

The use of a fan to palliate dyspnea at rest has been recommended by several authors.[6–8] Many patients discover for themselves that the use of a fan or a draught from an open window reduces their sensation of breathlessness. Despite these observations, there is little research evidence to support the use of a fan to improve symptom control. We designed a randomized, controlled, crossover trial to test the effectiveness of a handheld fan directed at the face in reducing the sensation of breathlessness for patients who are breathless at rest.

Methods

The study was approved by the local ethics committee (Peterborough and Fenland Local Research Ethics Committee, REC number 05/Q0106/64). Participants older than 30 years with refractory breathlessness from any nonmalignant or malignant cause and a dyspnea exertion scale (DES) Level 2 or above were recruited from Addenbrooke's Hospital (45 participants) and Sue Ryder Care St. John's Hospice, Bedford (five participants). The DES consists of five levels; Level 1: I am able to walk at my own pace on the level without getting out of breath, Level 2: I become breathless if I walk around the house or on the ward on the level at my own pace, Level 3: I become breathless if I move around in bed or get out of bed, Level 4: I become breathless on talking, and Level 5: I am breathless at rest.

The study comprised a single 60-minute assessment that took place in wards, outpatient clinic, or patients' homes. An independently generated simple 1:1 randomization list with no stratification or blocks was stored on a computer with password protection. Administrative staff not directly involved in the project accessed the randomization list at the request of investigators when a participant was recruited. Participants were randomized to use the fan directed at the face or leg first and not told which was being tested as the active treatment (i.e., fan to face).

The primary outcome measure was a decrease in breathlessness of 1 cm or more assessed by a 10cm vertical visual analog scale (VAS) with end anchors of "no shortness of breath" and "shortness of breath as bad as can be." The VAS was measured in millimeters by an independent clinician who was not involved in the study. Although participants were requested not to talk during the study, some made spontaneous comments when using the fan and all comments were noted.

The main exclusion criteria were fever >38°C in the preceding 48 hours, use of continuous or short-burst oxygen during the study period, hemoglobin <10 g/dL, and an inability to complete a VAS or to use the handheld fan. Additional exclusion criteria were trigeminal nerve disease/damage or treatment to this area, known autonomic neuropathy, peripheral vascular disease, severe cardiac or intrapulmonary arteriovenous shunts, use of beta blockers, and cerebral disease or ongoing

cerebral radiotherapy. Patients unable to understand or cooperate with the study also were excluded. Patients were included in the study while taking drugs, such as opioids, which were likely to affect breathlessness, as the intention was to assess use of the fan for patients who remained breathless despite receiving maximal medical treatment.

Written informed consent was obtained. Demographic data, recent blood gas analysis, hemoglobin level, participants' diagnoses, and drug treatments were noted from existing medical records. Room temperature and humidity were recorded. Researchers, following a script, recorded participant's DES level, oxygen saturation (SaO_2), pulse rate (PR) (Nonin 9550 Onyx II pulse oximeter on a finger; Nonin, Plymouth, MN), and VAS at baseline. The investigator demonstrated the VAS to participants by indicating the highest and lowest points of the scale and then instructing them "…to mark on the scale with the pen how breathless you feel at this moment."

The fans used were battery operated, with three flexible plastic blades and on/off switch operable by all participants (Smallfry, Design Effectiveness Award Winner 2004; Marks and Spencer, London, UK). The investigator demonstrated to participants how to hold the fan at a comfortable distance from their face, directing the airflow to the region innervated by the second and third branches of the trigeminal nerve. When directing the fan to the leg, the investigator held this at a constant 15 cm distance from the lateral aspect of the mid-calf. Use of the fan was timed for five minutes, with a 10-minute "washout" period to allow any effect of the fan to abate before using the fan on the alternative site. VAS, SaO_2, and PR were recorded after each five minutes' use of the fan and at the end of each 10-minute washout period. This resulted in five measurements for each subject; T_{i0} (baseline), T_{i5} (after first treatment of five minutes' use of the fan), T_{i15} (after first 10-minute washout period), T_{i20} (after second five-minute treatment with the fan), and T_{i30} (after second 10-minute washout period).

Statistical Analysis

A decrease of 1 cm in the VAS after five minutes' use of the fan directed at the face was considered to be clinically effective.[9,10] To achieve 90% power and detect a difference in VAS of 1 cm using a two-sided paired *t*-test at a significance level of 0.05, 49 participants were required, given an anticipated value for the standard deviation of 2.1. We aimed to recruit 50 participants.[10,11]

The ith individual in the study provides a measure of effect of their first treatment $T_{iA} = T_{i5} - T_{i0}$ and one for their second treatment $T_{iB} = T_{i20} - T_{i15}$. These two measures will map to the two treatments, dependent on treatment order; we also denote them as the effect of fan to face T_{iF} and fan to leg T_{iL}.

Results

In total, 167 patients were screened to recruit 50 participants between December 2005 and October 2007 (Fig. 1). Twenty-three of those recruited were male and 27 were female. The mean age was 71.3 years (range 33–90 years). There was no difference in the diagnoses of the participants recruited and not recruited (Table 1).

There were no adverse events during the study. This heterogeneous group of participants was taking a variety of drugs, including sedatives, steroids, and opioids. There was no association between room temperature and humidity and the VAS score at time 0, assessed graphically and through test of correlation. As could be anticipated from Schwarzstein's study,[12] there was no detectable effect on participants' SaO_2 or PR after use of the fan.

We found evidence of a reduction in VAS following use of the fan directed to the face compared with a fan directed to the leg. Statistical analysis was conducted blinded to order of treatment until the identity of the treatment arm was made clear by the effect size. Investigators were not blinded. There is evidence that the washout period did not give the effect of the treatment enough time to abate fully because $T_{i15} - T_{i0}$ is in the same direction as $T_{i5} - T_{i0}$ in 33 of 49 individuals that showed a change (if the treatment had "washed out," then we would expect this to happen in only a half of all individuals). The obvious test, a paired *t*-test comparing T_{iF} to T_{iL}, is, therefore, inappropriate because of the combination of this failing of the washout period and the imbalance between the randomization

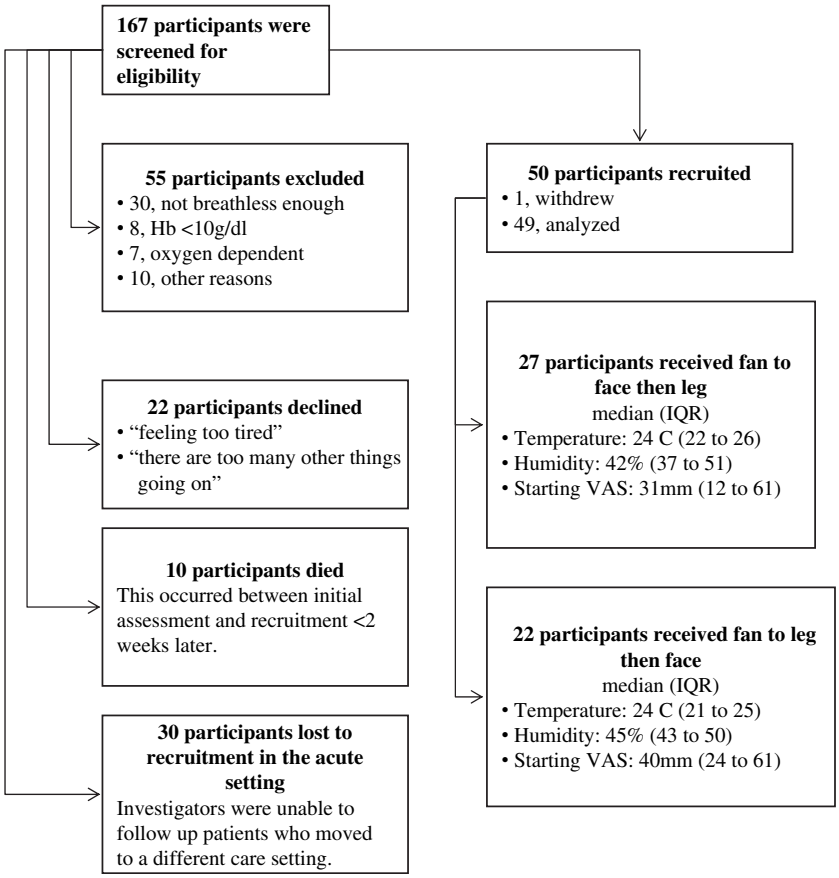

Fig. 1. Outcome of screened patients.

arms of the trial. A fair test was achieved by comparing $T_{iB}-T_{iA}$ between the two randomization arms of the trial (*t*-test: $P=0.003$) (Fig. 2).

If there were no differences between the treatments, then even allowing for the inadequacy of the washout, this value would be the same in both groups. The test conducted is fair, but the estimate generated for the difference between treatments (7.0 mm, 95% confidence interval [CI]: 2.5−11.7 mm) may be biased. Analyzing only the first period suggests that the effect size may indeed be overestimated, but this less-powerful approach leads to wider CI (3.2 mm, 95% CI: −4.4−10.8 mm).

Expressing the VAS change as a percentage change from the original VAS in the two groups, fan to face first and fan to leg first, is shown in Table 2. This includes the percentage change occurring during the washout period.

Irrespective of the order of treatments, a subgroup of 19 participants *continued* to gain benefit, recording a lower VAS at the end of the 10-minute washout period following the use of a fan directed to the face, although only eight had recorded an initial decrease in VAS >10 mm after five minutes' use of the fan.

In a further subgroup of eight participants, there was no decrease in the VAS after five minutes' use of the fan directed to the face, but a decrease in VAS *began* during the subsequent washout period.

Discussion

Our study supports the hypothesis that a handheld fan directed to the face reduces the sensation of breathlessness, demonstrating a significant reduction in VAS after five minutes' use of a fan directed to the face compared with five minutes' use of a fan directed to the leg. This reduction was irrespective of the order of use of the fan, directed to the face or leg first.

Table 1
Patient Diagnoses

Diagnosis	Recruited Patients Total $n=50$	Excluded Patients Total $n=55$	Patients Who Declined Total $n=22$	Patients Who Died Before Recruitment Total $n=10$	Patients Lost to Recruitment Total $n=30$
COPD	26	33	11	4	17
Primary or secondary lung cancer	11	5	4	4	2
Asthma	8	4	3	1	3
Heart disease	15	7	2	0	5
Bronchiectasis	7	4	1	1	2
Pneumonitis	4	4	3	0	2
Other	20	10	2	3	9
Multiple diagnoses (up to 4 in any one patient)	26	12	4	3	9

Schwartzstein et al.[12] have shown in healthy volunteers with induced dyspnea that a flow of cold air directed against the cheek reduced the sensation of breathlessness measured by a modified Borg scale without a significant reduction in ventilation.[13] The participants recorded no change in the sensation of breathlessness when cold air was directed at the leg. Baltzan et al.[14] found that a 42 cm diameter fan directed at the face of patients with COPD ($n=17$) exercising on a treadmill produced a small reduction in induced dyspnea measured by VAS and modified Borg scales. Marchetti et al.[15] showed that a 12 inch diameter fan directed to the face of patients with COPD undertaking leg ergometry at a constant workload ($n=4$) enabled them to achieve a longer exercise time than when a fan was directed to the leg ($P=0.2$). Minute ventilation was significantly lower with the fan directed to the face although there was no significant difference in the participants' Borg score at maximal exercise. Spence et al.[16] demonstrated that patients with COPD ($n=19$) had improved peak exercise performance and diminished end exercise breathlessness with an induced relative hypoventilation when breathing cold air compared with room air, suggesting a reduction in neural respiratory drive.

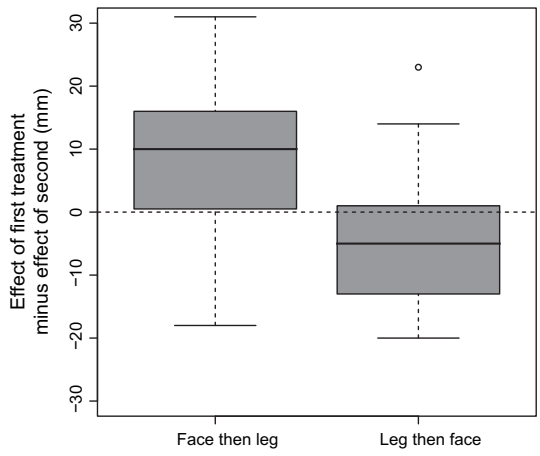

Fig. 2. The effects of fan directed to the face and fan directed to the leg.

The use of a handheld fan is an inexpensive, noninvasive, patient-directed, safe, practical technique for managing breathlessness in any setting and could be recommended for breathless patients throughout the world. All but one participant completed the study and found the fan directed to the face acceptable and comfortable. Many participants spontaneously made positive comments about the use of the fan, for example, "Oh. That's lovely! I feel so much better for it and it is so simple;" "I have used a big fan at home but this is more useful as I can take it with me;" "You need to hold it close to your face so you can feel the air being forced in;" and "It helps me recover quicker when I have gone upstairs" (a patient on returning for an unrelated appointment).

This study was designed to achieve a practical protocol based on our clinical experience. However, it is clear that the washout period of 10 minutes was insufficient for VAS levels to return to baseline, although this did not affect the positive outcome for the use of the fan overall. The optimum time to use the fan to achieve benefit and the length of time the benefit continues are unclear. Although not conclusively achieving the anticipated 10 mm decrease in VAS that was *a priori* considered to represent clinical effectiveness, we also cannot exclude the possibility of such a difference. We would anticipate that refinement of the

Table 2
Percentage and Millimeter Changes in VAS After the Use of Fan

VAS Decrease After Use of the Fan and During Washout Period	Fan to Face First 27 Patients	Fan to Leg First 22 Patients
VAS median (IQR) mm decrease after five minutes' use of fan	7.0 (1.5 to 14.5)	1.5 (−2.0 to 7.0)
VAS median (IQR) % decrease after five minutes' use of fan	29 (6 to 50)	2 (−6 to 27)
VAS median (IQR) mm decrease including 10-minute washout period	10.0 (3.5 to 17)	1.0 (−4.5 to 12.0)
VAS median (IQR) % decrease including 10-minute washout period	40 (15 to 57)	3 (−12 to 25)

IQR = interquartile range.

protocol may increase the effect sizes further still. Some authorities suggest that a 25% decrease in VAS is required to be clinically effective, and participants who had the fan directed to the face first achieved a median decrease in VAS of 29%.[17]

Participants who had previously used a fan to relieve breathlessness were not excluded from the study unless they had used a handheld fan in precisely the same way as in our study. Bias could, therefore, have occurred if participants had already found a fan beneficial. The attention of a researcher for 60 minutes may have introduced a placebo effect, but the crossover design should have largely eliminated this.

We had difficulty in identifying suitable study participants in the acute hospital. Hospital staff perceived patients to be more breathless than the patients themselves reported. This mismatch between staff and patient assessment of breathlessness could be the result of a response shift occurring in chronic breathlessness or an example of clinicians' poor ability to judge patient's symptoms.

We initially used Borg and DES scores as entry screening tools, but neither consistently corresponded to a breathlessness VAS at rest. Consequently, the protocol was amended, and only DES Level 2 or above continued to be used as a criterion for entry to the study. The Borg and DES scores were designed to assess breathlessness related to exercise; as we intended to recruit participants breathless at rest, this may explain why these scales were not effective entry screening tools. Use of the VAS or a numerical rating scale (NRS) as a screening tool may improve the selection of study participants. The NRS has been validated in assessing dyspnea in patients with COPD at rest.[18] The VAS has been shown to be effective in rating dyspnea, used in many studies assessing dyspnea response to treatments, and continues to be recommended to assess breathlessness at a point in time.[15,19–21] Morris et al.[22] have demonstrated that verbal NRS scores of breathlessness were reliable during exercise and preferred by participants to the VAS. Therefore, a verbal NRS may be a preferable measure for screening and to assess breathlessness response in future studies. A patient-centered outcome measure assessing the multidimensional impact of breathlessness would be appropriate to assess the benefit of a fan over a longer period of time in a patient's home. The Dyspnea 12, developed since the design of this study, may be a suitable measure.[23]

The mechanism by which the fan reduces breathlessness remains unclear. Several authors have undertaken studies in healthy volunteers or patients with COPD that suggest that physical stimulation or exposure to cold air of nasal or oral mucosa receptors results in decreased breathlessness.[24–27] The diving response, which causes ventilatory depression when the trigeminal area of the face is cooled, is one possible mechanism for this effect. Our study and Schwartzstein et al.'s[12] study in 1987 did not demonstrate any change in participants' SaO_2 or PR. Marchetti et al.[28] found that the use of a 12 inch fan directed at the face enabled higher ventilatory workloads with less central respiratory drive and a lower Diaphragmatic Electromyographic Activity/Tidal volume (EMGdia/Vt) ratio in healthy volunteers ($n = 3$) undergoing hypercapnic challenge. They suggest that this is achieved by improved diaphragmatic electromechanical coupling. Our study demonstrates that the fan directed to the face reduced the sensation of breathlessness. This reduction in breathlessness may have been achieved by the cooling of nasal or oral mucosal receptors and via the decreased central respiratory drive noted by Marchetti et al.

Further areas for research include assessment of long-term use of the fan by patients

at home and assessing the effectiveness of a fan directed at the face in reducing recovery time from exercise-induced breathlessness. This could add useful data to support patients' self-management of breathlessness using a fan. Work is also needed to clarify how long a fan must be used before it is beneficial and how long any benefit persists. A comparison of direct cooling of the face, for example, use of a cold pack, compared with the use of the fan could ascertain whether it is cooling or a draught of air that is most effective in reducing breathlessness. Further studies to assess changes in ventilation and muscle function during the use of a fan would be valuable to elucidate the mechanism of action of the fan.

We have demonstrated that, alongside other treatments, the handheld fan directed at the face is efficacious and acceptable to patients to reduce their breathlessness. We believe that the fan should be internationally recommended to all breathless patients as an evidence-based management strategy for their symptom.

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References

1. Booth S, Silvester S, Todd C. Breathlessness in cancer and chronic obstructive pulmonary disease: using a qualitative approach to describe the experience of patients and carers. Palliat Support Care 2003;1:337–344.

2. Higginson I, McCarthy M. Measuring symptoms in terminal cancer: are pain and dyspnea controlled? J R Soc Med 1989;82:264–267.

3. Edmonds P, Karlsen S, Khan S, Addington-Hall J. A comparison of the palliative care needs of patients dying from chronic respiratory diseases and lung cancer. Palliat Med 2001;15: 287–295.

4. Muers MF, Round CE. Palliation of symptoms in non-small cell lung cancer: a study by the Yorkshire Regional Cancer Organisation Thoracic Group. Thorax 1993;48:339–343.

5. British Thoracic Society. Burden of lung disease, 2nd ed. London, UK: British Thoracic Society, 2006.

6. American Thoracic Society. Dyspnea: mechanisms, assessment and management: a consensus statement. Am J Respir Crit Care Med 1999;159: 321–340.

7. Kerr D. A bedside fan for terminal dyspnoea. Am J Hospice Care 1989; Nov/Dec: 22.

8. Freeman D, Price D. ABC of chronic obstructive pulmonary disease. Primary care and palliative care. BMJ 2006;333:188–190.

9. Booth S. Improving research methodology in breathlessness—a meeting convened by the MRC Clinical Trials Unit and Cicely Saunders Foundation. Palliat Med 2006;20:219–220.

10. Abernethy A, Currow DC, Frith P. Randomised, double blind, placebo controlled crossover trial of sustained release morphine for the management of refractory dyspnoea. BMJ 2003;327:523–528.

11. Bruera E, MacEachern T, Ripamonte C, Hanson J. Subcutaneous morphine for dyspnea in cancer patients. Ann Intern Med 1993;119: 906–907.

12. Schwartzstein RM, Lahive K, Pope A, Weinberger SE, Weiss JW. Cold facial stimulation reduces breathlessness induced in normal subjects. Am Rev Respir Dis 1987;136:58–61.

13. Burdon JGW, Juniper EF, Killian FE, Hargreave FE, Campbell EJM. The perception of breathlessness in asthma. Am Rev Respir Dis 1982; 126:825–828.

14. Baltzan M, Alter A, Rotaple M, Kamel H, Wolkove N. Fan to palliate exercise-induced dyspnea with severe COPD. [abstract]. Am J Respir Crit Care Med 2000;161(Suppl 3):A59.

15. Marchetti N, Travaline JM, Criner GL. Air current applied to the face of COPD patients enhances leg ergometry performance. [abstract]. Am J Respir Crit Care Med 2004;169:A773.

16. Spence DP, Graham DR, Ahmed J, et al. Does cold air affect exercise capacity & dyspnoea in stable COPD? Chest 1993;103:693–696.

17. Wilcock A, Crosby V, Clarke D, Tattersfield A. Repeatability of breathlessness measurements in cancer patients. [letter]. Thorax 1999;54:375.

18. Gift AG, Narsavage G. Validity of the numeric rating scale as a measure of dyspnea. Am J Crit Care 1998;7:200–204.

19. Grant S, Atchison T, Henderson E, et al. A comparison of the reproducibility and the sensitivity to change of visual analogue scales, Borg scales and Likert scales in normal subjects during submaximal exercise. Chest 1999;116: 1208–1216.

20. Jennings AL, Davies AN, Higgins JP, Gibbs JS, Broadley KE. A systematic review of the use of opioids in the management of dyspnoea. Thorax 2002;57:939–944.

21. Bausewein C, Farquhar M, Booth S, Gysels M, Higginson IJ. Measurement of breathlessness in advanced disease: a systematic review. Respir Med 2007;101:399–410.

22. Morris NR, Sabapathy S, Adams L, et al. Verbal rating scales are as reliable and sensitive as visual analogue scales for rating dyspnoea in young and older subjects. Respir Physiol Neurobiol 2007;157: 360–365.

23. Yorke J, Moosavi SH, Shuldham C, Jones PW. Quantification of dyspnoea using descriptors: development and initial testing of the Dyspnoea-12. Thorax 2010;65:21–26.

24. McBride B, Whitelaw WA. A physiological stimulus to upper airway receptors in humans. J Appl Physiol 1981;51:1189–1197.

25. Folgering H, Olivier O. The diving response depresses ventilation in man. Bull Eur Physiopathol Respir 1985;21:143–147.

26. Liss HP, Grant JB. The effect of nasal flow on breathlessness in patients with chronic obstructive pulmonary disease. Am Rev Respir Dis 1988;137: 1285–1288.

27. Simon PM, Basner RC, Weinberger SE, et al. Oral mucosal stimulation modulates intensity of breathlessness induced in normal subjects. Am Rev Respir Dis 1991;144:419–422.

28. Marchetti N, Criner GJ, Gaughan J, et al. Effect of air directed to the face on diaphragm electromyographic activity (EMGDia) during hypercapnic challenge [abstract]. Proceedings of the 100th Anniversary International Conference, American Thoracic Society, May 20–25, 2005, San Diego, CA, A789.