Abnormal breathing pattern features in chronic refractory cough

Jordan Jeffery [1,2], Anne E. Vertigan[1,2,3], Sarah Bone[1] and Peter G. Gibson[2,3,4]

[1]Speech Pathology Department, John Hunter Hospital, Newcastle, Australia. [2]Asthma and Breathing Research Centre, Hunter Medical Research Institute, Newcastle, Australia. [3]School of Medicine and Public Health, The University of Newcastle, Newcastle, Australia. [4]Department of Respiratory and Sleep Medicine, John Hunter Hospital, Newcastle, Australia.

Corresponding author: Jordan Jeffery (jordan.jeffery@health.nsw.gov.au)

Shareable abstract (@ERSpublications)
Abnormal breathing features are common in patients with chronic refractory cough (CRC). Abnormal breathing features appear to be associated with laryngeal motor function but independent of laryngeal hypersensitivity that drives CRC and ILO. https://bit.ly/4bh4dXT

Cite this article as: Jeffery J, Vertigan AE, Bone S, *et al*. Abnormal breathing pattern features in chronic refractory cough. *ERJ Open Res* 2024; 10: 00416-2024 [DOI: 10.1183/23120541.00416-2024].

Received: 23 April 2024
Accepted: 20 June 2024

Abstract

Background Chronic refractory cough (CRC) is a challenging condition that responds to speech pathology intervention. Clinical observation suggests abnormal breathing patterns occur in CRC and may be indirectly addressed as part of behavioural treatment, yet breathing pattern changes in CRC are poorly understood. The aims of this study were to 1) describe breathing patterns in patients with CRC, 2) compare breathing pattern features between patients with CRC and inducible laryngeal obstruction (ILO), and 3) estimate the effect of breathing pattern features on clinical measures of laryngeal sensory and motor dysfunction.

Methods This retrospective cross-sectional observational study included 634 patients with CRC or ILO. A file audit of speech pathology assessment data was undertaken. Analysis of self-reported laryngeal symptoms (*via* questionnaires) and clinical assessment of voice and breathing of those with CRC and ILO was conducted.

Results Most participants with CRC (73%) demonstrated at least one abnormal breathing pattern feature. The most common feature was thoracic breathing (69%) followed by oral breathing (33%). The type and prevalence of abnormal breathing patterns were similar between CRC and ILO. Abnormal breathing patterns were associated with reduced maximum phonation time (MPT); however, there was no association between these features and Newcastle Laryngeal Hypersensitivity Questionnaire scores.

Conclusions Abnormal breathing features are common in patients with CRC and are not significantly different from those occurring in ILO. There is some association between abnormal breathing features and MPT, suggesting impairment of laryngeal motor function. Conversely, there is no association between abnormal breathing features and laryngeal hypersensitivity.

Introduction

Chronic cough, defined as a cough lasting for >8 weeks, is common and has a negative impact on morbidity and healthcare utilisation [1]. Chronic cough is refractory to medical treatment in up to 42% of cases [2] and is termed chronic refractory cough (CRC) (also known as refractory chronic cough). Inducible laryngeal obstruction (ILO) is a related condition whereby the vocal folds involuntarily adduct during respiration leading to dyspnoea, throat tightness, cough, dysphonia and stridor. Clinical observation suggests that abnormal breathing patterns can occur in CRC and ILO, and that speech pathologists indirectly address breathing pattern changes in their behavioural treatment of these conditions [3, 4]. Despite this, there is a lack of clarity around breathing pattern abnormalities in the CRC population.

Breathing pattern changes have been reported as a significant cause of dyspnoea in conditions such as dysfunctional breathing. These abnormal breathing patterns include elevated respiratory rate/hyperventilation [5–8], a thoracic-dominant breathing pattern, accessory muscle usage [9, 10] and mouth breathing [11]. Behavioural treatment that addresses abnormal breathing patterns in dysfunctional breathing significantly improves quality of life [12–14]. Dysfunctional breathing has also been thought to drive dyspnoea in long COVID [15]. These studies indicate that a breathing pattern disorder can be a significant

primary problem in patients with unexplained dyspnoea, and that recognition and treatment of breathing pattern disorders can offer significant benefits to patients. This raises the question of the role of an abnormal breathing pattern in CRC, and how it should be incorporated into the assessment and management of patients with CRC.

The prevalence and characteristics of abnormal breathing patterns in CRC have not been reported, and the impact of these features on clinical outcomes is also unknown. In this study we examined the significance of abnormal breathing patterns in CRC and compared the results to a positive control group with ILO without cough, where breathing pattern and dyspnoea are both recognised and managed. The aims of this study were to 1) describe breathing patterns in patients with CRC, 2) compare breathing pattern features between patients with CRC and those with ILO without cough, and 3) estimate the effect of abnormal breathing pattern features on clinical measures of laryngeal sensory and motor dysfunction.

Method

The study was a retrospective cross-sectional observational study conducted in a tertiary referral hospital. A file audit was undertaken to analyse self-reported laryngeal sensory symptoms, sustained phonation and breathing patterns. The study was reviewed and approved by the Hunter New England Human Research Ethics Committee and a waiver of consent was approved (authorisation number AU202103-23).

Participants

The study included 542 participants with CRC and a comparison group of 92 with ILO without cough. Participants were 634 adult patients referred consecutively to the Speech Pathology Department at John Hunter Hospital (Newcastle, Australia) for behavioural treatment of CRC or ILO. Participants were recruited between October 2018 and June 2022.

Inclusion criteria included CRC or ILO. CRC was diagnosed by a respiratory physician, and defined as a cough persisting for >8 weeks and refractory to medical management. ILO was diagnosed *via* functional transnasal laryngoscopy using accepted diagnostic procedures [16, 17] as well as clinical features such as inspiratory dyspnoea, noisy breathing and throat tightness. Abnormal glottal closure during respiration was diagnosed when >25% closure of the vocal folds during inspiration and/or >50% closure during expiration was observed. Participants were not asked to breath-hold, and breath holding that occurred spontaneously during tidal respiration during functional transnasal laryngoscopy was considered abnormal.

Additional inclusion criteria for both groups included optimal assessment and treatment from an otolaryngologist or respiratory physician prior to referral to exclude asthma and other pulmonary disease as a reason for respiratory symptoms. If participants did have a coexisting diagnosis of asthma, their treatment needed to be optimised by a respiratory physician prior to referral.

Exclusion criteria included recent upper respiratory tract infection, untreated asthma, untreated rhinitis, untreated gastro-oesophageal reflux disease, significant psychological factors that prevented participation in the assessment or neurological impairment. None of the participants reported previously seeing a respiratory physiotherapist for assessment or management of their symptoms and all were treatment naïve. None of the participants had been referred specifically for assessment of dysfunctional breathing.

Measurements

Participants attended a single 60-min assessment visit with a qualified speech pathologist with experience in the assessment and treatment of patients with CRC and ILO. Assessment measures, outlined in table 1, were completed as per the outpatient speech pathology clinical procedures of the department, and included self-reported laryngeal symptoms (*via* questionnaires) and clinical assessment of voice and breathing completed while sitting. The parameters of breathing region (thoracic *versus* abdominal), breathing route and breathing rate were used to describe breathing pattern features in this study. Additional features that were noted included stridor or noisy breathing, breath holding, and poor coordination of respiration and phonation. Definitions of these features and criteria for assessment are reported in table 1.

Data analysis

Descriptive statistics included mean (standard deviation), median (interquartile range) and number (percentage) as appropriate. The prevalence of abnormal breathing pattern features between CRC and ILO groups was compared using Fisher's exact test. Linear regression was conducted to estimate the effect of breathing pattern features on maximum phonation time (MPT) and Newcastle Laryngeal Hypersensitivity Questionnaire scores. Analysis was conducted using Stata version 16 (StataCorp, College Station, TX, USA). The significance level was set at $p<0.05$.

TABLE 1 Measurement of breathing characteristics and clinical measures

Breathing feature	Definition
Clinical assessment	
Region (area of primary muscular engagement and movement while breathing, observed and noted by the speech pathologist)	Normal: normal relaxed diaphragmatic breathing with abdominal movement observed during tidal breathing Abnormal: clavicular and/or thoracic movement observed during tidal breathing
Route (primary route the patient uses to breathe, observed and noted by the speech pathologist)	Normal: nasal breathing route observed during clinical assessment Abnormal: oral or mixed (oral/nasal) breathing route observed during clinical assessment
Rate (number of breaths counted by the speech pathologist in 1 min of observation while sitting)	Normal: 8–14 breaths·min^{-1} Abnormal: anything outside 8–14 breaths·min^{-1}
Stridor (recorded by the speech pathologist if present or absent during the session)	Normal: absent Abnormal: present
Breath holding (obtained through observation of the patient in the session and recorded by the speech pathologist)	Normal: no breath holding observed during the clinical assessment Abnormal: breath holding observed during the clinical assessment
Coordination of respiration and phonation (reported on by the speech pathologist after observing the patient in conversation and during voice assessment tasks[#])	Normal: adequate coordination of breathing and phonation onset as well as no breathing difficulties while speaking Abnormal: poor coordination and control of breathing and phonation when speaking, leading to observed breathlessness and a need to breathe more frequently within a spoken sentence
Questionnaires	
Newcastle Laryngeal Hypersensitivity Questionnaire [28]	Normal: score >17.1
Leicester Cough Questionnaire [29]	Normal: score >17.68 [30]
Vocal Cord Dysfunction Questionnaire [31]	Normal: score ⩽12
Dyspnoea Index [32]	Normal: score >10
Hospital Anxiety and Depression Scale [33]	Normal: score ⩽7
Instrumental assessment	
Maximum phonation time (recorded and analysed by the speech pathologist)	Normal: >15 s [34]
Forced expiratory volume in 1 s (% pred)	Normal: ⩾80% predicted
Forced vital capacity (% pred)	Normal: ⩾80% predicted
Forced expiratory ratio (% pred)	Normal: ⩾70% predicted

[#]: observation of respiratory/phonatory coordination during conversation, paragraph reading, prolonged counting and vowel prolongation.

Results

Demographics

The study included 542 participants with CRC and 92 with ILO without cough. 87 of the CRC participants also had paradoxical vocal fold movement (PVFM) present on laryngoscopy; however, cough was their predominant symptom. The mean age was 58 years and the majority were female (77%). The median duration of symptoms was 24 months. Comorbidities were common and had been addressed prior to assessment. Most participants (61%) were never-smokers. The mean pulmonary function test results were in the normal range. Mean scores on patient-reported symptom questionnaires and MPT values were in the abnormal range (table 2). Hospital Anxiety and Depression Scale scores were in the normal range.

Breathing assessment

Most participants with CRC (73%) demonstrated at least one abnormal breathing pattern feature. Thoracic/upper chest breathing was the most common abnormality (69%), followed by oral/mixed breathing route (33%), and combined thoracic and oral breathing (29%) (table 3). Of the patients with chronic cough, stridor was present in 87 participants (16%), breath holding in 23 (4%), and poor coordination of respiration and phonation in 165 (31%). Breathing pattern features in participants with CRC were similar to the positive control group with ILO without cough (table 3). The CRC group did have a higher prevalence of abnormal rate and route combined than the ILO group (8% *versus* 2%; p=0.048).

Linear regression was used to estimate the effect of abnormal breathing pattern features on laryngeal motor and sensory function, assessed as MPT (table 4) and laryngeal hypersensitivity (table 5), respectively. MPT values were lower when several abnormal breathing pattern features (thoracic pattern, oral breathing, combined thoracic and oral breathing, combined oral breathing and rapid breathing rate, and combined thoracic pattern, oral breathing and rapid rate) were present (table 4). In contrast, there was no significant

TABLE 2 Participant demographics and clinical features

	Total	CRC	ILO
Subjects	634	542	92
Age (years)	58±16	58±16	53±18
Gender			
Female	487 (77)	418 (77)	69 (75)
Male	147 (23)	124 (23)	23 (25)
Comorbidities			
Gastro-oesophageal reflux disease	406 (64)	358 (66)	48 (52)
Rhinitis/sinusitis	299 (47)	258 (48)	41 (45)
Asthma	218 (34)	174 (32)	44 (48)
Obstructive sleep apnoea	108 (17)	93 (17)	15 (16)
Smoking			
Never-smoker	388 (61)	341 (63)	47 (51)
Ex-smoker	216 (34)	178 (33)	38 (41)
Current smoker	30 (5)	23 (4)	7 (8)
Body mass index (kg·m^{-2})	32±8	32±8	31±6
Spirometry			
Forced expiratory volume in 1 s (% pred)	87±20	87±19	84±21
Forced vital capacity (% pred)	95±17	96±17	93±20
Forced expiratory ratio (% pred)	77±15	78±15	75±17
Questionnaire scores			
Newcastle Laryngeal Hypersensitivity Questionnaire	14±3	14±3	15±3
Leicester Cough Questionnaire	14±4	13±4	18±3
Vocal Cord Dysfunction Questionnaire	40±9	40±8	40±11
Upper airway Dyspnoea Index	21±10	21±11	22±9
Hospital Anxiety and Depression Scale: Anxiety	7±4	7±4	9±5
Hospital Anxiety and Depression Scale: Depression	6±4	5±4	6±4
Maximum phonation time (s)	11±6	11±6	12±5

Data are presented as n, mean±SD or n (%). CRC: chronic refractory cough; ILO: inducible laryngeal obstruction.

association between any breathing pattern feature and Newcastle Laryngeal Hypersensitivity Questionnaire scores (table 5).

Discussion

This is the first study to describe and compare abnormal breathing pattern features in patients with CRC and ILO. Dyspnoea and breathing pattern changes are an established feature of ILO and are addressed in therapy. We observed a high proportion of abnormal breathing pattern features in CRC that was similar to ILO. This suggests that abnormal breathing pattern features are a relevant part of the profile in CRC. We also found an association between abnormal breathing pattern features and laryngeal motor function, demonstrated by reduced MPT values. MPT is a reliable indirect measure of glottal control and

TABLE 3 Comparison of dysfunctional breathing features between chronic refractory cough (CRC) and inducible laryngeal obstruction (ILO) groups

	Total (n=634)	CRC (n=542)	ILO (n=92)	p-value[#]
Any abnormality	458 (72)	395 (73)	63 (69)	0.527
Abnormal region	432 (68)	372 (69)	60 (66)	0.905
Abnormal route	202 (32)	178 (33)	24 (26)	0.274
Abnormal region and route	181 (28)	159 (29)	22 (24)	0.380
Abnormal rate	150 (24)	128 (24)	22 (24)	0.895
Abnormal region and rate	145 (23)	123 (23)	22 (24)	0.788
Abnormal route and rate	45 (7)	43 (8)	2 (2)	0.048
All abnormal	44 (7)	42 (8)	2 (2)	0.071

Data are presented as n (%), unless otherwise stated. [#]: p-value calculated using Fisher's exact test.

TABLE 4 Association between breathing pattern features and maximum phonation time values

	Coefficient (95% CI)	p-value
Any abnormality	−1.1 (−2.2–0.1)	0.070
Abnormal region	−1.3 (−2.5– −0.1)	0.034
Abnormal route	−1.2 (−2.3– −0.2)	0.020
Abnormal rate	−0.3 (−1.4–0.9)	0.640
Abnormal region and route	−1.3 (−2.4– −0.3)	0.013
Abnormal region and rate	−0.4 (−1.6–0.7)	0.445
Abnormal route and rate	−2.1 (−3.9– −0.2)	0.027
All abnormality	−2.2 (−4.0– −0.3)	0.021

management of aerodynamic forces of the lungs, and provides important information about the interaction between the respiratory and phonatory systems [18, 19]; therefore, reduced MPT may be due to insufficient lung volume to sustain a vowel, glottic insufficiency during phonation, the presence of laryngeal muscle tension or a combination of these. This result suggests that phonation is less efficient when abnormal breathing pattern features are present. In contrast to laryngeal motor function, our data showed no association between abnormal breathing pattern features and self-reported laryngeal sensory dysfunction. Overall, these results might suggest that abnormal breathing patterns are prevalent in CRC and may be related to laryngeal motor dysfunction, rather than self-reported laryngeal sensory dysfunction in CRC and ILO.

The aim of the study was to report observable breathing features in individuals with CRC and compare breathing features observed in those with CRC and ILO. The purpose of this study was not to diagnose dysfunctional breathing or breathing pattern disorder; however, the type and prevalence of abnormal breathing pattern features in the current study aligns with previous work in dysfunctional breathing and extends the observations to CRC. De Vos *et al.* [20] reported dysfunctional breathing in 33 out of 34 participants referred to speech pathology for management of CRC. In an observational study, Selby *et al.* [21] reported abnormal breathing patterns, defined as a score of ⩾4 on the Brompton Breathing Pattern Assessment, in 41% of participants with ILO, which increased to 82% after provocation challenge. Denton *et al.* [22] reported that in their difficult asthma cohort, a thoracic-dominant breathing pattern was most common and often overlapped with hyperventilation and mouth breathing. While we reported increased respiratory rate, our study did not specifically address hyperventilation syndrome as this was beyond the scope of this study.

The breathing pattern features reported in the current study are similar to descriptions of dysfunctional breathing in the literature, where severe and refractory dyspnoea is a common symptom. However, dysfunctional breathing can be difficult to define and validate with standardised diagnostic criteria, which are limited. The mechanisms driving dysfunctional breathing integrate biochemical, biomechanical, psychological, social and physiological aspects [12, 23]; however, how these components interact to result in the patient experience remains difficult to define. In patients with dysfunctional breathing, treatment of breathing pattern can improve quality of life [13]. Dysfunctional breathing appears to be a different phenomenon to CRC as it does not appear to involve laryngeal sensory dysfunction. The relationship between dysfunctional breathing and CRC is unclear, but it would seem that they are different diagnoses

TABLE 5 Association between breathing pattern features and Newcastle Laryngeal Hypersensitivity Questionnaire scores

	Coefficient (95% CI)	p-value
Any abnormality	−0.7 (−0.7–0.5)	0.821
Abnormal region	0.10 (−0.5–0.7)	0.730
Abnormal route	−0.3 (−0.8–0.3)	0.359
Abnormal rate	−0.1 (−0.7–0.5)	0.680
Abnormal region and route	−0.3 (−0.9–0.3)	0.357
Abnormal region and rate	−0.02 (−0.6–0.6)	0.941
Abnormal route and rate	−0.9 (−1.9–0.1)	0.069
All abnormal	−0.9 (−2.0–0.1)	0.067

that share commonalities in symptoms and treatment [24]. Standardised assessment of laryngeal symptoms in patients with confirmed dysfunctional breathing both with and without ILO and CRC would be needed to better understand the overlap of symptoms, and the current study is unable to explore this relationship.

It is unclear whether the presence of abnormal breathing pattern features is a cause or result of laryngeal dysfunction. Selby *et al*. [21] suggested that abnormal breathing pattern features can contribute to the sensation of tightness and dyspnoea that mimics ILO. Denton *et al*. [22] suggested that abnormal breathing pattern features may be related to the use of maladaptive techniques involving suboptimal postures and learned responses. That is, an upper chest breathing pattern and increased breathing rate might be employed to compensate for the perception of breathlessness and mouth breathing might increase the sensation of airflow. Over time these patterns might become habitual. In contrast with this assumption, laryngeal abnormalities, including mass lesions and vocal fold palsy that partially occlude the airway, can change an individual's breathing pattern [25, 26]. It seems likely that the relationship between abnormal breathing patterns and laryngeal dysfunction is bidirectional and differs between patients.

The main clinical implication of this study is that patients with CRC are likely to demonstrate concomitant breathing pattern abnormalities, which should be noted during the clinical assessment. These patterns may impact laryngeal motor function during phonation but may be less likely to influence self-reported laryngeal sensory dysfunction. Therapy for CRC and ILO indirectly addresses breathing pattern abnormalities. For example, while PVFM release breathing focuses on optimal laryngeal postures during respiration, it simultaneously promotes nasal breathing, lower abdominal breathing and encourages a steady breathing rate and rhythm. It is a basic tenet of speech pathology treatment that sufficient breath is required for adequate performance of the vocal/laryngeal tasks required for therapy. Results suggest that an abnormal breathing pattern is associated with impaired laryngeal motor support. This provides a rationale for the current speech pathology approach to managing CRC where the breathing pattern abnormalities are identified and treated in order to support successful speech pathology management of CRC.

The limitations of this study are that it was a retrospective study utilising routinely collected clinical data from a single site. While this provides excellent validity, there is potential for misinterpretation of some of the fields and these results are unable to be generalised to the larger population. The assessment was conducted at a single time-point, hence reproducibility over time could not be assessed. There was no control group of healthy individuals in which to assess the presence of dysfunctional breathing and the clinical significance of a single breathing pattern feature, such as oral breathing. The measures used in the study were based on clinical assessment by speech pathologists with no instrumental analysis of breathing pattern (*e.g.* optoelectronic plethysmography). The Nijmegen Questionnaire was not included in the study as it was not part of routine clinical practice and, while it is commonly used in the assessment of individuals who present with features of dysfunctional breathing, there is controversy about the ability of this questionnaire to diagnose dysfunctional breathing [14].

Participants were seen by several speech pathologists in the department at the study site, all of whom have considerable experience in the assessment and management of CRC and ILO. The assessment procedures were standardised amongst the speech pathologists, and observational assessment of breathing pattern features is an inherent part of speech pathology assessment of patients with CRC and ILO. However, the retrospective nature of the study precluded assessment of inter-rater reliability. Furthermore, as this study was not designed to diagnose dysfunctional breathing, a standard classification system, such as the one outlined by Boulding *et al.* [12] and Barker and Everard [24], and known clinical features [27] were not included in the assessment.

Conclusions

Abnormal breathing pattern features are prevalent in patients referred to speech pathology for CRC and are similar to ILO. Abnormal breathing pattern features appear to be associated with laryngeal motor function and therefore might need to be addressed in treatment. In contrast, abnormal breathing patterns are independent of laryngeal hypersensitivity that drives CRC and ILO.

Provenance: Submitted article, peer reviewed.

Ethics statement: The study was reviewed and approved by the Hunter New England Human Research Ethics Committee and a waiver of consent was approved (authorisation number AU202103-23).

Conflicts of interest: All authors declare they have no competing interests.

References

1 Jin HJ, Kim CW. Understanding the impact of chronic cough on the quality of life in the general population. *Allergy Asthma Immunol Res* 2020; 12: 906–909.
2 Zhang M, Morice AH, Si F, *et al.* New insights into refractory chronic cough and unexplained chronic cough: a 6-year ambispective cohort study. *Allergy Asthma Immunol Res* 2023; 15: 795–811.
3 Vertigan AE, Theodoros DG, Gibson PG, *et al.* Efficacy of speech pathology management for chronic cough: a randomised placebo controlled trial of treatment efficacy. *Thorax* 2006; 61: 1065–1069.
4 Murry T, Tabaee A, Aviv JE. Respiratory retraining of refractory cough and laryngopharyngeal reflux in patients with paradoxical vocal fold movement disorder. *Laryngoscope* 2004; 114: 1341–1345.
5 Todd S, Walsted ES, Grillo L, *et al.* Novel assessment tool to detect breathing pattern disorder in patients with refractory asthma. *Respirology* 2018; 23: 284–290.
6 Courtney R, Greenwood KM. Preliminary investigation of a measure of dysfunctional breathing symptoms: the Self Evaluation of Breathing Questionnaire (SEBQ). *Int J Osteopath Med* 2009; 12: 121–127.
7 Tanaka Y, Morikawa T, Honda Y. An assessment of nasal functions in control of breathing. *J Appl Physiol* 1988; 65: 1520–1524.
8 Okuro RT, Morcillo AM, Ribeiro MÂGO, *et al.* Mouth breathing and forward head posture: effects on respiratory biomechanics and exercise capacity in children. *J Bras Pneumol* 2011; 37: 471–479.
9 Denton E, Bondarenko J, Tay T, *et al.* Factors associated with dysfunctional breathing in patients with difficult to treat asthma. *J Allergy Clin Immunol Pract* 2019; 7: 1471–1476.
10 Lee J, Denton E, Hoy R, *et al.* Paradoxical vocal fold motion in difficult asthma is associated with dysfunctional breathing and preserved lung function. *J Allergy Clin Immunol Pract* 2020; 8: 2256–2262.
11 Hallani M, Wheatley JR, Amis TC. Enforced mouth breathing decreases lung function in mild asthmatics. *Respirology* 2008; 13: 553–558.
12 Boulding R, Stacey R, Niven R, *et al.* Dysfunctional breathing: a review of the literature and proposal for classification. *Eur Respir Rev* 2016; 25: 287–294.
13 Thomas M, McKinley RK, Freeman E, *et al.* Breathing retraining for dysfunctional breathing in asthma: a randomised controlled trial. *Thorax* 2003; 58: 110–115.
14 Vidotto LS, Carvalho CRF, Harvey A, *et al.* Dysfunctional breathing: what do we know? *J Bras Pneumol* 2019; 45: e20170347.
15 Gaffney A. Dysfunctional breathing after COVID-19: recognition and ramifications. *Eur Respir J* 2024; 63: 2400149.
16 Forrest LA, Husein T, Husein O. Paradoxical vocal cord motion: classification and treatment. *Laryngoscope* 2012; 122: 844–853.
17 Leong P, Gibson PG, Vertigan AE, *et al.* Vocal cord dysfunction/inducible laryngeal obstruction – 2022 Melbourne Roundtable Report. *Respirology* 2023; 28: 615–626.
18 Latoszek BBV, Watts CR, Schwan K, *et al.* The maximum phonation time as marker for voice treatment efficacy: a network meta-analysis. *Clin Otolaryngol* 2023; 48: 130–138.
19 Maslan J, Leng X, Rees C, *et al.* Maximum phonation time in healthy older adults. *J Voice* 2011; 25: 709–713.
20 De Vos R, Rupani H, Brown T, *et al.* P64 Prevalence of breathing pattern disorders with chronic refractory cough and the outcomes of physiotherapy management. *Thorax* 2021; 76: A101.
21 Selby J, Tidmarsh B, Bailey E, *et al.* Breathing pattern disorder is prevalent in patients with subjective symptoms of inducible laryngeal obstruction. *Eur Respir J* 2019; 54: Suppl. 63, PA4348.
22 Denton E, Bondarenko J, O'Hehir RE, *et al.* Breathing pattern disorder in difficult asthma: characteristics and improvement in asthma control and quality of life after breathing re-training. *Allergy* 2019; 74: 201–203.
23 Karkouli G, Douros K, Moriki D, *et al.* Dysfunctional breathing in children: a literature review. *Children* 2024; 11: 556.
24 Barker N, Everard ML. Getting to grips with 'dysfunctional breathing'. *Paediatr Respir Rev* 2015; 16: 53–61.
25 Sapienza CM, Stathopoulos ET, Brown WS. Speech breathing during reading in women with vocal nodules. *J Voice* 1997; 11: 195–201.
26 Shergill GS, Shergill AK. Large vocal cord polyp: an unusual cause of dyspnoea. *BMJ Case Rep* 2015; 2015: bcr2015211542.
27 Clifton-Smith T, Rowley J. Breathing pattern disorders and physiotherapy: inspiration for our profession. *Phys Ther Rev* 2011; 16: 75–86.
28 Vertigan AE, Bone SL, Gibson PG. Development and validation of the Newcastle laryngeal hypersensitivity questionnaire. *Cough* 2014; 10: 1.
29 Birring SS, Prudon B, Carr AJ, *et al.* Development of a symptom specific health status measure for patients with chronic cough: Leicester Cough Questionnaire (LCQ). *Thorax* 2003; 58: 339–343.
30 Reynolds JE, Jetté ME, Slovarp LJ, *et al.* Normative values for the Leicester Cough Questionnaire in healthy individuals. *Ann Otol Rhinol Laryngol* 2023; 132: 705–708.
31 Fowler SJ, Thurston A, Chesworth B, *et al.* The VCDQ – a questionnaire for symptom monitoring in vocal cord dysfunction. *Clin Exp Allergy* 2015; 45: 1406–1411.

32 Gartner-Schmidt JL, Shembel AC, Zullo TG, *et al.* Development and validation of the Dyspnea Index (DI): a severity index for upper airway-related dyspnea. *J Voice* 2014; 28: 775–782.
33 Snaith RP. The Hospital Anxiety and Depression Scale. *Health Qual Life Outcomes* 2003; 1: 29.
34 Hirano M, Koike Y, Von Leden H. Maximum phonation time and air usage during phonation: clinical study. *Folia Phoniatr Logop* 1968; 20: 185–201.