Outcome Measures for Dysfunctional Breathing: A Scoping Review of Use, Validation, and Research Gap.

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***Title: Outcome Measures for Dysfunctional Breathing: A Scoping Review of Use, Validation, and Research Gap*.**

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Abstract

Introduction: Dysfunctional Breathing (DB) is a complex, multifactorial condition affecting respiratory function and quality of life. Its definition remains inconsistent, creating challenges in diagnosis and clinical management. The tools used to assess and monitor DB are heterogeneous, often lack validation, and are applied inconsistently, limiting comparability between studies and clinical decision-making.

Aims: This scoping review aims to systematically map the outcome measures used to assess dysfunctional breathing and identify gaps in their application and validation.

Methods: A comprehensive search including both peer-reviewed and grey literature was conducted across relevant databases. Screening and data extraction followed Joanna Briggs Institute (JBI) guidelines.

Results: Of 239 records identified, 69 studies met inclusion criteria. Twenty-two distinct outcome measures (OMs) were reported, assessing biomechanical (n = 10), biochemical (n = 6), and psychophysiological (n = 4) features of DB and two evaluated more than one dimension. The Nijmegen Questionnaire (NQ) was the most frequently used OM (n = 41). Only 12 studies formally evaluated psychometric properties of the OMs. Populations ranged from paediatric to adult, with fifty-six studies employing multiple OMs rather than a single tool.

Conclusion: Outcome measures used to assess dysfunctional breathing are highly heterogeneous, poorly standardised, and rarely fully validated, particularly in populations with comorbidities. No single tool captures all dimensions of the condition, and reliance on multiple measures highlights uncertainty in its definition and assessment rather than true diagnostic precision. Establishing a standardised suite of validated outcome measures, aligned with clearly defined domains of DB, is essential to improve assessment accuracy, clinical utility, and research comparability.

Keywords: Dysfunctional breathing, Outcome measures, Breathing pattern disorder, Psychometric properties, Respiratory assessment, Clinical evaluation.

Key Take-Home Messages

- Outcome measures for DB are highly heterogeneous and poorly standardised across clinical and research settings.
- No single tool captures all dimensions of DB, and current practice often relies on multiple measures to compensate for uncertainty.
- Few outcome measures have undergone formal validation; diagnostic thresholds, sensitivity, specificity, and minimal clinically important differences are largely unestablished.
- Misapplication of tools beyond their intended scope may risk diagnostic oversimplification, inconsistent assessment, and misclassification in patients, especially those with comorbid respiratory conditions.
- Multidimensional and 'cluster testing' approaches are common, reflecting DB's multifactorial nature, but lack standardisation and comparability.
- Future research should focus on establishing a standardised suite of validated outcome measures aligned with clearly defined DB domains, including biomedical, psychophysiological, and biochemical aspects, to improve clinical assessment and research consistency.

Educational Aims

- To raise awareness among clinicians and researchers about the wide variability in outcome measures used to assess dysfunctional breathing.
- To highlight the lack of a gold-standard assessment or agreed protocol, promoting critical appraisal of current clinical practices.
- To raise awareness of the challenges in diagnosing and monitoring DB across diverse populations, including those with comorbid respiratory conditions.
- To underscore the limited validation of commonly used tools, including the Nijmegen Questionnaire, and the importance of evaluating psychometric properties.
- To emphasize the fragmented nature of the evidence base, encouraging integration of findings across populations, outcome domains, and study designs.
- To inform clinical education by identifying gaps in reliable measurement and guiding evidence-based selection and application of outcome measures in DB.

Future Research directions

- Establish a consensus definition and classification framework for DB to guide consistent assessment and reporting.
- Develop and validate standardized outcome measures across biomechanical, biochemical, and psychophysiological domains.
- Conduct psychometric evaluations, including reliability, validity, and responsiveness, of commonly used tools such as the NQ and other emerging measures.
- Investigate the applicability and performance of OMs across diverse populations, including both adults and paediatric patients.
- Ensure translation and cultural validation of key OMs to support international applicability.

1. Introduction

Dysfunctional breathing (DB) is a complex, multidimensional condition involving biochemical, biomechanical, and psychophysiological processes [1]. Prevalence estimates suggest that DB affects approximately 6–10% of adults, with higher rates reported among females [2-4]. However, some adult samples report substantially higher prevalence, ranging from 60–80% [5]. These wide-ranging estimates reflect not only differences in study populations and methodology but also the lack of a consistent definition, terminology, and classification framework for DB, which continues to hinder clinical recognition and research comparability [6] .

DB is frequently used as an umbrella term for a heterogeneous array of breathing pattern disorders, yet its boundaries remain poorly delineated [4]. Recent efforts to characterise DB subtypes have improved understanding of its biomechanical components[7-9] ; however, substantial ambiguity persists regarding its psychophysiological and biochemical dimensions[6]. Both respiratory and non-respiratory symptoms are commonly reported under the DB condition, including dyspnoea, chest tightness, frequent sighing and yawning, palpitations, dizziness and paraesthesia[2, 4, 10-12]. These symptoms may be intermittent or persistent, further complicating the clinical picture [6] . DB has been linked to a spectrum of respiratory disorders, including asthma, chronic obstructive pulmonary disease (COPD), long COVID, and vocal cord dysfunction [4, 6, 13]. Emerging evidence highlights its association with mental health conditions such as anxiety and depression[14]. The presence of such comorbidities can substantially influence the manifestation of DB, making each presentation highly individual and introducing potential confounding factors in both research and clinical practice [4]. Symptom overlap may mask or mimic DB, increasing diagnostic uncertainty, limiting its identification in clinical practice, and potentially reducing patients' health-related quality of life [3, 4, 6, 15].

A wide variety of outcome measures have been described to capture different features of DB [16]. The Nijmegen Questionnaire, for example, is frequently applied in practice despite being developed for hyperventilation syndrome [17] . Other tools, including the Self-evaluation breathing questionnaire, Manual assessment of respiratory motion, and capnography, target specific psychophysiological, biomechanical, or biochemical components but do not provide a comprehensive or definitive assessment individually [5, 10, 18]. While combining multiple measures is common practice for assessment, there is currently no consensus regarding which outcomes should be selected, how they should be integrated, or the optimal stage at which they should be applied [3, 19] . This lack of standardisation contributes to inconsistency in clinical practice, complicates decision-making, and limits comparability of treatment outcomes across populations [7, 20, 21].

The aim of this scoping review is to systematically map the outcome measures used to assess dysfunctional breathing in both adult and paediatric populations across biomechanical, biochemical, and psychophysiological domains. It will additionally describe the frequency of use of these measures, the settings in which they are applied, the populations studied, and any reported psychometric properties. In the absence of a

universally accepted definition, examining how dysfunctional breathing is currently assessed provides a pragmatic and necessary approach to understanding how the construct is being operationalised in both research and clinical practice. Ultimately, this review seeks to clarify how dysfunctional breathing is currently assessed and identified within both clinical practice and the literature, while highlighting key gaps and inconsistencies in current assessment approaches. In doing so, it aims to support the development of more standardised, evidence-based measurement frameworks for future research and to improve understanding of dysfunctional breathing assessment in both research and clinical contexts.

2. Methods

2.1 Protocol and Framework

This scoping review was conducted following the Joanna Briggs Institute (JBI) methodology [22], which reflects refinements to the original Arksey and O'Malley framework for scoping reviews [23] . Reporting followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist [24] to ensure transparency and completeness.

2.2 Eligibility Criteria

Inclusion and exclusion criteria (Table 1) were defined using the population, concept, context (PCC) framework, as recommended for scoping reviews [22]

PCC criteria	Inclusion	Exclusion
Population	Studies involving individuals of any age or demographic presenting with dysfunctional breathing (DB).	Studies involving populations with no reference to dysfunctional breathing or its recognised terminology. Non-human participants.
Concept	Studies that assess, evaluate, or monitor dysfunctional breathing using a clearly defined outcome measure, including established or newly developed measures.	Studies that do not use, report, or clearly define an outcome measure related to dysfunctional breathing.

Context	Studies conducted in any geographical location and setting, published in English, with no restrictions on publication date.	Non-English publications; studies unavailable for full-text review

Table 1: Eligibility Criteria

2.3 Search Strategy

A comprehensive search strategy was developed in collaboration with the subject librarian at Sheffield Hallam University to identify relevant studies across multiple disciplines. The databases screened included the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Medical Literature Analysis and Retrieval System Online (MEDLINE), Scopus and National institute of health database (NIH). A targeted search of Google Scholar was conducted to capture grey literature, with the first 50 records screened to assess relevance [25].

An initial exploratory search was conducted in CINAHL and MEDLINE to identify relevant terminology, keywords, and indexing terms used within the literature. Keywords included "physiotherapy", "dysfunctional breathing", "abnormal breathing", "dyspnoea", "breathing pattern disorder", "hyperventilation", "respiratory physiotherapy", "outcome measures", and "The Nijmegen Questionnaire". MeSH terms included "physical therapy modalities", "respiratory tract diseases", "respiratory mechanics", "outcome assessment", "respiratory function test", "respiratory dysfunction", and "respiratory conditions". Truncation and wildcard symbols were applied where appropriate to increase search sensitivity. Search terms were combined using Boolean operators (AND, OR) to optimise retrieval across information sources. The NOT operator was not applied to minimise the risk of excluding potentially relevant records, consistent with the exploratory objectives of a scoping review [22, 26] .

All information sources were searched from inception to 2025. Records retrieved from the searches were exported to RefWorks for reference management and subsequently imported into Covidence™ [27].

2.5 Selection of Sources of Evidence.

Screening of records was conducted in a three-stage process using Covidence™ software [27]. After duplicates were removed, titles and abstracts were independently assessed against the predefined inclusion and exclusion criteria and relevant keywords. Articles passing this initial screening underwent full-text review. At each stage, screening decisions were made by two reviewers, with a third independent reviewer consulted to resolve any disagreements.

2.6 Data Extraction and Synthesis

Data extraction was undertaken by four researchers using Covidence for database-derived studies and a shared spreadsheet for grey literature sources. To ensure consistency, one study was piloted collaboratively, after which the remaining studies were assigned for independent extraction. Every extraction was checked by a second reviewer.

A standardised charting table, was used to extract key study information, including Title, Study Design, population demographics, Outcome measures, and conclusion. See supplementary materials 1. Qualitative and quantitative evidence was synthesised descriptively to identify recurring patterns, themes, and gaps within the literature. In line with scoping review methodology, no formal quality appraisal was undertaken[22].

3.Results

A total of 239 records were identified through the initial database search. Thirty-two duplicates were removed, including 30 by Covidence™ [27] and 2 manually, leaving 207 records for title and abstract screening. Of these, 83 were excluded based on the predefined criteria. The remaining 124 articles underwent full-text review for eligibility. Fifty-five studies were excluded at this stage for not meeting with the eligibility criteria. Sixty-nine studies were included into the scoping review for data extraction [4, 5, 7, 11, 13, 15, 16, 28-89]. The study selection process is summarised in a PRISMA flow diagram (Figure 1).

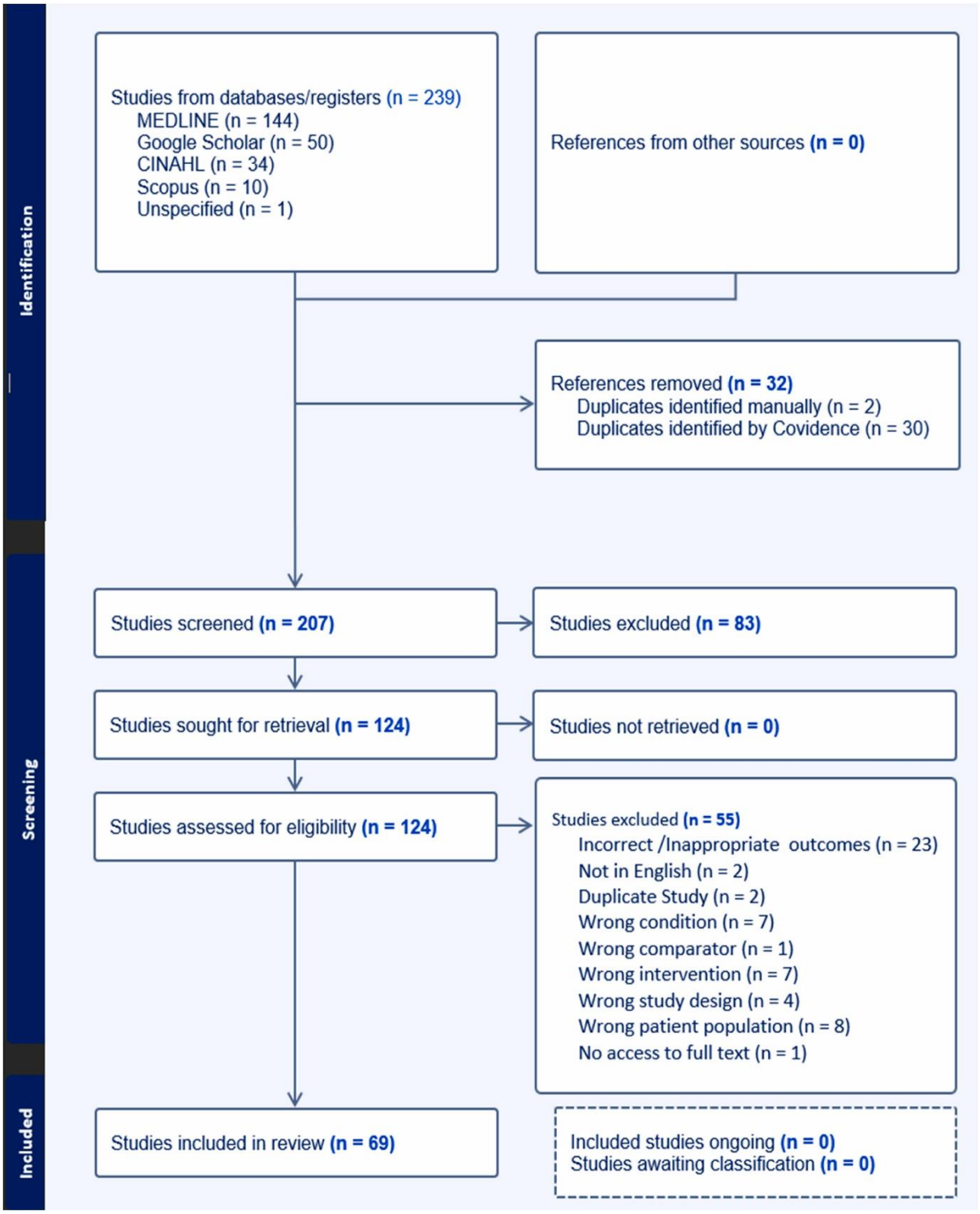

Figure 1 Prisma Flow chart

Of the included studies, 49 (71%) were quantitative, 18 studies (26%) used qualitative methods, and two studies (3%) used mixed methods. There were 14 different methodologies within the included studies. More information in the study designs can be found in Figure 2.

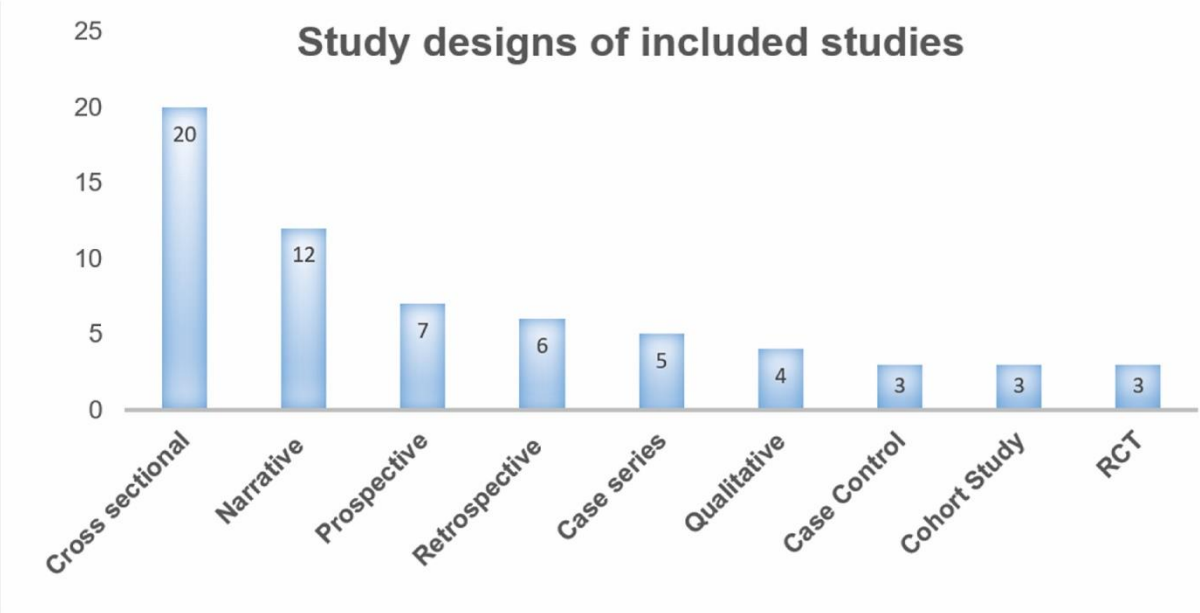

Figure 2 Prevalence of Study designes

Four key themes were identified across the included studies: the range of outcome measures used in DB, Application and settings of Outcome Measures in Dysfunctional Breathing, the populations for which they are used to diagnose or monitor DB, and the psychometric properties of these outcome measures. Details of the studies that contributed to the development of these themes are provided in Supplementary Material

3.1. Range of Outcome Measures in Dysfunctional Breathing

Across the included studies, 22 distinct outcome measures related to DB were identified. The Nijmegen Questionnaire was the most frequently reported across the different studies (n = 41), followed by cardiopulmonary exercise testing (CPET) (n = 27). The Manual Assessment of Respiratory Motion (n = 12) and the Self-Evaluation of Breathing Questionnaire (n = 10) were also commonly reported (Figure 3).

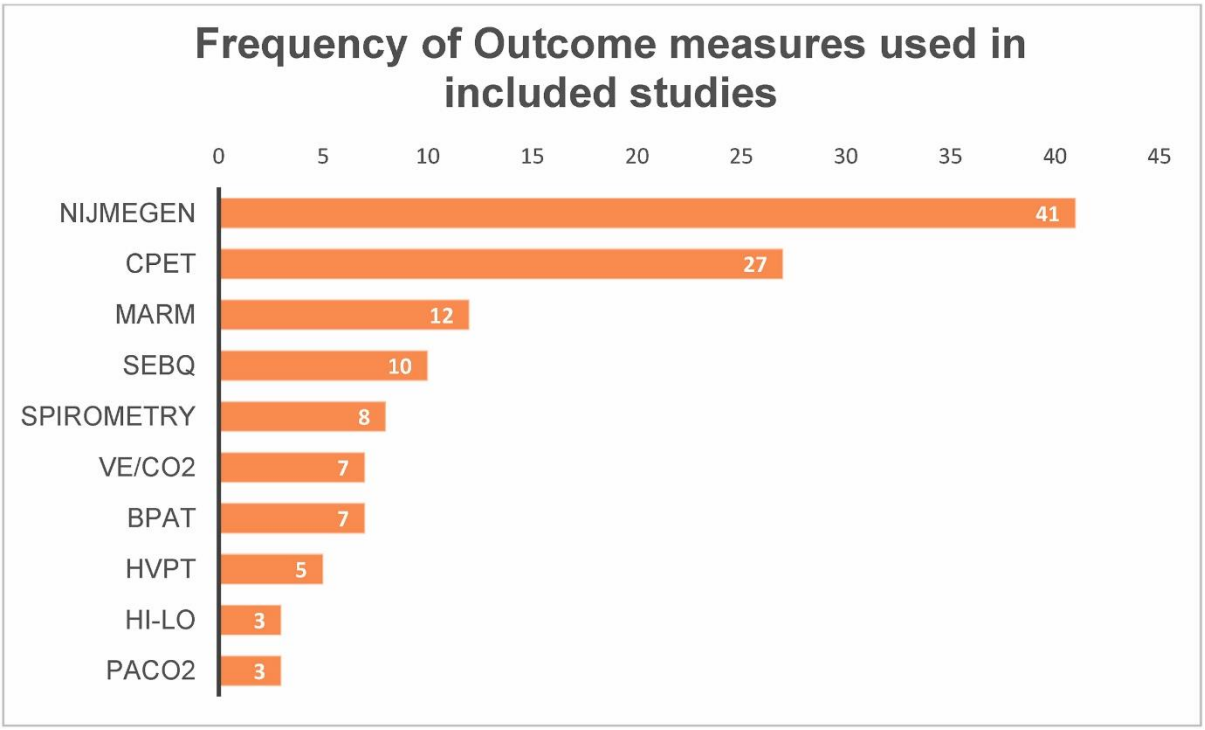

Figure 3 Frequency of use of the outcome measures in the literature.

A range of objective assessment tools was identified, including spirometry (n = 8), respiratory inductance plethysmography (n = 3), electromyography (n = 1), $PaCO_2$ measurement (n = 3), ventilatory equivalent CO_2 (n = 7), and breathing pattern angle (n = 1). Less commonly reported DB-specific measures included the Breathing Pattern Assessment Tool (n = 7), Dyspnoea-12 (n = 1), Hi-LO test (n = 3), breath-hold test (n = 3), and hyperventilation provocation test (n = 5).

Several measures were reported in only one or two studies: the Breathing Vigilance Questionnaire (n = 1), the Totally Faulty Breathing Scale (n = 1), the Breathing IQ (n = 1), the Milstein Breathing Pattern Assessment Index (n = 1), and the eucapnic voluntary hyperventilation provocation test (n = 1). CPET with laryngoscopy was reported in two studies (n = 2), and lateral rib expansion was used in one study (n = 1) to distinguish between functional and dysfunctional breathing. (Figure 3)

3.2 Application of Outcome Measures in Dysfunctional Breathing

Of the 69 included studies, 14 (20%) used a single outcome measure to diagnose, observe, or monitor dysfunctional breathing (DB), whereas 55 studies (80%) used two or more outcome measures. One study used six outcome measures.

Of the 22 identified outcome measures, five were primarily patient-reported questionnaires: the Nijmegen Questionnaire, Self-Evaluation of Breathing Questionnaire, Breathing IQ, Dyspnoea-12, and the Hyperventilation Provocation Test. The remaining

measures were predominantly clinician-led. Ten outcome measures primarily assessed biomechanical features of dysfunctional breathing, including the Breathing Pattern Assessment Tool, Hi-LO breathing assessment, breath-hold test , Manual Assessment of Respiratory Motion, Manual Breathing Pattern Assessment Index, eucapnic voluntary hyperpnoea, breathing pattern angle, the Total Faulty Breathing Scale, and lateral rib expansion.

Assessment of the psychophysiological dimension of dysfunctional breathing relied mainly on four tools: the SEBQ, Nijmegen Questionnaire, Dyspnoea-12, and the Breathing-VQ. Six measures were used to evaluate biochemical features, including respiratory inductance plethysmography, electromyography, capnography, arterial $PaCO_2$, and ventilatory equivalent for carbon dioxide. Finally, two measures—cardiopulmonary exercise testing and CPET combined with laryngoscopy—integrated both biomechanical and biochemical components, enabling a more comprehensive assessment of dysfunctional breathing.

3.3 Population Characteristics and Conditions Assessed by the outcome measures

The populations assessed across the 69 included studies were heterogeneous. Forty-seven studies (68%) focused exclusively on adult populations aged 17–85 years, five studies (7%) investigated paediatric populations aged 16 years or younger, and 17 studies (25%) included mixed adult and paediatric samples without specifying exact age ranges.

A total of 13 comorbidities were examined either independently or in conjunction with DB across the 69 included studies. Fourteen studies (20%) investigated DB in populations with asthma, making asthma the most frequently studied comorbidity. Two studies (3%) recruited populations with diagnosed DB and asthma, while one study (1.5%) examined DB alongside induced laryngeal obstruction (ILO) and asthma. A further study explored populations with DB, exertional dyspnoea, and asthma. Exertional dyspnoea and its variants were also examined in isolation in eight studies (12%), whereas ILO was investigated independently in two studies (3%). Finally, only two studies (3%) included a population with multiple comorbidities, such as, asthma, COPD, obesity, post-viral conditions, and anxiety-related disorders.

COVID-19-related conditions were also commonly reported. Eight studies (12%) examined post-acute SARS-CoV-2 infection (long COVID), while four studies (6%) focused on acute SARS-CoV-2 infection. Dysfunctional breathing and COVID-19 were examined concurrently in one study (1.5%). Hyperventilation syndrome (HVS) was investigated in isolation in four studies (6%), with one additional study (1.5%) examining the overlap between DB and HVS. Postural orthostatic hypotension was reported in only one study (1.5%) across the included literature.

Dysfunctional breathing, described as an umbrella term without reference to specific comorbid conditions, was examined in isolation in five studies (7%). One study (1.5%) differentiated between primary DB (psychogenic) and secondary DB associated with cardiopulmonary, neurological, or asthma-related conditions.

The remaining studies focused on less clearly defined populations, including individuals presenting with concerns regarding their breathing or unexplained breathlessness (n = 4, 6%), unspecified respiratory symptoms (n = 1, 1.5%), and other respiratory conditions that were not explicitly defined (n = 1, 1.5%). Finally, six studies (9%) included healthy participants with no diagnosed dysfunctional breathing, comorbidities, or respiratory symptoms.

3.4 Psychometric Properties

Of the 69 studies identified, 12 (17%) explicitly aimed to evaluate the psychometric properties of outcome measures used in dysfunctional breathing. The remaining 57 studies (83%) did not formally assess psychometric properties and either omitted discussion of outcome measures or identified the absence of validated tools as a study limitation.

Among the 12 studies with a psychometric focus, validity testing was reported for several outcome measures across different populations. Validity of the Breathing Pattern Assessment Tool, including sensitivity and specificity, was examined in individuals with refractory asthma. Two editorials reported on the validity of the Nijmegen Questionnaire for hyperventilation syndrome, including sensitivity and specificity, and discussed its applicability across respiratory population. Multiple psychometric properties of the Total Faulty Breathing Scale, including intra-rater and inter-rater reliability, were evaluated in a single study conducted in the context of “faulty breathing”.

Physiological validation approaches were less commonly reported. One cohort observational study assessed end-tidal carbon dioxide kinetics during the hyperventilation provocation test, with comparison to the NQ. Development and validation of the Breath-VQ were reported in a cross-sectional study, including test–retest reliability analysis. Diagnostic utility of the modified Breathing Pattern Assessment Index for identifying breathing pattern disorder in individuals with exercise-induced laryngeal obstruction was evaluated in a prospective observational study.

Cross-cultural validation of outcome measures was reported for the NQ in two cross-sectional studies during translation into Thai and Japanese. Qualitative methods were used in one study to translate and culturally adapt the Self-Evaluation of Breathing Questionnaire into Danish, with a focus on face validity. The Dyspnoea-12 was identified as an outcome measure used in dysfunctional breathing in one study; however, no detailed psychometric evaluation was reported.

4. Discussion

The aim of this scoping review was to map the OM used in the literature to assess DB, including their frequency of use, target populations, psychometric properties, and modes of application. The review identified a heterogeneous body of evidence, encompassing a wide range of study designs and source types. Overall, the findings indicate that outcome measures used in DB research are poorly standardised and highly variable, reflecting the ongoing lack of consensus surrounding the characterisation of DB. Furthermore, significant gaps remain in relation to the ability of existing measures to reliably detect DB and its proposed subtypes, particularly in populations with co-existing comorbidities [32, 81].

This review did not identify evidence supporting the existence of a gold-standard assessment framework for DB. Multiple assessment tools are described in the literature, with the Nijmegen Questionnaire emerging as the most frequently used OM. However, a study by the original author of the tool emphasised that the Nijmegen Questionnaire was designed specifically for HVS and was not intended to diagnose DB or differentiate between dysfunctional breathing subtypes[35] Despite this, it has often been applied beyond its intended scope, reflecting misinterpretation by clinicians and researchers, which risks diagnostic oversimplification and may obscure the underlying mechanisms contributing to patients' symptoms. Consequently, a range of alternative measures—including the Manual Assessment of Respiratory Motion (MARM), the Breathing Pattern Assessment Tool (BPAT), cardiopulmonary exercise testing, and the Self-Evaluation of Breathing Questionnaire —have been reported as commonly used in clinical practice [4, 37, 52, 57, 71, 88] . However, these tools differ substantially in scope and purpose, demonstrating limited consistency in clinical application [83] .

Studies frequently compare OMs in terms of their ability to detect DB and their psychometric properties [57, 83]. However, given the multifactorial nature of DB, individual OMs typically assess only specific dimensions of the condition. Combined with ongoing uncertainty surrounding the definition and scope of DB, this may lead to inappropriate or misleading comparisons between tools [37, 73]. For example, comparisons between MARM and NQ are difficult to interpret, as MARM focuses on biomechanical breathing patterns, whereas NQ assesses psychophysiological features associated with hyperventilation[35, 90] . Consequently, the lack of conceptual alignment between OMs undermines cross-study comparability and poses a significant barrier to the development of reliable,

standardised assessment strategies for DB. Taken together, these limitations may compromise clinical interpretation, reduce consistency in assessment, and hinder the appropriate application of these tools in both research and practice.

Few of the identified tools have undergone formal validation, representing a significant gap in the current evidence base [81]. To date, only the NQ and BPAT have reported sensitivity and specificity for the identification of HVS or other selected DB subtypes respectively [28, 60]. No studies included in this scoping review reported a validated minimal clinically significant difference, with existing thresholds typically derived from expert consensus or clinician judgement rather than empirical validation [59, 72, 81, 85]. Similarly, validated diagnostic cut-offs remain scarce. For example, a threshold score of 20 has been proposed for the NQ in a Japanese translation for hyperventilation syndrome, although its cross-cultural validity remains uncertain and it is not consistently applied in other studies [72]. Consequently, the absence of robust validation parameters limits confidence in the use of these tools for accurate identification, stratification, and monitoring of patients presenting with complex breathlessness, where dysfunctional breathing frequently overlaps with established respiratory disease.

The validity of tools for DB in populations with comorbidities is not yet well established. This reflects both the small number of studies specifically addressing OMs in the context of coexisting conditions, and the symptom overlap between DB and other chronic disorders [6, 7] . Although tools such as spirometry, and respiratory inductance plethysmography are well-established in the diagnosis of asthma and other respiratory disorders [91] , their suitability for detecting DB in patients with comorbidities remains unclear. Moreover, the use of un-adapted DB assessment tools across both paediatric and adult populations raises concerns about potential bias in the identification of the condition. In addition, no studies have directly evaluated the sensitivity or specificity of these measures for detecting DB in these populations. Given that DB has been reported in up to 42% of individuals with asthma [92], potentially exceeding prevalence in the general population, the lack of standardised outcome measures undermines diagnostic accuracy and clinical utility, leaving clinicians with limited evidence-based guidance for the reliable identification of DB across populations [4, 81, 85].

Outcome measures for DB described in the 69 included studies appear to be highly heterogeneous, reflecting the condition's multifaceted nature. Some tools are grounded in a biomedical model, assessing physical manifestations through cardiopulmonary exercise testing, manual assessment of respiratory motion, and capnography. Others adopt a biopsychosocial perspective, capturing psychological and social contributors, such as the Nijmegen Questionnaire and the Self-Evaluation of Breathing Questionnaire[7, 37, 81, 85]. However, no single tool has been developed to assess all dimensions of the condition, and there is no standardised framework for combining available tools to capture the full breadth of DB while mitigating the limitations of individual measures.

Consequently, a ‘cluster testing’ approach—combining multiple outcome measures—has become common in clinical practice [43, 52, 54]. This approach contrasts with recurring calls in the literature for a single diagnostic gold standard [15, 81]—a philosophical paradox given DB’s multifactorial nature. Such tensions may underscore the clinical uncertainty that often accompanies the assessment and diagnosis of DB [58], emphasising the need for a multidimensional evaluation strategy.

Research into OMs for dysfunctional breathing remains constrained by limited methodological guidance, poor standardisation, and an incomplete conceptual understanding of the condition, hindering meaningful validation and comparison across studies and tools. Although a multidimensional conceptual framework has been proposed [4, 5, 34], it remains largely theoretical, with no empirical validation of the relative contribution or weighting of its constituent domains. Recent efforts to advance the field—such as more explicit classification of the biomechanical dimension of DB [8, 9]—represent important progress; however, these developments have yet to be translated into standardised diagnostic criteria or validated measurement strategies. Consequently, the widespread reliance on multiple OMs appears less reflective of diagnostic precision and more indicative of ongoing uncertainty, with individual tools frequently acknowledged as insufficient when used in isolation [54] .

Addressing these limitations requires a fundamental shift in the conceptualisation and application of OMs for DB. Greater emphasis should be placed on clearly defining what each OM objectively measures, evaluating its alignment with contemporary models of DB, and determining its suitability for assessing specific dimensions of the condition. Rather than continuing to develop isolated tools, the establishment of a standardised suite of OMs—each validated for a distinct DB domain—may offer greater clinical and research utility [4, 34, 85] . Further conceptual development of the psychophysiological and biochemical dimensions of DB is also required to support the creation of an integrated, standardised framework for both classification and assessment.

In summary, the assessment of dysfunctional breathing remains hampered by heterogeneity, limited validation, and the absence of a consensus framework. No single outcome measure captures all dimensions of the condition, and the reliance on multiple tools reflects uncertainty rather than diagnostic precision. Moving forward, the development of a standardised suite of validated measures, aligned with clearly defined DB domains, alongside further conceptual refinement of its psychophysiological and biochemical aspects, is essential to enhance both clinical assessment and research comparability.

4.1 Strengths

This scoping review provides a comprehensive and methodologically rigorous synthesis of how DB is characterised and assessed within the clinical literature. Conducted in

accordance with the Joanna Briggs Institute framework and reported in line with PRISMA-ScR guidelines, it represents the first systematic effort to map the full breadth of outcome measures used in DB research across 69 studies. The inclusion of quantitative, qualitative, and mixed methods designs enabled a nuanced examination of how OMs are applied across diverse research and clinical contexts. Broad inclusion criteria facilitated a multidisciplinary perspective, which is essential given the complexity and heterogeneity of DB. Furthermore, thematic synthesis extends beyond psychometric evaluation to deliver a structured and clinically meaningful synthesis of the conceptual, methodological, and practical foundations of dysfunctional breathing assessment, strengthening the evidence base for clinical decision-making and delineating priorities for future research.

4.2 Limitations

Two limitations should be acknowledged. Restricting inclusion to English-language publications introduces the potential for language bias and may have resulted in the omission of relevant international literature. In addition, consistent with scoping review methodology, no formal critical appraisal of included studies was undertaken; consequently, the methodological quality of the evidence was not assessed. These factors necessitate cautious interpretation of the findings, particularly with respect to their clinical applicability.

4.3 Recommendations

Future research should prioritise achieving consensus on the definition of DB as a prerequisite for the robust development and validation of outcome measures. In particular, the psychophysiological and biochemical dimensions of DB remain comparatively underdeveloped, limiting the establishment of clear assessment criteria and constraining measurement validity. Progress in this field may be facilitated by the development of a structured assessment framework, either through a comprehensive tool encompassing all 3 recognised dimensions of DB or through the validation of 3 distinct outcome measures aligned to each domain. Concurrently, research should prioritise the critical appraisal and validation of existing outcome measures against clearly defined DB dimensions. Such an approach may enable the development of a standardised suite of outcome measures, improving methodological consistency, interpretability of findings, and clinical applicability across respiratory and allied health settings.

Conclusion

This scoping review highlights the considerable heterogeneity and limited standardisation of outcome measures used to assess dysfunctional breathing, reflecting

the condition's multifactorial nature and the absence of a consensus definition. No single tool currently captures all dimensions of DB, and the widespread use of multiple OMs compensates for uncertainty rather than providing diagnostic precision. Conceptual frameworks remain theoretical, and few measures have been formally validated, particularly in populations with comorbidities. Moving forward, establishing a standardised suite of OM, each validated for specific DB domains, alongside further development of psychophysiological and biochemical conceptual models, is critical to improve assessment accuracy, clinical utility, and research comparability.

AI acknowledgment

During the preparation of this work, the author(s) utilized ChatGPT to support the writing process. Following the use of this tool, the author(s) thoroughly reviewed and edited the generated content to ensure accuracy, clarity, and alignment with the intended message. The author(s) take full responsibility for the final content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to acknowledge James Vowles, Chan Ka Miu, Kin Lok LAU for their contribution to the protocol development, data collection, extraction and analysis in this work. The authors also sincerely thank Joe Palmer for his valuable guidance and supervision during the academic stage of this project.

References

1. Courtney R. Breathing training for dysfunctional breathing in asthma: taking a multidimensional approach. ERJ Open Res. 3(2) (2017): 00065-2017. DOI: 10.1183/23120541.00065-2017.
2. de Groot EP, Duiverman EJ, Brand PLP. Dysfunctional breathing in children with asthma: a rare but relevant comorbidity. Eur Respir J. 41(5) (2013): 1068–1073. DOI: 10.1183/09031936.00130212.
3. Kopitović I, Mirić M. Dysfunctional Breathing – View of Pulmonologist. In: Škrgat S, editor. Severe Asthma Forum: Monitoring and Treatable Traits in Severe Asthma. Koper: University of Primorska Press; 23–41 (2023). Available from: https://www.hippocampus.si/ISBN/978-961-293-297-8/978-961-293-297-8.63-75.pdf
4. Vidotto LS, de Carvalho CRF, Harvey A, Jones M, et al. Dysfunctional breathing: what do we know?. J Bras Pneumol. 45(1) (2019): e20170347. DOI: 10.1590/1806-3713/e20170347.
5. Kiesel K, Burklow M, Garner MB, Hayden J, Hermann AJ, Kingshott E, McCullough G, Ricard R, Stubblefield G, Volz J, Waskiewicz D, Englert A, et al. Exercise intervention for individuals with dysfunctional breathing: a matched controlled trial. Int J Sports Phys Ther. 15(1) (2020): 114–125. DOI: 10.26603/ijspt20200114.
6. SanchezBracero D, Barker K, Archer T, Shaw T, Palmer J. How is dysfunctional breathing characterised in the clinical literature? A scoping review. Respir Med. 251(1) (2025): 108546. DOI: 10.1016/j.rmed.2025.108546.-Bracero
7. Barker N, Everard ML. Getting to grips with 'dysfunctional breathing'. Paediatr Respir Rev. 16(1) (2015): 53–61. DOI: 10.1016/j.prrv.2014.10.001.
8. Pinder T, Jones A, Jacob I, Milligan J. A critical review of dysfunctional breathing. J Bodyw Mov Ther. 44(1) (2025): 770–774. DOI: 10.1016/j.jbmt.2025.07.009.
9. Guerreiro I, Bringard A, Weber P, Leverington V, Kharat A, Genecand L, Taboni A, Lador F. Description of three dysfunctional breathing patterns in postCOVID dyspnea. Respir Physiol Neurobiol. 341(1) (2026): 104543. DOI: 10.1016/j.resp.2026.104543.-COVID
10. Crawford AL, Blakey JD, Baumwol K. Paroxysmal dyspnoea in asthma: Wheeze, ILO or dysfunctional breathing?. Front Allergy. 3(1) (2022): 1054791. DOI: 10.3389/falgy.2022.1054791.
11. Depiazzi J, Everard ML. Dysfunctional breathing and reaching one's physiological limit as causes of exerciseinduced dyspnoea. Breathe (Sheff). 12(2) (2016): 120–129. DOI: 10.1183/20734735.007216.-induced dyspnoea. Breathe (Sheff). 12(2) (2016): 120
12. Henry H, Wells C. Identification and management of dysfunctional breathing in primary care. Pract Nurs. 32(12) (2021): 474–480. DOI: 10.12968/pnur.2021.32.12.474.

13. Sedeh FB, Von Bülow A, Backer V, Bodtger U, Petersen US, Vest S, Hull JH, Porsbjerg C. The impact of dysfunctional breathing on the level of asthma control in difficult asthma. Respir Med. 163(1) (2020): 105894. DOI: 10.1016/j.rmed.2020.105894.
14. Vlemincx E. Dysfunctional breathing: a dimensional, transdiagnostic perspective. Eur Respir J. 61(6) (2023): 2300629. DOI: 10.1183/13993003.00629-2023.
15. Karkouli G, Douros K, Moriki D, Moutsatsou P, Giannopoulou I, Maratou E, Koumpagioti D. Dysfunctional Breathing in Children: A Literature Review. Children (Basel). 11(5) (2024): 556. DOI: 10.3390/children11050556.
16. Genecand L, Altarelli M, Binkova A, Loew S, Vaudan S, Gex G, Bridevaux PO, Frésard I. Dysfunctional breathing symptoms, functional impact and quality of life in patients with long COVID19: a prospective case series. BMJ Open Respir Res. 10(1) (2023): e001770. DOI: 10.1136/bmjresp-2023-001770.-O, -19: a prospective case series. BMJ
17. Ruane LE, Denton E, Bardin PG, Leong P. Dysfunctional breathing or breathing pattern disorder: new perspectives on a common but clandestine cause of breathlessness. Respirology. 29(10) (2024): 863–866. DOI: 10.1111/resp.14807.
18. Mohan V, Rathinam C, Yates D, Paungmali A, Boos C. Validity and reliability of outcome measures to assess dysfunctional breathing: a systematic review. BMJ Open Respir Res. 11(1) (2024): e001884. DOI: 10.1136/bmjresp2023001884.-2023-001884.
19. Grillo L, Russell AM, Shannon H, Lewis A. Physiotherapy assessment of breathing pattern disorder: a qualitative evaluation. BMJ Open Respir Res. 10(1) (2023): e001395. DOI: 10.1136/bmjresp2022001395.-2022-001395.
20. Thomas M, McKinley RK, Freeman E, Foy C, Price D. The prevalence of dysfunctional breathing in adults in the community with and without asthma. Prim Care Respir J. 14(2) (2005): 78–82. DOI: 10.1016/j.pcrj.2004.10.007.
21. Barker NJ, Jones M, O'Connell NE, Everard ML. Breathing exercises for dysfunctional breathing/hyperventilation syndrome in children. Cochrane Database Syst Rev. 12(12) (2013): CD010376. DOI: 10.1002/14651858.CD010376.pub2.
22. Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, McInerney P, Godfrey CM, Khalil H. Updated methodological guidance for the conduct of scoping reviews. JBI Evid Synth. 18(10) (2020): 2119–2126. DOI: 10.11124/JBIES2000167.-20-00167.
23. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 8(1) (2005): 19–32. DOI: 10.1080/1364557032000119616.
24. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, et al. A scoping review on the conduct

and reporting of scoping reviews. BMC Med Res Methodol. 16(1) (2016): 15. DOI: 10.1186/s12874-016-0116-4

25. Bramer WM, De Jonge GB, Rethlefsen ML, Mast F, Kleijnen J. A systematic approach to searching: an efficient and complete method to develop literature searches. J Med Libr Assoc. 106(4) (2018): 531–541. DOI: 10.5195/jmla.2018.283.
26. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. Int J Evid Based Healthc. 13(3) (2015): 141–146. DOI: 10.1097/xeb.0000000000000050.
27. Veritas Health Innovation. *Covidence systematic review software* [software]. Melbourne: Veritas Health Innovation; accessed 22 June 2025. Available from: https://www.covidence.org
28. Todd S, Walsted ES, Grillo L, Mortimer K, Hamilton WK, Houghton K, Gibson P. Novel assessment tool to detect breathing pattern disorder in patients with refractory asthma. Respirology. 23(9) (2018): 844–850. DOI: 10.1111/resp.13173.
29. Petch KA. The development of a palpation-based clinical assessment of breathing motion: a nominal group technique approach [Master's thesis]. Auckland (NZ): Unitec Institute of Technology; 2018. Available from: https://hdl.handle.net/10652/4501
30. Courtney R. *Dysfunctional breathing: its parameters, measurement and relevance* [doctoral thesis]. Melbourne (AU): RMIT University, School of Health and Biomedical Sciences; 2011. Available from: https://research-repository.rmit.edu.au/articles/thesis/Dysfunctional_breathing_its_parameters_measurement_and_relevance/27587139?file=50758773
31. Courtney R, Greenwood KM, Cohen M. Relationships between measures of dysfunctional breathing in a population with concerns about their breathing. J Bodyw Mov Ther. 15(1) (2011): 24–34. DOI: 10.1016/j.jbmt.2010.06.004.
32. Agache I, Ciobanu C, Paul G, Ciobanu R, Oancea C, Constantin C, Agache C. Dysfunctional breathing phenotype in adults with asthma: incidence and risk factors. Clin Transl Allergy. 2(1) (2012): 18. DOI: 10.1186/2045-7022-2-18.
33. van Dixhoorn J, Folgering H. Use of the Nijmegen Questionnaire in asthma. ERJ Open Res. 1(1) (2015): 000372015. DOI: 10.1183/23120541.00037-2015.-2015. DOI: 10.1183/23120541.00037-2015.
34. Kiesel K, Rhodes T, Mueller J, et al. DEVELOPMENT OF A SCREENING PROTOCOL TO IDENTIFY INDIVIDUALS WITH DYSFUNCTIONAL BREATHING. Int J Sports Phys Ther. 12(5) (2017): 774–786. DOI: 10.26603/ijspt20170774..
35. van Dixhoorn J, Folgering H. The Nijmegen Questionnaire and dysfunctional breathing. ERJ Open Res. 1(1) (2015): 000012015. DOI: 10.1183/23120541.00001-2015-2015. DOI: 10.1183/23120541.00001-2015

36. Thomas M, McKinley RK, Freeman E, Foy C, Price D. Prevalence of dysfunctional breathing in patients treated for asthma in primary care: cross sectional survey. BMJ. 322(7294) (2001): 1098–1100. DOI: 10.1136/bmj.322.7294.1098.
37. Courtney R, Greenwood KM, Cohen M. Relationships between measures of dysfunctional breathing in a population with concerns about their breathing. J Bodyw Mov Ther. 15(1) (2011): 24-34. DOI: 10.1016/j.jbmt.2010.06.004.
38. Stanton AE, Vaughn P, Carter R, Everard ML. An observational investigation of dysfunctional breathing and breathing control therapy in a problem asthma clinic. J Asthma. 45(8) (2008): 689–694. DOI: 10.1080/02770900802252093.
39. Morgan MDL. Dysfunctional breathing in asthma: is it common, identifiable and correctable?. Thorax. 57(Suppl 2) (2002): II31–II35. DOI: 10.1136/thorax.57.suppl_2.ii31
40. Johansen T, Jack S, Dahl R. Normalizing CO2 in chronic hyperventilation by means of a novel breathing mask: a pilot study. Clin Respir J. 7(4) (2013): 301–307. DOI: 10.1111/crj.12016.
41. Denton E, Bondarenko J, Tay T, Patel M, Bardin P, Ruane LE. Factors associated with dysfunctional breathing in patients with difficult to treat asthma. J Allergy Clin Immunol Pract. 7(5) (2019): 1471-1476. DOI: 10.1016/j.jaip.2018.11.037.
42. Ok J, Park Y. Disruption of pathological patterns in a young population with dysfunctional breathing. Evid Based Complement Alternat Med. 2020 (2020): 9614574. DOI: 10.1155/2020/9614574.
43. Connett GJ, Thomas M. Dysfunctional Breathing in Children and Adults With Asthma. Front Pediatr. 6 (2018): 406. DOI: 10.3389/fped.2018.00406.
44. Mohan V, Branney J, Clark C, Yates D, Rathinam C. Reliability and preliminary reference values for the Total Faulty Breathing Scale (TFBS): a cross-sectional study. Health Sci Rep. (2022): e661. DOI: 10.1002/hsr2.661.
45. Courtney R, van Dixhoorn J, Greenwood KM, et al. Medically unexplained dyspnea: partly moderated by dysfunctional (thoracic dominant) breathing pattern. J. Asthma 48(3) (2011): 259–265. DOI: 10.3109/02770903.2011.554942.
46. Horris H, Anderson BE, Bay RC, Halaki M, Parfitt G, Loveridge N, Doyle J, Vicenzino B. Clinical breathing mechanics differ based on test and position. J Sport Rehabil. 28(4) (2019): 396–403. DOI: 10.1123/jsr.2018-0027
47. Bokov P, Peiffer C, Gallego J, Chauvet X, Petiet A, Olivier M, Savajols E, Lacombe F, Clément A, Cuvelier A, Berger P. A decrease in plant gain, namely CO2 stores, characterizes dysfunctional breathing whatever its subtype in children. Front Physiol. 14 (2023): 1217391. DOI: 10.3389/fphys.2023.1217391.
48. Bokov P, Fiamma M, Chevalier-Bidaud B, Peiffer C, Gallego J, Chauvet X, Cuvelier A, Clément A, Berger P. Increased ventilatory variability and complexity in patients with hyperventilation disorder. J Appl Physiol (1985). 120(1) (2016): 55–63. DOI: 10.1152/japplphysiol.00859.2015.

49. Hagman C, Janson C, Emtner M. A comparison between patients with dysfunctional breathing and patients with asthma. Clin Respir J. 2(2) (2008): 86-91. DOI: 10.1111/j.1752-699X.2007.00036.x.
50. Henderson Y. Recognising dysfunctional breathing in asthma consultations. Nurs Stand. 22(3) (2007): 40–41. DOI: 10.7748/ns2007.09.22.3.40.c4635.
51. Pauwen NY, Faoro V, Boucharessas F, Pinciroli R, Lammers JWJ, Tamis JW. Validation criteria for PETCO2 kinetics during the hyperventilation provocation test in the diagnosis of idiopathic hyperventilation syndrome. J Clin Med. 11(21) (2022): 6482. DOI: 10.3390/jcm11216482
52. Ionescu MF, Mani-Babu S, Degani-Costa LH, et al. Cardiopulmonary Exercise Testing in the Assessment of Dysfunctional Breathing. Front Physiol. 11(620955) (2020):1-12. DOI: 10.3389/fphys.2020.620955.
53. Mancini DM, Brunjes DL, Lala A, Trivieri MG, Contreras JP, Natelson BH, Aaron SD, Bensimhon D, Collier D, Gluckman TJ. Use of cardiopulmonary stress testing for patients with unexplained dyspnea post-coronavirus disease. JACC Heart Fail. 9(12) (2021): 927–937. DOI: 10.1016/j.jchf.2021.10.002.
54. Watson M, Ionescu MF, Sylvester K, et al. Minute ventilation/carbon dioxide production in patients with dysfunctional breathing. Eur Respir Rev. 30(160) (2021): e200182. DOI: 10.1183/16000617.0182-2020.
55. Steinmann J, Lewis A, Ellmers TJ, et al. Validating the Breathing Vigilance Questionnaire for use in dysfunctional breathing. Eur Respir J. 61(6) (2023): e2300031. DOI: 10.1183/13993003.00031-2023.
56. Milstein CF, Patel RR, Laurash E, Bhattacharyya N, Sandberg KR, Hull JP. Identification of breathing pattern disorder in athletes with exercise-induced laryngeal obstruction: a novel assessment tool. J Voice. 39(4) (2025): 1139.e11-1139.e17. DOI: 10.1016/j.jvoice.2023.01.006.
57. Grillo L, Russell A, Shannon H, et al. Physiotherapy assessment of breathing pattern disorder: a qualitative evaluation. BMJ Open Resp Res 10(1) (2023): 1-9. DOI: 10.1136/bmjresp-2022-001395
58. Grillo LJ, Easton I, Schreuder FM, Jensen D, Molassiotis A, Weston R, Volpe S, Todd S. Physiotherapy assessment of breathlessness and disordered patterns of breathing: defining a consensus on terminology and assessment. Chron Respir Dis. 22 (2025): 14799731251315483. DOI: 10.1177/14799731251315483.
59. Pakdee S, Piya-Amornphan N. The Thai version of the Nijmegen questionnaire. Heliyon. (2022): e12296. DOI: 10.1016/j.heliyon.2022.e12296.
60. Greiwe J, Gruenke J, Zeiger JS. The impact of mental toughness and postural abnormalities on dysfunctional breathing in athletes. J Asthma. 59(10) (2022): 730-738. DOI: 10.1080/02770903.2021.1871739.

61. Crawford AL, Blakey JD, Baumwol K. Paroxysmal dyspnoea in asthma: Wheeze, ILO or dysfunctional breathing? Front Allergy 17(3) (2022): e 1054791 DOI: 10.3389/falgy.2022.1054791.
62. Altmann CH, Zvonova E, Richter L, Bozkurt S, Römer K, Römer J, Bringard A, Weber P. Pulmonary recovery directly after COVID-19 and in Long-COVID. Respir Physiol Neurobiol. 315 (2023): 104112. DOI: 10.1016/j.resp.2023.104112.
63. Ingul CB, Edvardsen A, Follestad T, Pettersen TE, Ueland T, Holte KB, Høydal MA, Wisloff U. Changes in cardiopulmonary exercise capacity and limitations 3–12 months after COVID-19. Eur Respir J. 61(2) (2023): 2200745. DOI: 10.1183/13993003.00745-2022.
64. Milne KM, Cowan J, Schaeffer MR, Faghy MA, Stenton C, Oldham JA, Gibb A, Guo Y, Hardwick BE, Hurst JR. Exercise responses and mental health symptoms in COVID-19 survivors with dyspnoea. ERJ Open Res. 19;9(3) (2023): 006062022. DOI: 10.1183/23120541.00606-2022.-2022. DOI: 10.1183/23120541.00606-2022.
65. Crawford AL, Setty N, Kyle B, Everard ML. Untangling asthma, inducible laryngeal obstruction, and dysfunctional breathing in a competitive sportsperson. Respirol Case Rep. 12(4) (2024): e1282. DOI: 10.1002/rcr2.1282
66. Bode SFN, Schwender A, Toth M, Schubert C, Kohlhäufl M, Schuster F, Kaestner F, Krammer K, Seume F, Fuchs O, Haller B, Moser K, Seidel C, et al. Characterization of adolescents with functional respiratory disorders and prior history of SARS-CoV-2. Mol Cell Pediatr. 10(1) (2023): 14. DOI: 10.1186/s40348-023-00165-3.
67. da Silveira AD, Scolari FL, Saadi MP, Ribeiro S, Siqueira MM, Chaves DG, Lopes R, Alkmim A, Furlan RL. Long-term reduced functional capacity and quality of life in hospitalized COVID-19 patients. Front Med (Lausanne). 10 (2023): 1289454. DOI: 10.3389/fmed.2023.1289454.
68. Kersten J, Hoyo L, Wolf A, Lindner T, Alpers J, Horstkotte D, Scharhag J. Cardiopulmonary exercise testing distinguishes between post-COVID-19 as a dysfunctional syndrome and organ pathologies. Int J Environ Res Public Health. 19(18) (2022): 11421. DOI: 10.3390/ijerph191811421
69. Frésard I, Genecand L, Altarelli M, et al. Dysfunctional breathing diagnosed by cardiopulmonary exercise testing in 'long COVID' patients with persistent dyspnoea. BMJ Open Respir Res. 9(1) (2022): e001126. DOI: 10.1136/bmjresp-2021-001126.
70. Djokovic D, Nikolic M, Muric N, Aleksic I, Milosevic I, Milenkovic B, Lalic D. Cardiopulmonary exercise test in the detection of unexplained post-COVID-19 dyspnea. Int Heart J. 62(5) (2021): 951–957. DOI: 10.1536/ihj.21-069.
71. Reilly CC, Floyd SV, Raniwalla S, et al. The clinical utility of the Breathing Pattern Assessment Tool (BPAT) to identify dysfunctional breathing (DB) in individuals

living with postural orthostatic tachycardia syndrome (POTS). Auton Neurosci. 248 (2023): e103104. DOI: 10.1016/j.autneu.2023.103104.

72. Kotera S, Maruoka S, Kurosawa Y, et al. Validity study of the Japanese version of the Nijmegen Questionnaire for verifying dysfunctional breathing in Japanese asthma patients. J Allergy Clin Immunol Glob. 3(3) (2024): e100247. DOI: 10.1016/j.jacig.2024.100247.
73. Peiffer C, Pautrat J, Benzouid C, et al. Diagnostic tests and subtypes of dysfunctional breathing in children with unexplained exertional dyspnoea. Pediatr Pulmonol. 57(10) (2022): 2428-2436. DOI: 10.1002/ppul.26052.
74. **Hudler A, Holguin F, Althoff M, Rieg AD, Watz H, Laveneziana P. Pathophysiology and clinical evaluation of the patient with unexplained persistent dyspnea. Expert Rev Respir Med. 16(1) (2022): 511-518. DOI: 10.1080/17476348.2022.2030222.**
75. Andreasson KH, Sandell Jacobsen J, Leth Egsgaard A, Bjerre J, Østergaard B, Kjærgaard J, Rasmussen L. Translation and cross-cultural adaptation of the self evaluation of breathing questionnaire (SEBQ) into Danish. Eur Clin Respir J. 11 (2024): 2413318. DOI: 10.1080/20018525.2024.2413318.
76. Ritter O, Noureddine S, Laurent L, Vergès S, Huguet M, Bringard A, Weber P. Unraveling persistent dyspnea after mild COVID: insights from a case series on hyperventilation provocation tests. Front Physiol. 15 (2024): 1394642. DOI: 10.3389/fphys.2024.1394642.
77. Mendes NBS, Plachi F, Guimarães A, de Oliveira K, de Souza D, Borges R, Santos E. Cardiopulmonary exercise testing to indicate increased ventilatory variability in subjects with dysfunctional breathing. Clin Physiol Funct Imaging. 43(6) (2023): 645–655. DOI: 10.1111/cpf.12820.
78. Vranich B, Lee R, Zapanta J, Johnson A, Smith K, Thompson L. The Breathing IQ: an anthropometric index of diaphragmatic breathing efficiency. Front Physiol. 15 (2024): 1394109. DOI: 10.3389/fphys.2024.1394109
79. Burman J, Lukkarinen H, Elenius V, Hedman L, Koivikko A, Malmberg LP. Eucapnic voluntary hyperventilation test in children. Clin Physiol Funct Imaging. 38(4) (2018): 600–607. DOI: 10.1111/cpf.12458.
80. Knöpfel G, Baty F, Uhl F, et al. Quantification of breathing irregularity for the diagnosis of dysfunctional breathing using proportional tidal volume variation: a cross-sectional, retrospective real-world study. BMJ Open. 14(6) (2024): e083401. DOI: 10.1136/bmjopen-2023-083401.
81. Mohan V, Rathinam C, Yates D, et al. Validity and reliability of outcome measures to assess dysfunctional breathing: a systematic review. BMJ Open Resp Res 11(1) (2024): e001884. DOI: 10.1136/bmjresp-2023-001884..
82. Paul S. Effect of breathing retraining in improving dysfunctional breathing in patients with asthma [Master's thesis]. Bengaluru (IN): Rajiv Gandhi University of Health Sciences; 2012. Available at:

https://www.proquest.com/docview/2786883199?%20Theses&fromopenview=true&pq-origsite=gscholar&sourcetype=Dissertations%20

83. Genecand L, Jaksic C, Desponds R, Girardin E, Follador D, Rochat S, Schlegel C, Laffargue C. Comparing methods to measure the dispersion of breathing parameters during exercise testing: a simulation study based on real-life parameters from patients with dysfunctional breathing. Physiol Rep. 13(2) (2025): e70233. DOI: 10.14814/phy2.70233.
84. Pelgröm AT, de Jongh FHC, van den Aardweg JG, van den Berg JP, Janssen NC, Smeets EJM. Analysis of the breathing pattern in patients with asthma during physical exercise: a cross-sectional study. Respir Med. 229 (2025): 108037. DOI: 10.1016/j.rmed.2025.108037

85. Courtney R, Biland G, Ryan A, Jones M, Greenwood KM. Improvements in multi-dimensional measures of dysfunctional breathing in asthma patients after a combined manual therapy and breathing retraining protocol: a case series report. Int J Osteopath Med. 31 (2019): 36-43. DOI: 10.1016/j.ijosm.2019.01.003.
86. Jones M, Troup F, Nugus J, Courtney R, Greenwood KM. Does manual therapy provide additional benefit to breathing retraining in the management of dysfunctional breathing? A randomised controlled trial. Disabil Rehabil. 37(9) (2015): 763-770. DOI: 10.3109/09638288.2014.941020.
87. Fagevik Olsén M, Lannefors L, Nygren-Bonnier M, Bergman S, Ljungberg C. Long COVID – respiratory symptoms in non-hospitalised subjects – a cross-sectional study. Eur J Physiother. 25(1) (2023): 283-290. DOI: 10.1080/21679169.2022.2101692.
88. Hylton H, Long A, Francis C, Cheung D, Weller S. Real-world use of the Breathing Pattern Assessment Tool in assessment of breathlessness post-COVID-19. Clin Med (Lond). 22(4) (2022): 376-379. DOI: 10.7861/clinmed.2021-0759.
89. Boulding R, Stacey R, Niven R, et al. Dysfunctional breathing: a review of the literature and proposal for classification. Eur Respir Rev. 25(141) (2016): 287–294. DOI: 10.1183/16000617.0088-2015..
90. Courtney R, Greenwood KM. Preliminary investigation of a measure of dysfunctional breathing symptoms: The Self Evaluation of Breathing Questionnaire (SEBQ). Int J Osteopath Med. 12(4) (2009): 121-127. DOI: 10.1016/j.ijosm.2009.02.001.
91. Myers L, Bellander M, Ljungberg H, et al. Assessing diagnostic accuracy for asthma with home spirometry in primary care. *npj Prim Care Respir Med*. **36** (3) (2025). DOI: 10.1038/s41533-025-00471-5.
92. Maltinsky W, Henton S, Spaltro G, et al. Illness perceptions, symptom severity and psychosocial outcomes in adults with dysfunctional breathing. J Asthma. (2025). DOI: 10.1080/02770903.2024.2397656.