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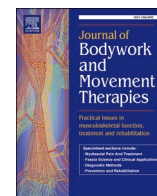
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# A critical review of dysfunctional breathing

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## ABSTRACT

Dysfunctional breathing (DB) refers to various abnormalities breathing patterns. Whilst a formal definition exists, subsequent research has inconsistently applied or omitted it. As interest in breathing techniques grows among both healthcare professionals and the public, it is important to reach a consensus on DB's definition to ensure effective assessment and treatment. This critical review explores how DB is currently defined and applied within respiratory and musculoskeletal health. A lack of consistency in the literature identified the need for a more comprehensive framework of DB. To address this, a new model of DB is proposed that includes three sub-categories: biomechanical, biochemical and psychophysiological DB. This revised model offers a foundation for future research and clinical application.

## 1. Introduction

Normal breathing mechanics have been well established for decades with very little research in recent times debating the fundamentals of normal breathing. It is generally accepted that the diaphragm contracts and pulls downward during inhalation whilst the muscles in the thorax contract and pull upward (Drake et al., 2024). There remains a lack of clarity amongst researchers, and evidence-based practitioners, around the topic of abnormal breathing mechanics (Vidotto et al., 2019). The term 'dysfunctional breathing' (DB) has been inconsistently used within research (Courtney, 2009; Barker and Everard, 2015; Boulding et al., 2016; Kiesel et al., 2017; Vidotto et al., 2019) to describe the chronic or recurrent biomechanical adaptations experienced where breathing becomes abnormal. Initially, it was claimed that DB can affect more than 1 in 10 people and is more common in women than it is in men (Thomas et al., 2005). More recently, Kiesel et al. (2017) claimed that some level of DB is prevalent in as much as 50–80 % of the adult population (see Table 1). The difference in estimations is likely due to a difference in understanding of what DB is, therefore, highlighting the need for further clarity in this topic area. Without a consistent definition or reliable assessment tools, such estimates are unreliable. This review evaluates existing definitions and models to consolidate understanding and guide future research by proposing an updated and inclusive model of DB.

## 2. Defining dysfunctional breathing

### 2.1. Barker and everard's (2015) proposed formal definition and model of db

Ambiguity around the term 'dysfunctional breathing' existed (Chaitow et al., 2014). However, since Vidotto et al.'s (2019) narrative review DB is now considered an umbrella term for conditions which lead to abnormal breathing mechanics. Earlier definitions focused mainly on excluding broader physiological and psychological components (Courtney et al., 2011; Chaitow et al., 2014). Barker and Everard (2015) defined DB as: 'An alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may be respiratory and/or non-respiratory' (Barker and Everard, 2015, pp. 54).

More recently, several research studies investigating DB have been completed and have not acknowledged this formal definition: instead, either not defining DB at all, defining it loosely, (Kiesel et al., 2017; Henry and Wells, 2021), or describing it as an umbrella term for abnormal breathing mechanics (Boulding et al., 2016; Courtney, 2017; Vidotto et al., 2019). It is plausible to suggest that Barker and Everard's (2015) definition of DB may not be widely adopted because it does not consider all three primary functions of breathing, namely.

- the gaseous exchange of air in the lungs (biochemical)
- the movement of the rib cage and trunk to act as the air pump whilst also playing an important role in posture and movement (biomechanical)

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**Table 1**  
Proposed definitions of dysfunctional breathing and their descriptions.

Author	Proposed Definition of DB	Description of definition	No. of times cited (at the point of publication)
Thomas et al. (2001)	'Abnormal breathing patterns have been shown to cause breathlessness, chest tightness, chest pain, light-headedness, paraesthesia, and anxiety ... referred to as the hyperventilation syndrome, behavioural breathlessness and dysfunctional breathing'	Linked DB with HVS and behavioural breathlessness, suggesting the three conditions are one in the same. Suggested the term DB be used going forward to describe HVS.	346
Courtney (2009)	'Breathing which is unable to perform its various functions efficiently and is inappropriate for the needs of the individual at that time.'	Breathing has several functions; moving air into and out of the lungs, maintenance of correct O <sub>2</sub> and CO <sub>2</sub> levels, regulation of the body's PH, affects motor control and postural stability, influences homeostatic functions, self regulates emotion and stress.	268
Barker and Everard (2015)	'An alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may be respiratory and/or non- respiratory.'	Barker and Everard (2015) suggested a formal definition for DB and offered a model of DB consisting of two subtypes (extra-thoracic and thoracic) as well as two subcategories within each subtype (functional DB and structural DB).	139
Boulding et al. (2016)	'A group of breathing disorders in patients where chronic changes in breathing pattern result in dyspnoea and often non respiratory symptoms in the absence of, or in excess of, organic respiratory disease.'	Boulding et al. (2016) suggested that DB can be classified in to 5 categories: hyperventilation syndrome, periodic deep sighing, thoracic dominant breathing, forced abdominal expiration, thoraco-abdominal asynchrony.	333
Kiesel et al. (2017)	'Individuals who display divergent breathing patterns and have breathing problems that cannot be attributed to a specific medical diagnosis, such as asthma.'	Loosely based off principles suggested by to Courtney (2009) and Courtney (2010) however goes further to classify three subcategories of dysfunctional breathing: biomechanical, biochemical and psychophysiological.	49
Vidotto et al. (2019)	'a respiratory condition characterized by irregular breathing patterns that occur either in the absence of concurrent diseases or secondary to cardiopulmonary diseases'	The most recent attempt at offering a definition of DB, after conducting a narrative review to summarise DB and it's assessment within healthcare.	89

- the 'subjective experience of breathing' (psychophysiological) (van Dixhoorn and Folgering, 2015).

Therefore, a more inclusive definition should be developed.

To support their definition of DB, Barker and Everard (2015) also produced a model of DB (see Figure 1). Their model categorises DB into thoracic dysfunctional breathing (T-DB) and extra-thoracic dysfunctional breathing (ET-DB), further subdivided into functional and structural forms. T-DB refers to abnormal breathing patterns (breathing pattern disorder) which may or may not be associated with hyperventilation. ET-DB refers to pattern disordered breathing with upper airway involvement. Functional DB is when the organic structure is not impaired, but irregularity occurs in the use of that structure. For example, in pattern disordered breathing the diaphragm has no structural abnormalities but an individual may use the diaphragm in an atypical manner (Todd et al., 2018; Ogilvie et al., 2019). Structural DB refers to abnormalities in the anatomical and/or neurological systems which affect normal breathing mechanics.

Although Barker and Everard's (2015) model of DB provides a breakdown of different types of DB the model itself does not consider the potential biochemical or psychophysiological adaptations of DB. This limits the model to excluding key influences on breathing, such as variable conditions like asthma, which may influence breathing mechanics and cause symptoms of DB.

Furthermore, using the term 'functional' to describe a subcategory of breathing that is dysfunctional could be confusing for readers. The two contradictory terms could provide more confusion than clarity when implementing this model of DB.

In 2016 Boulding et al. published a review of the literature appraising DB and proposed there be five classifications.

- Hyperventilation syndrome
- Periodic deep sighing
- Thoracic dominant breathing
- Forced abdominal expiration
- Thoraco-abdominal asynchrony

The authors proposed that the classifications of DB could be present in isolation or could coexist with one another. This was one of the first reviews to attempt to summarise previous research into DB to clarify the topic area and direct future research. However, as there was no recognition of Barker and Everard's (2015) definition or model of DB, it is unclear how their proposed definition and model would coexist with Boulding et al.'s (2016) classifications.

A total of 64 % of the research cited by Boulding et al. (2016) exclusively explored hyperventilation syndrome (HVS). Hornsveid and Garssen (1997) proposed that the term HVS be abandoned in future literature after finding the term was being misused to represent an unexplained symptom that could be linked to a patient's breathing. HVS is defined as 'a respiratory disorder, psychologically or physiologically based, involving breathing too deeply and/or too rapidly,' (Jones et al., 2013, pp. 4). An example of psychologically initiated HVS is when an individual is experiencing stress and/or anxiety, whilst HVS can also be caused physiologically by heart or lung problems (Jones et al., 2013). HVS appears in the early literature (Folgering, 1999; Thomas et al., 2001, 2005; Gardner, 2003) to be considered one in the same as DB (Barker and Everard, 2015; Vidotto et al., 2019). Barker and Everard (2015) agreed listing 'dysfunctional breathing, hyperventilation syndrome, disproportionate breathlessness, behavioural breathlessness, sighing dyspnoea, psychogenic functional breathing disorders, and somatoform respiratory disorders,' as terms previously used interchangeably to describe the same breathing problem. Since clarity has been achieved in defining HVS (Jones et al., 2013), its inclusion as a subcategory or classification of a type of DB is appropriate.

Boulding et al.'s (2016) second classification was termed 'periodic deep sighing'. It was said to often overlap with HVS. It is defined as

‘frequent sighing and irregular breathing patterns’ (Boulding et al., 2016). However, it is not clear how periodic deep sighing differs from normal sighing as to whether the two are exclusive to one another or the same condition. Han et al. (1997) observed that sighing became more frequent (up to fifteen times in a 15-min period) in those suffering with HVS and anxiety disorders. This researcher has not identified any published evidence as to how prevalent periodic deep sighing is.

Thirdly, Boulding et al. (2016, p292) defined thoracic dominant breathing (also referred to by Boulding et al. (2016) as apical breathing) as a ‘predominant use of the upper thorax with a lack of lateral costal expansion.’ Increased vertical motion of the rib cage and shoulders signals a thoracic dominant breathing pattern where there is an increased activity in the scalenes, sternocleidomastoid, trapezius (upper fibres) and the hyoid and long colli which are the accessory muscles of breathing (Chaitow et al., 2014). This is usually to compensate for an increased ventilatory demand or when normal breathing is inefficient (De Troyer, 1983; Verschakelen and Demedts, 1995; Hruska, 1997; Courtney, 2009). However, its presence can be normal and functional if there is a necessary demand for rapid inspiration, increased ventilatory need or during physical activity.

The fourth of the five classifications by Boulding et al. (2016) is forced abdominal expiration. Boulding et al. (2016) states it is the least frequently described breathing pattern in current literature. This may explain the ambiguity of their definition of the category. Boulding et al. (2016) stated that forced abdominal expiration coexists frequently in patients with chronic obstructive pulmonary disease (COPD) as this patient group have excessive and inappropriate abdominal muscle contraction which aids expiration. However, this is based on only two studies (Parameswaran et al., 2006; Myrrha et al., 2013) both of which were exploring specific disease related breathing adaptations (being COPD and obesity). There is no clarity provided by Boulding et al. (2016) whether it has the same clinical presentation in patients with and without diagnosed COPD or obesity nor whether this breathing pattern adaptation could be another symptom of COPD or obesity or if DB is a secondary condition to COPD or obesity.

Lastly, Boulding et al. (2016) stated the fifth classification of DB as thoraco-abdominal asynchrony, or in extreme cases, referred to as paradoxical breathing. This is when the chest and abdomen oppose each other; contrary to normal breathing mechanics, the abdomen will contract and move inwards, during inhalation (Boulding et al., 2016). Roussel et al. (2007) described thoraco-abdominal asynchrony as the lower abdomen being constricted during inhalation, rather than the lower abdomen expanding to draw air in, and this was considered an asynchronous breathing motion. It is often observed and clinically assessed as a sign of respiratory distress and increased effort when breathing and has been reported to be the most severe breathing pattern disorder (Perri and Halford, 2004).

For the most part, Boulding’s proposed classifications are reasoned with supportive literature. However, forced abdominal expiration needs

further exploration and research to support its inclusion. Boulding et al.’s (2016) four remaining classifications of HVS, periodic deep sighing, thoracic dominant breathing and thoraco-abdominal asynchrony contribute to the understanding of DB and provide further clarity of how DB can be used as an overarching term to describe biomechanical breathing dysfunctions. Boulding et al. (2016) suggested their classifications after using the search terms ‘dysfunctional breathing, hyperventilation, Nijmegen questionnaire (a questionnaire designed to assess for symptoms of DB) (van Dixhoorn, 2015) and thoraco-abdominal asynchrony’ and provided minimal explanation of how these classifications were reached. The use of these terms, whilst relevant may have forecast what Boulding et al.’s (2016) classifications were to be as two of the classification terms used were also search terms.

## 2.2. Vidotto et al.’s (2019) Narrative review

More recently, Vidotto et al. (2019) agreed with Courtney’s (2009) and Kiesel et al.’s (2017) attempts to define DB as well as progressing the current state of DB research from the incipient stage to a developed stage, where more research is conducted into the diagnosis and treatment of DB. They provided an overview of the current state of evidence surrounding DB and concluded that DB is still poorly understood by researchers and practitioners alike. As such, further research is necessary to improve the understanding of DB.

They also stated that without a gold standard tool for diagnosing DB then it would be difficult to reach a consensus particularly on the prevalence of DB. This would also make it more difficult for evidence-based practitioners to recognise DB when assessing the public in their respective professions. Vidotto et al.’s (2019) contribution to this topic area provides clarity on the current state of the literature surrounding DB and highlights a need for further clarification to move towards a consensus on what DB is and how it should be assessed and treated.

## 2.3. Kiesel et al.’s (2020) Summary of DB

Kiesel et al. (2020, pp. 115) defined DB as ‘an overarching term used to describe a detrimental adaptation in breathing’ suggesting a concise framework that identifies three subcategories of DB: biomechanical, biochemical, and psychophysiological DB. Biochemical DB was defined as ‘individuals who exhibit reduced levels of carbon dioxide in the blood’ which is commonly referred to as hypocapnia (Kiesel et al., 2020, pp. 115). Psychophysiological DB was defined as ‘individuals who may have no issues with breathing during normal daily activities but can have abnormal or dysfunctional breathing under particular situations that are commonly stress-related’ (Kiesel et al., 2020, pp. 115). Studies demonstrating this can be dated as far back as the mid-1950s and 1960s (Seidenfeld, 1955; Lapicciarella, 1968) with further research published in the 1990’s with Carr et al. (1994) and Howell (1997). Finally, biomechanical DB was described as individuals demonstrating ‘an abnormal

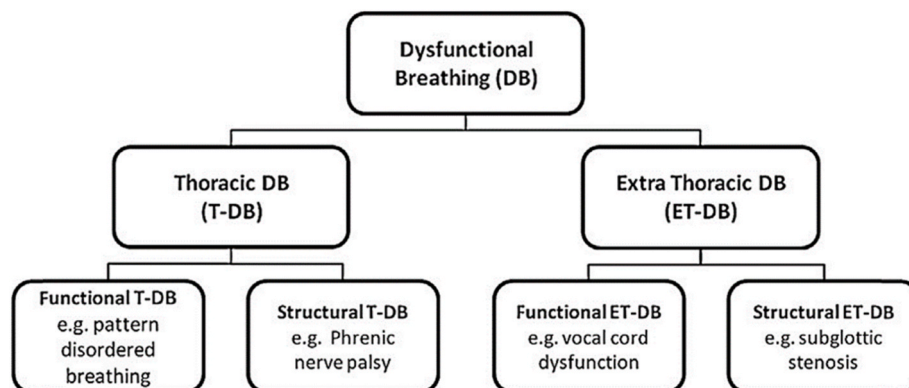


Fig. 1. Barker and Everard’s (2015) model of Dysfunctional Breathing Classification.

mechanical breathing pattern' or someone lacking a normal diaphragmatic breathing pattern at rest (Kiesel et al., 2020, pp.115). Whilst this approach is more concise for readers and clinicians, they risk oversimplifying complex interactions or confusing causes with categories. Psychophysiological DB because of heightened stress, for example, could be argued as being a normal change in an individual's breathing due to an increased sympathetic drive, as opposed to an example of DB.

#### 2.4. Summary of the proposed definitions of dysfunctional breathing

Commonality between research highlighted in this review show that DB should be considered an umbrella term rather than a distinct condition (Boulding et al., 2016; Vidotto et al., 2019; Kiesel et al., 2020). However, existing definitions fail to capture the full scope of DB's physiological and psychological dimensions. Therefore, a more expansive definition and model of DB is necessary. This would provide direction for further research to identify a valid assessment tool or a cluster of tests to diagnose biomechanical DB, thereby guiding evidence-based practitioners on how to recognise and assess DB.

#### 2.5. Clarifying dysfunctional breathing

Given the inconsistencies in definitions and models it is argued that clarity can best be achieved through a comprehensive model rather than a single formal definition. Barker and Everard's (2015) model remains useful for understanding biomechanical DB but omits key elements such as biochemical and psychophysiological factors. Boulding et al.'s (2016) classifications focus narrowly on breathing patterns and do not fully address extra-thoracic issues. Kiesel et al.'s (2020) subcategories provide a broader conceptual framework but lack diagnostic specificity. The overlapping symptoms across categories, such as hyperventilation syndrome being both biomechanical and psychophysiological, illustrate the need for a more integrated model. The use of contradictory terminology like "functional dysfunctional" further complicates understanding. By integrating existing models, this review proposes a new, clearer

classification system that better supports research and clinical practice.

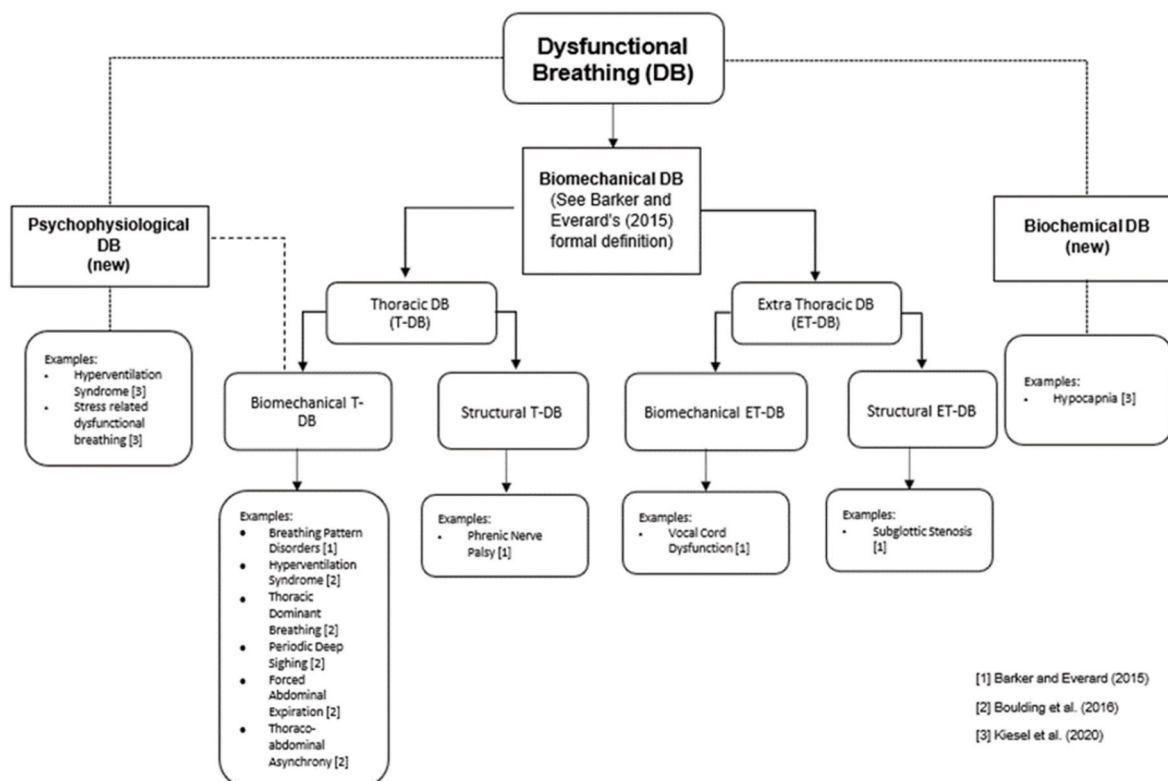
More clarity is needed for future research to have a higher validity and be recognisable amongst practitioners assessing and treating DB. The terminology used by Barker and Everard (2015) to describe each category, namely the use of 'functional' and 'dysfunctional' together could cause ambiguity for readers and healthcare practitioners as these are two contradictory terms; perhaps biomechanical DB may have been better suited. It is suggested that a combination of Barker and Everard (2015) and Boulding et al. (2016) be formulated, as both attempts at providing clarity have grounds to argue their case.

#### 2.6. A new model of dysfunctional breathing

Based upon the findings of this review a new model of DB has been produced by the leading author of this paper, and the authorship team with the inclusion of psychophysiological and biochemical DB sub-categories (see Figure 2). The model aims to represent the different elements of DB more clearly and highlight some of the potential relationships between the different sub-categories of DB. This model of DB is intended as a starting point and further research studies are needed to validate the contents and viability of the model.

Based upon the research that has been published to date this new model proposes the use of Barker and Everard's (2015) formal definition of DB to solely define biomechanical DB. At present, there are no formal definitions for the psychophysiological and biochemical DB. However, the term 'functional' used by Barker and Everard (2015) has been amended to 'biomechanical' to provide more clarity. This model has been developed further in biomechanical DB, rather than in psychophysiological DB or biochemical DB, to benefit evidence-based practitioners from a physical therapy background. The psychophysiological DB and biochemical DB branches of this model are an expansion and a direct contribution as a result of this review, but fall outside the expertise of this author, and thus need further development.

Further research is required to add to the psychophysiological and the biochemical elements of this model. Exploration of the relationships



[1] Barker and Everard (2015)

[2] Boulding et al. (2016)

[3] Kiesel et al. (2020)

Fig. 2. A new proposed model of Dysfunctional Breathing.

between each category is also recommended as there may be crossovers between categories as demonstrated by the categorisation of HVS in this model. This current model highlights, using a dotted line rather than a solid line, that there are links between the psychophysiological elements and biomechanical elements of DB. For example, hyperventilation syndrome is considered a change in the biomechanics of breathing but is also caused by psychophysiological factors (Jones et al., 2013; Wilson, 2018) and could arguably be considered an example of both biomechanical DB and psychophysiological DB. This is the first model of DB to provide an in-depth view of what DB as an umbrella term could encompass. Further research is now required to add definitions and clarity around the more contemporary elements that have been introduced.

#### CLINICAL RELEVANCE.

- Clarification of the use of the term ‘dysfunctional breathing’ has been provided, to confirm and explain its use within research and clinical practice.
- A new expanded model of DB has been proposed to inform further research and clinical practice moving forwards.
- The proposed model has implications beyond musculoskeletal practice providing a foundation for an interdisciplinary framework focussed around DB.
- This new model of DB, once expanded and justified fully, would provide a platform to develop clinically relevant assessment tools and batteries to identify DB and direct the treatment of DB patients moving forward.
- Given the variability in understanding and defining FB this review underscores the need to enhance the education of interdisciplinary clinicians in recognising and managing diverse presentations of DB.

#### CRediT authorship contribution statement

**Tom Pinder:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Data curation, Conceptualization. **Ashley Jones:** Writing – review & editing, Supervision. **Isobel Jacob:** Writing – review & editing, Supervision. **James Milligan:** Writing – review & editing, Supervision.

#### Ethical approval

N/A.

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#### 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.

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