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***AN INVESTIGATION INTO THE CURRENT USE OF
DYSFUNCTIONAL BREATHING ASSESSMENT WITHIN
MUSCULOSKELETAL THERAPY PRACTICE***

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33363300

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
OF LEEDS BECKETT UNIVERSITY FOR THE DEGREE OF MASTER OF RESEARCH

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Abstract

The purpose of this dissertation was to explore the relevance of dysfunctional breathing (DB) in musculoskeletal (MSK) practice. As exposure to breathing practices become increasingly more prevalent across healthcare professionals and the public, and progressively more treatment modalities related to breathing mechanics are emerging, it is important to explore whether breathing mechanics are a relevant consideration within MSK practice.

Initially, a critical review was conducted to explore the term 'dysfunctional breathing', its definition and the current evidence around DB in MSK health. One suggested formal definition of DB was identified, by Barker and Everard (2015), but there remains no consensus on what DB is within the reviewed literature. One model of DB was also identified (Barker and Everard, 2015), but it needs further modification and adaptation to meet the requirements of the most recent research published on DB.

In addition, a literature review of the potential effects that DB can have on the MSK system was conducted. Anatomical, biomechanical, physiological and neurological effects of DB on the MSK system were identified, some grounded in research and others more narrative in nature and needing further exploration.

Finally, an explorative focus group interview and one individual interview were conducted to acquire the beliefs and opinions of current MSK practitioners on the relevance of DB, their assessment methods, interventions and their beliefs on what effects DB can have on the MSK system. Thematic analysis was used to develop themes and classifications. This study revealed that DB assessment methods can be classified into three categories: observational assessment, manual assessment, and subjective assessment. Three types of breathing intervention were identified: breathing re-education, breathing exercises, and manual therapy. In total, fourteen potential effects of DB on the MSK system were identified by the participants.

Unlike previous research exploring DB this dissertation has only focused on the implications within MSK health as opposed to exploring DB within respiratory and cardiovascular medicine.

It adds to the debate of the need for a formal definition of DB and has identified areas for further research that are needed around the perceived effects of DB on the MSK system. In the absence of an overarching and accurate definition a new model of DB has been produced as a result of this dissertation to provide a suggested framework of what DB could potentially look like, when divided into three subcategories. These subcategories are biomechanical DB, biochemical DB and psychophysiological DB. It is proposed by this author that the work produced in this study enables a future consensus to be reached on the formal definition, model and signs and symptoms of DB.

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1.0 Introduction

This researchers' professional background is as a clinical sports and exercise therapist. The topic of this dissertation has been chosen as a result of this researchers' own experiences within their clinical practice. As part of their clinical practice, they regularly observe dysfunctional breathing (DB) mechanics in their caseload of patients attending with musculoskeletal (MSK) conditions. As an autonomous, evidence-based clinician, this researcher has identified a lack of consensus on the relevance of DB to their own and other MKS health clinicians' practice. In particular, identifying a variety of assessment and intervention methods, some founded in science and others not. This researchers' experiences in clinical MSK practice is that patients will attend primarily focussed on addressing their MSK issue. However, in some circumstances, their MSK health issue can be related to the abnormal mechanics of breathing they are displaying. An example of this is when a patient has a history of anxiety and is demonstrating fast and shallow breathing, increasing the workload and therefore tonicity in the accessory respiratory muscles in the neck and shoulders. Since the COVID-19 pandemic, this researcher has also seen an increase in the interest from their patients surrounding breathing and how it can alter and adapt post-illness. This researcher has therefore seen an increase in the number of patients that are aware of their own breathing mechanics and how they have changed or can change.

The concept of conscious breathing is becoming increasingly popular amongst the general population. Breathing practices for the benefits of promoting health have simultaneously gathered wider interest. This is demonstrated by the increase in attention of the public to breathing practices, such as the Wim Hof Method, which was the subject of a television series broadcast on national television in the UK (Freeze the Fear with Wim Hof, 2022). Breathing is generally controlled by the autonomic nervous system. It is also one of the few autonomic functions that humans can consciously control also. Varying breathing mechanics can consciously be used by most healthy humans for example voluntary diaphragmatic breathing or voluntary hyperventilation can be initiated consciously. It is generally accepted that

breathing has three primary functions: biochemical, biomechanical and psychophysiological (van Dixhoorn and Folgering, 2015). This concept will be discussed further in chapter two.

Normal breathing mechanics have been well established for decades with very little research in recent times debating the fundamentals of normal breathing. There does remain several areas of breathing mechanics that are still debated or have been left unanswered in the current literature. Hence, it is important to outline what the currently accepted normal breathing mechanics are.

1.1 Normal Breathing Mechanics

Breathing can be separated into two parts namely inhaling (inspiration) air into the lungs and exhaling (expiration) air out of the lungs (Hall, 2016). In inspiration, the thoracic diameters are increased by muscle action and the pressures in the lung spaces and the pleural cavity become less than that of the atmosphere causing air to rush in and the lungs to expand (Soames and Palastanga, 2019). Relaxed expiration (as opposed to forced expiration) is argued to be a passive process (Hough, 2014; West and Luks, 2016). During expiration the thoracic diameters decrease with the recoil of the lungs, relaxation of the inspiratory muscles (unless forced) and atmospheric pressure acting on the chest wall causing air to expel from the lungs (Hough, 2014; West and Luks, 2016).

The muscles involved in changing the shape of the chest wall can be split in to three groups: the diaphragm, the abdominal muscles and the muscles of the rib cage/thorax (Hough, 2014; West and Luks, 2016). In their normal relaxed states these muscles create an efficient respiratory pump moving in a coordinated action (bucket handle movement) (Courtney, 2009). This pump handle motion changes the diameter of the rib cage to allow for sufficient inspiration and expiration (Hough, 2014; West and Luks, 2016).

The muscles involved in inspiration are the diaphragm, the intercostals, the levatores costorum and the serratus posterior superior (Soames and Palastanga, 2019). The accessory muscles of inspiration are the scalenes, sternocleidomastoid, upper trapezius, hyoid and longus colli

muscles of the upper rib cage which assist by lifting the rib cage. The muscles of expiration are the transversus thoracis, subcostals, serratus posterior inferior, external and internal obliques, transversus abdominis and the latissimus dorsi (Courtney, 2009; Soames and Palastanga, 2019; Drake et al., 2020).

The diaphragm is considered to be the primary respiratory muscle in normal breathing mechanics (McLaughlin, 2009; Chaitow et al., 2014). During normal breathing inflation of the lungs and contraction of the diaphragm will produce expansion of the rib cage, creating abdominal motion also, which is easily observable, and is commonly referred to as diaphragmatic breathing (Courtney, 2009; Chaitow et al., 2014; Horris et al., 2019). During inhalation, the diaphragm descends and flattens from a domed or umbrella shape to lift laterally and expand anteriorly the lower six ribs of the thorax (Courtney, 2009; Soames and Palastanga, 2019). During diaphragmatic breathing it is expected that most individuals' abdomen will displace anteriorly. During expiration, the diaphragm relaxes back to its resting position, using the elastic recoil of the lungs (Hough, 2014; West and Luks, 2016).

The intercostal muscles are a group of muscles passing between all adjacent ribs, occupying the intercostal space (Soames and Palastanga, 2019). The intercostals consist of three layers of muscles: the external intercostals, internal intercostals and innermost intercostals (Drake et al., 2020). The external intercostals are active during inspiration to elevate the rib inferiorly towards the rib above (Soames and Palastanga, 2019). The role of the internal interosseous intercostals is to have an expiratory function (De Troyer et al., 2005). Soames and Palastanga (2019) speculate that the intercostals contribute to producing a rigid cavity for the diaphragm to act upon by resisting the drawing in and out of the intercostal rib spaces, but there is no evidence to support this claim at present. Drake et al. (2020) alternatively states that during expiration the internal intercostals are the most active, as they maintain the intercostal space between the ribs and contribute to the depression of the ribs.

Twelve small, triangular levatores costorum muscles between C7 vertebrae and T11 vertebrae also assist in elevating the ribs during inspiration. The serratus posterior superior is located

anterior to the rhomboids and is suited to elevate the ribs during inspiration also (Soames and Palastanga, 2019). If required, the sternocleidomastoid, scalenes, upper trapezius and anterior neck muscles increase their activity to assist in lifting the rib cage during inspiration, often referred to as the accessory muscles of respiration (Courtney, 2009). The serratus posterior inferior contributes to inferior and posterior motion of the ribs during exhalation.

The abdominals eccentrically contract to oppose the diaphragm during inhalation. They act to control the length-tension relationship and maintain the dome shape of the diaphragm (Kocjan et al., 2017). During expiration, the abdominals act to increase intra-abdominal pressure to assist the diaphragm in returning to its normal resting position further upwards into the thoracic cavity (Chaitow et al., 2014).

Expiration can also be an active process for the abdominals, as opposed to a passive process involving relaxation (Abe et al., 1996; Courtney, 2009). The abdominal muscles can concentrically contract to assist the diaphragm in forcibly expelling air back out of the lungs into the atmosphere, such as in coughing and sneezing (Courtney, 2009). Abe et al. (1996) specifically found that during resting expiration the transverse abdominis is the most active abdominal muscle, followed by the internal and external oblique, with the rectus abdominis showing the least activity during expiration. The transverse abdominis previously had not been considered a muscle of respiration nor an accessory muscle to breathing. It is acknowledged by this researcher that breathing adaptations will occur during exercise, however this dissertation is solely exploring the normal or otherwise abnormal mechanics of breathing when an individual is at rest.

Research by Montes et al. (2017) supported the role of the internal obliques during inspiration, as well as expiration, but measured a lesser extent of activity in the transversus abdominis.

Both Montes et al. (2017) and Abe et al. (1996) used surface electromyography to detect changes in activation intensity of the abdominal muscles during a standardised breathing protocol. However, Montes et al. (2017) compared the activity of the abdominals during breathing in different postures. The rectus abdominis activity was consistent across supine,

tripod and four-point kneeling positions, but increased in standing. There was less activity from the transversus abdominis and internal obliques during breathing in supine than in standing. It remains unclear as to whether these changes in abdominal activity occurred solely because of the changes in posture or whether the abdominals have a greater influence on breathing mechanics than first considered.

Figure 1 represents the sequence of events involved in inspiration and respiration, as published by Marieb and Hoehn (2023).

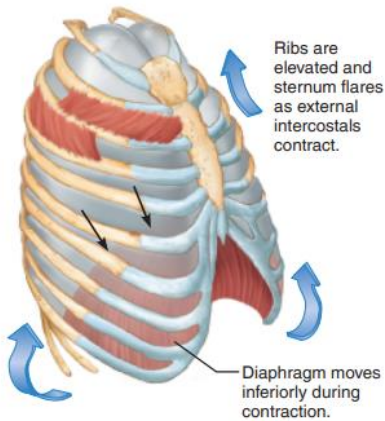
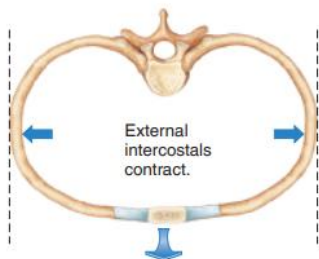
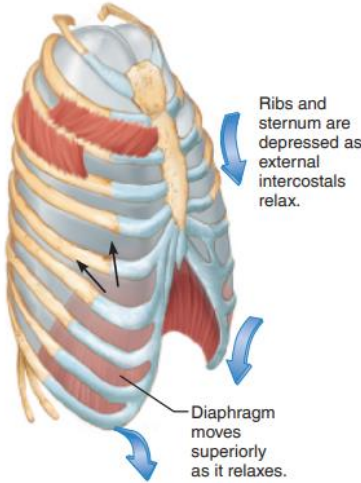
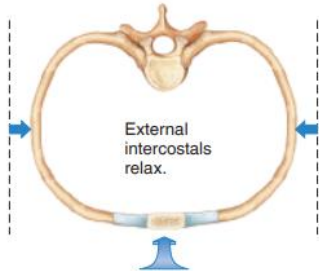
	Sequence of events	Changes in anterior-posterior and superior-inferior dimensions	Changes in lateral dimensions (superior view)
Inspiration	<ol style="list-style-type: none"> ① Inspiratory muscles contract (diaphragm descends; rib cage rises). ② Thoracic cavity volume increases. ③ Lungs are stretched; intrapulmonary volume increases. ④ Intrapulmonary pressure drops (to -1 mm Hg). ⑤ Air (gases) flows into lungs down its pressure gradient until intrapulmonary pressure is 0 (equal to atmospheric pressure). 		
Expiration	<ol style="list-style-type: none"> ① Inspiratory muscles relax (diaphragm rises; rib cage descends due to recoil of costal cartilages). ② Thoracic cavity volume decreases. ③ Elastic lungs recoil passively; intrapulmonary volume decreases. ④ Intrapulmonary pressure rises (to $+1$ mm Hg). ⑤ Air (gases) flows out of lungs down its pressure gradient until intrapulmonary pressure is 0. 		

Figure 1 represents the sequence of events of respiration (Marieb and Hoehn, 2023)

1.2 Breathing in Healthcare

Some effects of breathing practices are well documented in current literature specifically in

respiratory and cardiovascular healthcare. They can be used effectively to treat various conditions most notably asthma, chronic obstructive pulmonary disease, hypertension, and to accelerate recovery after cardiac surgery (Carlsson et al., 2019; Santino et al., 2020; Marotta et al., 2020; Yau and Loke, 2021). Yet, the implementation of breathing practices within wider MSK healthcare professions is still undetermined. Throughout this dissertation MSK health will be regarded as the condition and state of the MSK system as a component of overall human health. Therefore, when referring to MSK healthcare professions, this dissertation is referring to qualified therapists and professionals who regularly work to improve, intervene and positively influence an individuals' MSK health and wellbeing. Breathing interventions are a regular consideration in some specific MSK healthcare practices like yoga (Hakkeed et al., 2017; Sheela, 2021). However, it remains unclear whether and how frequent breathing mechanics are considered by other MSK healthcare professions who assess treat and manage MSK disorders as part of their daily role within their professional capacity.

1.3 Breathing in Research

Consensus on the mechanics of normal breathing have been outlined in sub-chapter 1.1. There remains a lack of clarity amongst researchers, and subsequently evidence-based practitioners, around some of the terminology used in relation to abnormal breathing mechanics or breathing pattern disorders, specifically when used in MSK healthcare. The umbrella term 'dysfunctional breathing' (DB) has been proposed and adopted by numerous researchers as a term that could describe the chronic or recurrent biomechanical adaptations experienced where breathing becomes abnormal yet there is still no consensus on the definition of DB. Multiple papers have attempted to provide an overview of DB (Courtney, 2009; Jones et al., 2015; Boulding et al., 2016; Kiesel et al., 2017) but only one formal definition of DB has been proposed in recent research (Barker and Everard, 2015). Vidotto et al. (2019) produced a narrative review of DB and covered multiple proposed definitions and classifications of DB. As there are multiple attempts at defining or classifying DB any future research on the topic could be misinterpreted by fellow researchers who understand DB to be

an alternative concept to what the researcher's opinions are. Therefore, it is important for this dissertation project to identify further direction for future research on this topic area.

The knowledge and understanding surrounding DB in MSK practice is in its infancy. Multiple papers have been published exploring some specific effects of DB and breathing practices on specific elements of the MSK system but its use in current MSK practice has not been established. It remains unclear what the precise effects of DB might be upon MSK health. It also seems unclear if DB assessments are used within current MSK practice and the rationale for its use.

The focus of this dissertation will be to address the following research topic:

‘An investigation into the current use of dysfunctional breathing assessment within musculoskeletal therapy practice’.

To achieve this, the following aims and objectives have been set for this research dissertation.

There are two overarching aims of this dissertation:

1. To identify if, why and how DB should be assessed in MSK practice and explore the current methods of intervention in treating DB in an MSK health setting.
2. To explore and gain an understanding of various MSK practitioner's beliefs on the causes and effects of DB on the MSK system.

The study will therefore identify the key factors that these clinician's believe affect MSK health in order to direct future research into this topic area.

To achieve these aims, the following dissertation objectives have been set:

1. To produce a critical review of the current evidence on the definition of DB.
2. To produce a literature review on the effects of DB on the MSK system.
3. To explore MSK practitioner's beliefs and opinions of the causes and effects of DB on the MSK system.
4. Identify assessment tools used in diagnosing DB.

5. Identify interventions used in the treatment of DB.
6. Identify what effects DB may have on the MSK system.
7. To analyse the findings and determine specific factors which are suggested to affect the MSK system, to identify potential pathways for future research.

To the author's knowledge such a dissertation has not been undertaken to date. In particular considering the effects of DB within MSK practice whilst exploring the practices, beliefs, and opinions of currently practicing MSK therapists.

Chapter Two of this dissertation will address Objective One. It will attempt to provide an overview of the current situation surrounding the definition of DB. Chapter Three of this dissertation will focus on Objective two. The potential effects of DB on the MSK system will be explored. Chapter Four of this dissertation will include the main study, addressing objectives Three, Four, Five and Six. It will explore the views and beliefs of currently practicing MSK therapists on the topic of DB within their own practice. This is to help provide clarity of breathing assessment methods currently in use within MSK practice, presently used interventions for DB and the effects that these practitioners believe DB to have on an individual's MSK health. Chapter Five will address Objective Seven.

The purpose of the study is to identify any gaps in the current literature of DB assessment and intervention in MSK practice to provide direction for further research into this topic area. It will also look to provide direction for practicing therapists in identifying the most commonly used assessment methods and interventions for DB. Furthermore, it will provide further clarity as to the importance of DB in consideration of MSK healthcare practices, leading to further exposure, education and research in future practice.

2.0 Dysfunctional Breathing: A Critical Review

This chapter will provide a critical discussion of the published evidence regarding a formal definition of DB whilst exploring the methods of assessment of DB. It will argue that a new proposed model of biomechanical DB is required based on adaptations to previously published research on defining and classifying DB. A critical review methodology (Grant and Booth, 2009) was used to produce a critical discussion of the literature surrounding DB with the purpose of resolving competing schools of thought. As numerous narrative style reviews have already been conducted on this topic area, it is assessed by this researcher that more critique of the current publications around DB is needed in attempt to consolidate and narrow the focus of future research on DB.

The following databases were searched in this critical review, as these databases were the databases available through the Leeds Beckett Library search engine (Discover): Directory of Open Access Journals, Gale Academic OneFile, PubMed Central (MEDLINE), Scientific Electronic Library Online, Taylor and Francis Online, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complimentary Medicine Database (AMED) and Wiley Online Library. All databases were established to publish peer reviewed scientific journals which could possibly contain peer reviewed articles relevant to this review. In addition, Google Scholar was also used. Both CINAHL and AMED were searched retrospectively for further research. No additional relevant literature was found that had not already been found or that impacted on what was already found. Table 1 identifies the rationale behind the inclusion of each database.

Database	Rationale for Inclusion
Allied and Complementary Medicine Database (AMED)	Produced by the Health Care Information Service of the British Library providing a specialised bibliographic database designed for clinicians in alternative and allied therapies.
Cumulative Index to Nursing and Allied Health Literature (CINAHL)	Indexes the leading nursing and allied health literature
Directory of Open Access Journals (DOAJ)	A unique and extensive index of diverse open access journals from around the world
Gale Academic OneFile	Indexes over 17,000 scholarly journals and other authoritative sources including science and healthcare
PubMed Central (MEDLINE)	Comprises more than 36 million citations for biomedical literature from MEDLINE, life science journals, and online books.
Scientific Electronic Library Online	A bibliographic database, digital library, and cooperative electronic publishing model of open access journals.
Taylor and Francis Online	Indexes millions of quality, peer-reviewed journal articles published under the Taylor & Francis, Routledge and Dove Medical Press imprints.
Wiley Online Library	Allows searching of articles from hundreds of electronic journals published by Wiley and related companies

Table 1 identifies the rationales for the inclusion of the searched databases

The search terms used for this review are laid out in Table 2 below.

Search Terms for DB	Boolean Terms Used	Search Terms relating DB
Dysfunctional Breathing	AND	Breathing Pattern
Breathing Pattern (Disorder)		Respiration
Hyperventilation (Syndrome)		Diaphragm
		Breathing

Table 2 Search criteria used for the Critical Review of Dysfunctional Breathing

These ‘search terms for DB’ were identified in early reading for this dissertation as terms that had been used interchangeably to refer to the same condition. The term dyspnoea was also identified and considered as a possible search term, however this researcher concluded that dyspnoea (meaning shortness of breath) was too vague a search term to identify papers specifically focussing on DB. The ‘search terms relating to DB’ were chosen by this researcher as common terms that would appear in the titles and abstracts of the texts that would be relevant to this topic area. ‘Breathing Pattern’ and ‘Hyperventilation’ were identified as MeSH terms. No further significant search terms arose in subsequent reading in the later stages of the study.

2.1 Defining Dysfunctional Breathing

Ambiguity around the term ‘dysfunctional breathing’ has existed (Chaitow et al., 2014). Often, DB has been used interchangeably with “breathing pattern disorders”. It was previously suggested that, when an individual is at rest, hyperventilation (rapid breathing) with hypocapnia (reduced carbon dioxide in the blood) was the only form of DB (Courtney et al., 2011; Chaitow et al., 2014). However, more recent research has moved away from these definitions as other types of DB have been identified (Barker and Everard, 2015; Boulding et al., 2016). This section will explore the different definitions and classifications of DB.

A collation of the different proposed definitions of DB is available in Table 3.

Table 3 Suggested definitions of dysfunctional breathing identified.

Author	Year Published	Proposed Definition of DB	Description of definition	No. of times cited (at the point of submission)
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.	316
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 ² and CO ² levels, regulation of the body's PH, affects motor control and postural stability, influences homeostatic functions, self regulates emotion and stress.	158
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).	72
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.	132
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.	12
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.	48

2.1.1 Barker and Everard's (2015) Proposed Formal Definition of DB

A definition of DB was suggested by Barker and Everard (2015, p.54):

“An alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may be respiratory and/or non-respiratory”.

This definition has not been widely accepted as the formal definition for DB. Recently published research does not refer to this definition when defining DB (; Boulding et al., 2016; Kiesel et al., 2017;). Few studies have used the suggested 2015 definition of DB as a standalone definition; these studies were authored by the same researchers who proposed the definition (Depiazzi and Everard, 2016; Barker et al., 2016).

Other researchers have used a combined approach to defining DB (Keisel et al., 2017; Courtney, 2017). It is important when trying to define DB to consider that the action of breathing has at least three primary functions:

- 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)
- the “subjective experience of breathing” (psychophysiological) (van Dixhoorn and Folgering, 2015, pg. 2).

Currently, Barker and Everard's (2015) definition does not consider the biochemical or psychophysiological functions within their proposed model of DB. Direct omission of these functions suggests that Barker and Everard's (2015) definition may be limited and could explain why other researchers have not adopted their definition in more recent DB publications.

2.1.2 Barker and Everard's (2015) Model of DB

Barker and Everard (2015) identified two categories of DB being referred to in the current literature: thoracic dysfunctional breathing (T-DB) and extra-thoracic dysfunctional breathing (ET-DB). T-DB refers to abnormal breathing patterns (breathing pattern disorder) which may or may not be associated with hyperventilation whilst ET-DB refers to pattern disordered breathing with upper airway involvement. Barker and Everard (2015) further suggested the two subcategories of thoracic DB and extra-thoracic DB: functional DB or structural DB. 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.

Figure 2 represents an overview of Barker and Everard's (2015) model of DB.

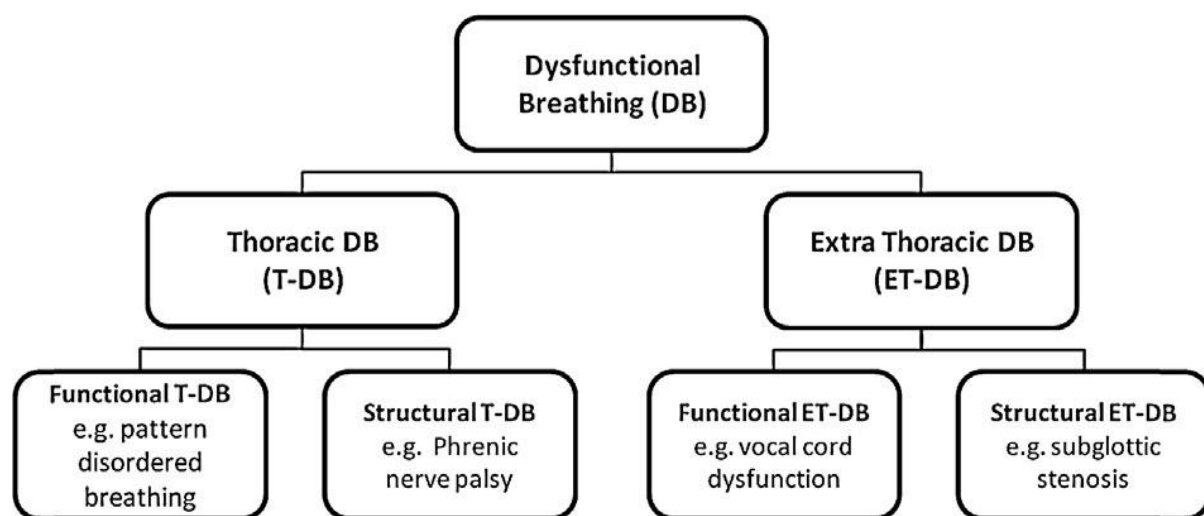


Figure 2: Barker and Everard's (2015) model of Dysfunctional Breathing Classification

Barker and Everard's (2015) model of DB provides some clarity to the different types of DB and allows for future research to refer to a model which defines the different types of DB. A criticism could be that this review does not commit to listing the known conditions of each category, which would clarify the types of DB further, to avoid any additional confusion amongst researchers in the future. Furthermore, naming the subcategories as functional and structural

individually but then defining each category using the same terminology could be confusing for readers and subsequently result in misunderstanding of the proposed model. The use of the word 'functional' should be questioned particularly when defining breathing that is 'dysfunctional'. The two contradictory terms could provide more confusion than clarity.

2.1.3 Boulding et al.'s (2016) proposed DB Classifications

In contrast, Boulding et al. (2016) published a review of the literature analysing DB fourteen months after Barker and Everard's (2015) formal definition was published in January 2015. It claims that there is no formal definition of DB. A search of the PubMed database using the method described in Boulding et al. (2016) confirmed that Barker and Everard's (2015) review was available at the time of Boulding et al.'s publication which may suggest publication bias. However, it should be noted that no literature search timeline was provided in the review by Boulding et al. (2016) and therefore the final search may have preceded the publication of Barker and Everard's (2015) review.

Boulding et al. (2016) suggested DB patterns should be categorised in to five different classifications:

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

The authors proposed that the breathing patterns can present in isolation or can coexist with one another. This was one of the first reviews to attempt to summarise previous research into DB in order to clarify the topic area and direct future research. However, as there was no recognition of Barker and Everard's (2015) proposed formal definition, nor their proposed model of DB, it is unclear how they would coexist with Boulding et al.'s (2016) classifications.

Most research into breathing pattern disorders and DB has explored hyperventilation syndrome (HVS); most of the studies (forty-three of sixty-seven) reviewed by Boulding et al. (2016) investigated the effects of HVS specifically. HVS is defined as “a respiratory disorder, psychologically or physiologically based, involving breathing too deeply and/or too rapidly,” (Jones et al. 2013, p.4). An example of when an individual can encounter psychologically initiated HVS is when an individual is experiencing stress and/or anxiety, whilst it can also be caused physiologically by heart or lung problems (Jones et al., 2013). HVS appears in the literature (Folgering, 1999; Thomas et al., 2001; Gardner, 2003) to be considered one in the same as DB. Barker and Everard (2015, p. 54) agreed listing “dysfunctional breathing, hyperventilation syndrome, disproportionate breathlessness, behavioural breathlessness, sighing dyspnoea, psychogenic functional breathing disorders, and somatoform respiratory disorders,” as being terms in previous literature which have been used interchangeably to describe the same breathing problem. Hornsveld 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. 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, p.292). It is not clear how periodic deep sighing differs from normal sighing, whether the two are exclusive to one another or the same condition. Han et al. (1997) observed that sighing became more frequently (up to fifteen times in a 15-minute period) in those suffering with HVS and anxiety disorders. It remains unclear as to how prevalent periodic deep sighing is.

Boulding et al. (2016, pg. 292) 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, such as in HVS or when exercising (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.

Forced abdominal expiration is said to be the least frequently described breathing pattern by Boulding et al. (2016) which 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 (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, and whether this breathing pattern adaptation could be another symptom of COPD or obesity or is a secondary condition to COPD or obesity.

Thoraco-abdominal asynchrony, or in extreme cases, referred to as paradoxical breathing, 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).

Newth and Hammer (2005) suggested that paradoxical breathing patterns can be further divided in to two categories: asynchronous rib cage motion or asynchronous abdomen motion.

Inward motion of the abdomen during inspiration can be a sign of a dysfunctional diaphragm and therefore a breathing pattern disorder (Fitting and Grassino, 1987). Decreased normal abdominal activity in breathing can be compensated by increasing expansion in the lateral rib cage, otherwise enabling inspiration to continue (Fitting and Grassino, 1987; De Troyer and Estenne, 1988). Newth and Hammer (2005) and Hammer and Newth (2009) have based much of their research around breathing patterns in infants and children and speculated that breathing patterns will change and often become more efficient as one reaches adulthood. Therefore, their findings are likely not representable of the adult population, as they do not account for this potential change.

For the most part, Boulding's proposed classifications are coherent with supportive literature. However, forced abdominal expiration has little evidence to support inclusion in this classification and therefore requires further justification. 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. There was and remains no current consensus on the definition of DB. This is likely due to the ambiguity in some of the classification types that were suggested by Boulding et al. (2016). Boulding et al. (2016, p.288) suggested their classifications after using the search terms "dysfunctional breathing, hyperventilation, Nijmegen questionnaire 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.

2.1.4 Vidotto et al.'s (2019) Narrative Review

More recently, Vidotto et al. (2019) summarised DB using a narrative review generally agreeing with Courtney (2009) and Kiesel (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, and further research is necessary to improve the understanding of DB. They also stated that without a gold standard tool for diagnosing DB, it would be difficult to reach a consensus, particularly on the prevalence of DB.

2.1.5 Kiesel et al.'s (2020) Summary of DB

Kiesel et al. (2020, pg. 115) defined DB as “an overarching term used to describe a detrimental adaptation in breathing” suggesting three subcategories: 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). Psychophysiological DB was defined as individuals who experience normal breathing during their usual daily activities but when placed in a situation, usually with heightened stress, have an abnormal breathing pattern (Kiesel et al., 2020). Studies demonstrating this can be dated as far back as the mid-1950s and 1960s (Seidenfeld, 1955; Lapicciarella, 1968) or more recently to Carr et al. (1994) and Howell (1997). Finally, biomechanical DB was described as individuals demonstrating an abnormal mechanical breathing pattern or someone lacking a normal diaphragmatic breathing pattern at rest (Kiesel et al., 2020). Whilst this approach is simpler and more concise for readers to understand it could be argued that Kiesel (2020) is more referring to the causes of DB than to different types of DB. Psychophysiological DB being as a result 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.

2.1.6 Summary of the Proposed Definitions of Dysfunctional Breathing

Recent research suggests that some consensus has been reached on the concept that DB should be considered an overarching term as opposed to a specific medical condition (Boulding et al., 2016; Vidotto et al., 2019; Kiesel et al., 2020). Barker and Everard's (2015) proposed

definition of DB cannot be used as the formal definition for DB as an overarching term because it does not consider the psychophysiological, nor the biochemical aspects of breathing, solely referring to the biomechanics of breathing becoming dysfunctional. Instead, it would be suitable for defining the biomechanical element of DB. However, Barker and Everard's (2015) model of DB is a useful tool to visualise what DB might look like, although some amendments are needed. When combined with Boulding et al.'s (2016) classifications a clear proposal of what biomechanical DB should be considered as is formed. Keisel et al. (2017), Vidotto et al. (2019) and Keisel et al. (2020) and merely add to and support the need for a formal definition to be accepted, allowing for further clarification and classification to then be implemented. This should then provide direction for further research to identify a valid assessment tool or cluster of tests to diagnose DB.

2.2 Assessing Dysfunctional Breathing

Thomas et al. (2005) proposed the use of the Nijmegen Questionnaire (NQ) to assess HVS, which has been validated for use in asthmatics (Grammatopoulou et al., 2014) and HVS (Van Dixhoorn and Duivenvoorden, 1985). However, the outcome measure has not been validated for use in diagnosing other types of breathing dysfunction as the NQ was initially designed to assess HVS only. The NQ is used by respiratory clinicians to assess for symptoms of hyperventilation syndrome and is a self-reporting questionnaire that is completed by patients as part of a holistic approach to the assessment of DB (Van Dixhoorn and Duivenvoorden, 1985; Ogilvie et al., 2019). Ogilvie and Kersten (2015) suggest that the NQ is widely used to screen for HVS in healthcare. The questionnaire consists of 16 questions about symptoms relating to HVS (Boulding et al., 2016) (see Appendix 1 for the NQ). Van Dixhoorn and Duivenvoorden (1985) suggested the NQ had a sensitivity of 91% and specificity of 95% in assessing HVS. Ogilvie et al.'s (2019) validity study met the criteria for the evaluation of content validity as described by the Scientific Advisory Committee of the Medical Outcomes Trust (Aaronson et al., 2002). This means that further research using the NQ will produce findings which are comparable between similar sample populations. Due to the lack of validity testing

for the NQ in all suggested classifications of DB, Van Dixhoorn and Folgering (2015) concluded that a multicomponent assessment is recommended when trying to diagnose DB due to the “multidimensionality of breathing”. Another method of assessment of symptoms of DB is the Self Evaluation of Breathing Questionnaire (SEBQ) (Courtney and Greenwood, 2009). The SEBQ was originally designed with seventeen items and users are expected to respond to these items in one of four fixed responses (see Appendix 2). Two outcome dimensions were identified by Courtney and Greenwood (2009, p.124) as “lack of air” reflecting dysfunction in the biochemical aspect of breathing and “perception of inappropriate and restricted breathing” which reflects the biomechanical dysfunctions of DB. The SEBQ contains a greater number of respiratory items than the NQ and can therefore differentiate between two dimensions of breathing discomfort which the NQ cannot, indicating the need for a multidimensional approach to assessing DB. The SEBQ has limitations of its own, however, as it only detects changes in breathing, as opposed to identifying DB, as there are no normative values for this assessment technique published. Courtney and Van Dixhoorn (2014) re-evaluated the assessment of DB and concluded the SEBQ should be expanded to twenty-five items to gather more information on individuals breathing changes. Mitchell et al. (2016) concluded that the SEBQ has high test-retest reliability and internal consistency with an acceptable measurement error and so can be used in isolation or complementary to other techniques of assessing DB. One limitation of Mitchell et al. (2016) study is that the participants used were over 18-years old and so it is still unclear whether the SEBQ is a reliable test for children and adolescents. This study also used convenience sampling, excluding any individuals who were undergoing or planning any major life changes like increasing exercise and reducing smoking, making these results less applicable to these populations. In order for the SEBQ to be a tool relied upon regularly for clinically assessing DB, normative values in different populations with varying health conditions, including healthy participants, need to be established.

Another technique, which can reportedly be used to assess DB is the Manual Assessment of Respiratory Movement (MARM) tool. This tool has been used by manual therapists for a long time to assess diaphragm function (Chaitow et al., 2014). MARM is used for assessing

abdominal motion during respiration and requires therapists to palpate across a patient's abdomen and chest to measure changes in the dimensions of the ribcage and abdomen during inspiration and expiration (Courtney et al., 2008). No study has been done to validate the sensitivity and specificity of using the MARM to diagnose DB. Courtney et al. (2008) and Courtney et al. (2009) did conclude that the use of the MARM when compared with other assessment techniques was a valid and replicable tool to use. Courtney et al. (2008) compared the MARM with respiratory induction plethysmography (RIP), which is considered a valid and accurate method of measuring the breath-by-breath variability of respiration (Fiamma et al., 2007). Courtney et al. (2008) concluded that both the MARM and RIP both measured the abdominal and thoracic breathing patterns accurately, but only MARM was able to detect changes to breathing due to postural differences. This study was only conducted using a small sample size (12 participants, 2 examiners) and so consideration should be given to the impact of this research.

Courtney et al. (2009) compared to manual assessments of breathing: the MARM and the Hi-Lo breathing assessment tool (Hi-Lo). The patient places one hand on the upper abdomen and the other on the upper chest and instructed to inhale and exhale several times. The clinician observes the type, direction and amount of movement in the chest and the abdomen to identify DB (Chaitow et al., 2014). The key difference between the Hi-Lo and the MARM is that during the MARM the therapist will be assessing from behind the patient with their hands placed on their mid thoracic and lateral lower rib cage, whereas during the Hi-Lo the patient is observed from the front (Courtney et al., 2009). At present there is limited validity and reliability testing conducted on this method of assessment but if it is a commonly used method of assessment then validity testing should be conducted with the aim of providing normative values also. Courtney et al. (2009) compared the MARM with the Hi-Lo and found that both tests were easily administered by the practitioners using these tools, but the Hi-Lo assessment was inconsistent when attempting to identify paradoxical breathing, whereas the MARM was accurate in doing so. This study also found that practitioners using the MARM were more confident in doing so when compared to using the Hi-Lo breathing assessment tool.

Chaitow et al. (2014) suggested many clinicians may also record breath-hold times as a way of assessing breathing however there is no standardised test that exists, nor any normative values produced. It is suggested that failure to hold beyond 30 seconds is a positive test for DB (Chaitow et al., 2014). A standardised protocol is needed to test the validity and reliability of using this method of assessment to assess DB.

Another method identified of assessing DB is through measurement of an individual's end-tidal carbon dioxide levels using capnography (Boulding et al., 2016). Capnography measures the levels of carbon dioxide during expiration (Askar et al., 2020). During hyperventilation it is expected that an individual's end-tidal carbon dioxide levels will be low and so capnography could potentially aid in diagnosing DB (Courtney and Cohen, 2008). It is suggested by this researcher that capnography should only be used to assess for HVS specifically, as opposed to DB, as it hasn't yet been validated in assessing other types of DB.

Kiesel et al. (2017) proposed that four questions and breath hold time can be used to detect whether DB is present or not and reported that if this specific screening is passed, there is an 89% chance that DB is not present. However, the authors were hesitant in stating that it can be used to diagnose DB and proposed that further assessment is needed if the screening is failed.

The use of criterion lists has also been suggested in the past (Hagman et al. 2011; see Appendix 3). Participants were required to meet at least five of the criteria on a ten-item criterion list of symptoms of DB before they were considered to have DB. However, this method has not been externally validated. Caution should be taken in using this method until it is validated as a reliable tool to assess for DB.

2.2.1 Summary of Assessment of DB

As there is no single definition of DB it is difficult to assess and confidently diagnose an individual with DB. The multidimensional nature of DB, as an umbrella term, also makes it difficult to have one protocol of assessing all types of DB. Focusing specifically on functional thoracic DB, it is suggested that a multidimensional assessment be used. The MARM, SEBQ and NQ have been proposed as the three assessment methods which are most complimentary

to each other and can give the most accurate method of assessment of DB when used together as a cluster (Chaitow et al., 2014). Depending on the type of DB, this assessment would need to adapt also. Assessment methods for structural extra thoracic DB would vary from functional thoracic DB.

2.2.2 How prevalent is Dysfunctional Breathing?

Kiesel et al. (2017) cites Thomas et al. (2001) and Courtney et al. (2011) as stating that 50-80% of adults are estimated to suffer with DB, however the original data in these publications state much lower figures (6-10% in the general population). Thomas et al. (2005) was conducted in the UK, based on a sample taken from a general practitioner clinic, as opposed to Kiesel et al.'s (2020) study based in the USA; varying factors such as the time difference between these studies and international populations may be the reason for different percentile estimations of the prevalence of DB, however this has not been demonstrated in the literature. In contrast, Law et al. (2018) found that DB was present in 17% of their sample size for their general population control group.

The variance in estimations could be due to the variety of sample population assessed in each study; different breathing pattern disorders would be present in populations suffering with asthma and COPD, for example and Thomas et al. (2001) and Thomas et al. (2005) concentrated their research primarily on hyperventilation syndrome in asthmatics and non-asthmatics. It could also be due to a lack of clarity between researchers and no accepted formal definition of DB, there is no gold standard method of assessment of DB to accurately estimate how prevalent DB is.

It is also very important to consider how each author defines DB, as previously mentioned in Table 3. Due to the varying definitions of DB, each researcher mentioned in the above paragraphs may have been measuring different signs, symptoms and measuring in different methods to measure how much of their samples suffer with DB.

2.3 Aetiology of Dysfunctional Breathing

It is not yet understood whether DB is a secondary condition (caused by) or whether it is coincidental with other illnesses and diseases. DB appears to be more prevalent in individuals with asthma and COPD, than in healthy individuals (Thomas et al., 2001; Law et al., 2018; Sedeh et al., 2020), although some authors and practitioners might dispute this (Kiesel et al., 2017; Kiesel et al., 2020).

2.4 Clarifying Dysfunctional Breathing

2.4.1 Defining DB

Although multiple attempts at defining DB and providing clarity over the topic area have been suggested, there is still no recognised definition of DB. This makes it difficult to formulate an accurate assessment method to diagnose DB. It appears that initially authors were referring to DB and hyperventilation syndrome (HVS) as the same condition until HVS and DB were better understood (Barker and Everard, 2015). Furthermore, HVS was proposed as a subcategory of DB (Boulding et al., 2016) as opposed to a separate condition altogether.

Barker and Everard's (2015) model of DB and suggested formal definition could be used to help define biomechanical DB in research and improve the quality of research being conducted. However, researchers (Boulding et al., 2016; Kiesel et al., 2017; Kiesel et al., 2020) seem to be reluctant to use the proposed formal definition. Seemingly, this is because there is no inclusion within Barker and Everard's (2015) model of all three primary functions of breathing. Boulding et al. (2016) offered a classification system of DB which appears to be recognised more than Barker and Everard's (2015) definition. Presumably because Boulding et al. (2016) provides specific types of DB that can be recognised amongst practicing clinicians easily when assessing their patients. Nevertheless, Boulding et al.'s (2016) classification system has not been accepted by all as providing clarity of the definition of DB. This could be due to the overspecification of their classifications as there is no discussion around extra-thoracic DB conditions such as vocal cord dysfunction or subglottic stenosis, for example. Instead, it appears Boulding et al. (2016) provides classifications for breathing pattern disorders, defined

as functional thoracic DB by Barker and Everard (2015), rather than DB. Kiesel et al. (2017) attempted to produce his own definition of DB, similar to Van Dixhoorn and Folgering's (2015) and Courtney et al.'s (2011) summary of the primary functions of breathing and the possible dysfunctions which can occur within these. Whilst this definition is logical, it is not clear how different types of DB would be classified using this rationale. For example, HVS which has been linked to psychosocial conditions like panic disorder (Howell, 1997), can be categorised as psychosocial DB, but it could also be categorised as a biomechanical dysfunction as the breathing biomechanics would also change.

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... 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. As such, Figure 3 shows a new suggested collaborative model of DB generated by, and within, this dissertation.

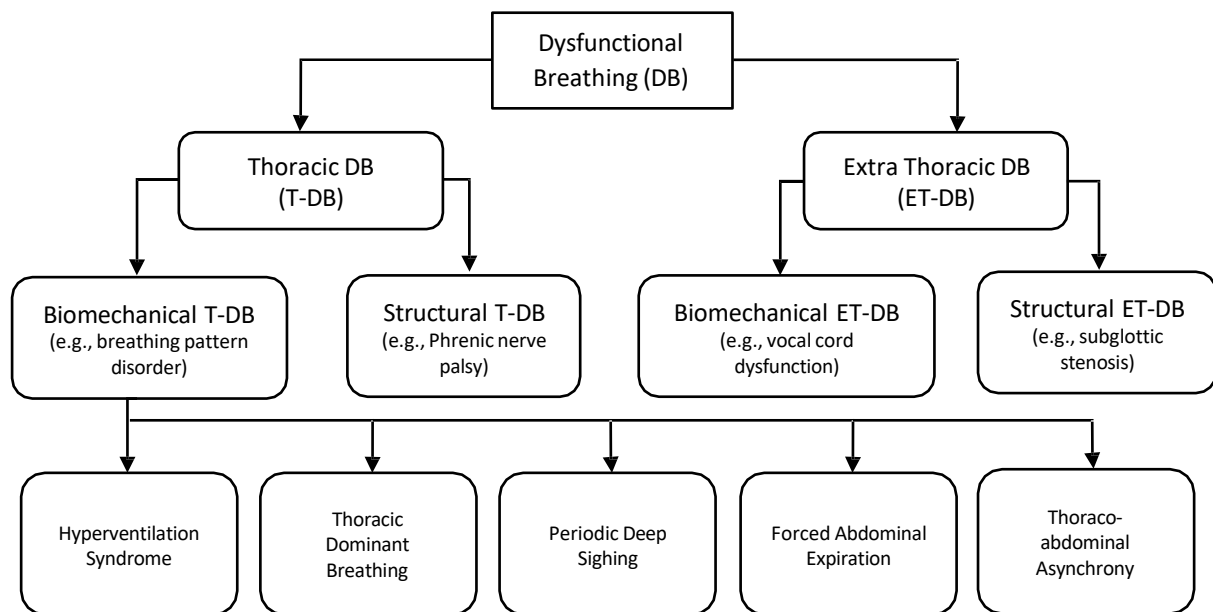


Figure 3: Suggested modified model of dysfunctional breathing.

For the purpose of this review the suggested model is specifically focused on biomechanical thoracic DB as this study is exploring the views and beliefs of musculoskeletal practitioners and their perceptions of the effects of DB on the musculoskeletal system. Any mechanical effects of DB on the musculoskeletal system will be interpreted as part of a breathing pattern disorder, which Barker and Everard (2015) categorised as functional thoracic DB. Also, as it is still unclear as to what extra thoracic DB is then it is pertinent to focus on thoracic DB, rather than explore extra-thoracic DB also.

A combined approach between the two models addresses the limitations of each. By adding Boulding et al.'s (2016) classification to Barker and Everard's (2015) model of DB there is more clarity of the biomechanical branch of DB and suggested criteria for assessing DB biomechanics. Combining Boulding et al.'s (2016) classifications with Barker and Everard's (2015) formal definition and model provides context to Boulding et al.'s (2016) classifications and a formal definition to support them.

In this study, this suggested modified model of biomechanical DB will be used as the definition, classification and model of DB. There are still limitations to this model, as it only attempts to provide further clarification of biomechanical thoracic DB and not structural DB or biomechanical extra thoracic DB. It still excludes the possibility of any biochemical and

psychophysiological breathing adaptations. This is where further research is necessary, to identify the different conditions which could be categorised under these classifications.

2.4.2 Assessment of DB

DB is a complex and multifaceted issue which requires extensive assessment. Multiple attempts have been made at creating a tool to assess for DB and no single tool has been validated in doing so to date. Therefore, a multifaceted assessment is needed to accurately assess and diagnose DB. The NQ is the most used tool in assessment of DB at present (Vidotto et al., 2019), however the SEB-Q, proposed by Courtney and Greenwood (2009) and later revaluated by Courtney and Van Dixhoorn (2014) claims higher validity than the NQ when assessing all aspects of DB. The NQ has been proven valid in identifying HVS alone. The MARM and Hi-Lo assessment have also been suggested as an assessment tool, to be used alongside a subjective questionnaire, like the SEB-Q. Courtney et al. (2009) found that participant or patient preference may dictate which manual therapy method of assessment is used, as the MARM was preferred to the Hi-Lo assessment but identified the validity of both methods is still in question. Other methods of assessment could be considered, such as breath hold time, proposed as a reliable method of excluding DB from assessment by (Kiesel et al. 2017). It is yet to be validated in the positive outcome assessment of DB, however.

2.5 Conclusion

To summarise DB is a complex issue. It does not yet have an accepted formal definition of DB, however there is a clear, proposed formal definition suggested by Barker and Everard (2015). They have also offered a model of the overview of DB which uses confusing terminology, and this should be amended. A new model could also include further examples of each sub-category suggested by Barker and Everard (2015) and Boulding et al. (2016), and include the three subcategories of biochemical, biomechanical and biopsychosocial breathing.

Without a formal definition of DB it is difficult to suggest a means of assessment. Most research into the assessment of DB proposes that a battery of assessment techniques be used to accurately assess and diagnose DB. It remains up for discussion as to which assessment

techniques are combined and used to do so with the most accuracy. No validity studies have been conducted to identify a gold-standard multi-assessment tool at the time of submission of this dissertation.

3.0 Dysfunctional Breathing and the effects on the MSK System

Chapter Two (critical review of dysfunctional breathing (DB)) found that there is still no consensus on the definition of DB. A model has been proposed for DB, which focuses on biomechanical DB, identifying the presence of breathing pattern disorders as a type of DB (Barker and Everard, 2015). Presently, it is unclear how DB mechanics could affect the musculoskeletal (MSK) system.

Research into respiration and the MSK system has focused on the delivery of oxygen and ventilation during exercise and how exercise affects breathing (Chaitow et al., 2014). It is understood that an increase in activity of the MSK system leads to a higher oxygen consumption (McArdle et al., 2015). Subsequently, an increase in oxygen consumption leads to an oxygen deficit and so the breathing rate increases (McArdle et al., 2015). However, it is less understood how breathing mechanics effect the MSK system. Summaries, narrative reviews and descriptive literature of breathing mechanics and their relationship with the MSK system have been published in previous literature (Kocjan et al., 2017; Hamasaki, 2020). Fewer studies involving primary data collection have been published.

The purpose of this chapter is to review the evidence base surrounding the effects of DB on the MSK system, through the method of a literature review (Grant and Booth, 2009; Snyder, 2019). It is understood that narrative style literature reviews are susceptible to critique and are opinion-biased (Basheer, 2022), but the aim of this review is to create academic discussion and give future direction to research, clinical practice, and education.

Comprehensive searches were conducted of the current and relevant literature relating to breathing and its effects on the MSK system accessing the Leeds Beckett University library catalogue and Google Scholar. The University's databases included in the search were: Directory of Open Access Journals, Gale Academic OneFile, PubMed Central (MEDLINE), Scientific Electronic Library Online, Taylor and Francis Online, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Allied and Complimentary Medicine Database (AMED) and Wiley Online Library. As in Chapter Two, both CINAHL and AMED were searched

retrospectively with no additional relevant literature found that had not already been found or that impacted on what was already found. All included databases post scientific and medical journals and therefore had relevance to the research question (see table 1 for rationale of database inclusion). The review considered all peer reviewed published research and considered few relevant key texts to support the anatomical descriptions within this review. The search terms used are presented in Table 4.

Search Terms relating to DB	Boolean Terms Used	Search Terms relating to MSK
Dysfunctional Breathing	AND	Musculoskeletal
Breathing		Function
Hyperventilation Syndrome		Diaphragm
Breathing Pattern Disorder		Movement
Breathing Pattern		Mobility
		Muscle
		Posture
		Joint
		Ligament
		Tendon
		Fascia

Table 4 Search Terms Used for the literature review of the effects of Dysfunctional Breathing on the Musculoskeletal System

Each term and their combinations were searched specifically to be included in either the title or abstract of the relevant papers. This review aims to identify any possible effects on the MSK system that DB could have. As such, after prior reading and conducting a critical review of DB the following terms were identified as search terms relating to DB: “Dysfunctional Breathing”, “breathing” and “Hyperventilation Syndrome”. Furthermore, “Breathing Pattern” and “Breathing Pattern Disorder” are common terms used in relation to the mechanics of breathing or the dysfunction of breathing mechanics, as identified by Barker and Everard (2015) therefore are also included as terms relating to DB and included in the search. “Function”, “movement”,

“mobility” and “posture” are terms that relate to specific functions of the MSK system, and if studies have been conducted in relation to each of them affected by DB or breathing then the search should reveal them. The terms “muscle”, “diaphragm”, “joint”, “ligament”, “tendon” and “fascia” are terms relating to specific structures within the MSK system which could be affected by DB. The term dyspnoea was excluded from the search terms as this term was not deemed specific to DB, but a wider term used to describe shortness of breath. In excluding dyspnoea from this search, the number of papers returned in the searches will have been reduced and mostly relating to DB specifically.

The inclusion criteria for all papers identified are set out in Table 5 below.

Inclusion Criteria	Exclusion Criteria
Peer reviewed journal article / textbook	All forms of dissertation, theses or non-peer review journal articles
Published in English	Not published in English
Article contains specific information relating to breathing and its effect on the MSK system.	Article provides no insight in to breathing and its effect on any aspects of the MSK system.
Qualitative and quantitative studies Accepted	n/a
Narrative publications (as long as supported by evidence throughout)	Narrative publications with minimal evidence to support its claims
Relevant case study reports to DB or breathing mechanics and MSK system	Case study reports not relevant to DB and MSK system

Table 5 shows the inclusion and exclusion criteria applied to all papers identified using the search terms and Booleans terms set out for this review

The literature search was conducted, and found four possible types of effects DB could have on the MSK system:

- Anatomical Effects

- Biomechanical Effects
- Physiological Effects
- Neurological Effects

3.1 Anatomical Effects of DB on the MSK System

The diaphragm is primarily involved in respiration but has been said to influence posture, organ function by way of supporting pelvic organs, the pelvis and the vascular and lymphatic systems (Bordoni and Zanier, 2013). As the diaphragm has more than one function, and has multiple anatomical connections throughout the body, it forms a “network of breathing” (Kocjan et al., 2017, p. 224). It is proposed that any dysfunction of the diaphragm could consequently cause dysfunction in any structures directly or indirectly anatomically connected to it (Sajko and Stuber, 2009; Tufo et al., 2012).

Anatomically, the diaphragm separates the abdominal and thoracic cavity and is separated into two domes: the left dome and the right dome (Soames and Palastanga, 2019). Between the two domes is the central tendon of the diaphragm which is found at the level of the xiphisternal joint (Kocjan et al., 2017). The centre of the diaphragm, between its attachments on the 12th ribs and the central tendon, is referred to as the Zone of Apposition (ZOA) (De Troyer, 1988; Kocjan et al., 2017). The ZOA is the area of the diaphragm that can descend into the abdominal cavity, creating more space in the thoracic cavity during inspiration.

The lumbar section of the diaphragm arises from the medial and lateral arcuate ligaments which are lateral to the crura (Soames and Palastanga, 2019). The medial arcuate ligament is a thickening of the fascia covering the psoas major, whilst the lateral arcuate ligament is a thickening of the fascia covering the quadratus lumborum (Soames and Palastanga, 2019). Figure 4 shows a diagram of the diaphragm and its proximity to the psoas major and quadratus lumborum as mentioned above (Drake et al., 2020, p 261).

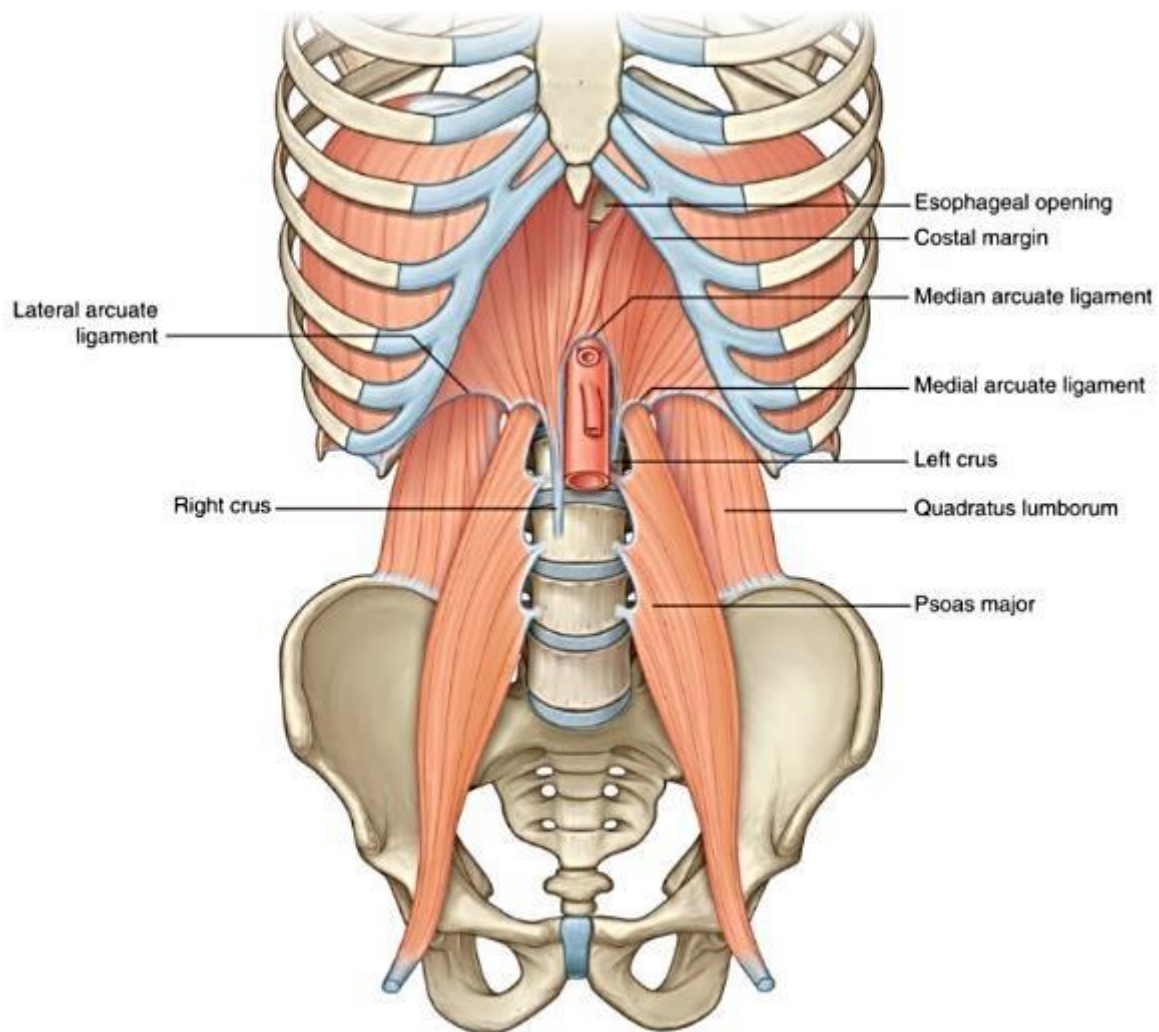


Figure 4 - The anatomical locations of the psoas major, quadratus lumborum and diaphragm muscles, demonstrating the proximity of each structure and the locations of the medial and lateral arcuate ligaments (Drake et al., 2020, pg. 261).

It is widely accepted that the psoas major's main actions are as a flexor of the hip joint, and a flexor of the trunk, and has little direct involvement in respiration even though their anatomical connection with the diaphragm is well documented (Kocjan et al. 2017; Soames and Palastanga, 2019; Drake et al., 2020). However, the psoas major and minor (psoas complex) is surrounded by a fascial sheath stemming from the transversalis fascia and the thoracolumbar fascia. The superior psoas fascia continues superiorly to the diaphragm via the medial arcuate ligament (Sajko and Stuber, 2009). It was further reported that the crus of the diaphragm and their fascia overlap the psoas major and present as a continuation of the psoas major until the crus come more anterior and join the anterior longitudinal ligament of the spine (Sajko and

Stuber, 2009). Tufo et al. (2012) proposed that due to the existence of these fascial connections between the diaphragm and the psoas major a dysfunctional psoas major could cause DB, and conversely, DB has the potential to cause dysfunction of the psoas major muscles. This was a sole case study and hence needs to be considered with caution. At present, no studies have investigated this theory, but Tufo et al. (2012) implies that DB could have a direct causal relationship with psoas syndrome. Symptoms of psoas syndrome are often reported as lower back pain, pain when standing from sitting, pain on standing fully erect and pain in the contralateral gluteal and radiating pain down the contralateral leg (Tufo et al., 2012). Whilst this may be plausible and related to the anatomical attachments of the psoas, these suggestions are based on a case study report meaning the results are not generalisable and further research is required to confirm these findings. No primary data studies have been found to support this. Other studies that were identified highlighting the link between the diaphragm and the psoas major were mostly narrative (Bartoskova, 2021).

Similarly, because of the attachments of the quadratus lumborum and the lateral arcuate ligaments it could be hypothesised that dysfunction of the diaphragm could cause altered function of the quadratus lumborum. No research has been found exploring this notion. The function of the quadratus lumborum within breathing mechanics, however, remains disputed in literature. From studies of six cadavers Phillips et al. (2008) proposed that due to the anatomical attachments of the quadratus lumborum muscle its primary role could be to act as a respiratory muscle. This, they argued, is because it braces the 12th rib to give the diaphragm a stable base to contract from. In opposition to this, using fine-wire electromyography (EMG) on twelve healthy participants, Park et al. (2012) found a significant change in activity of the posterior fibres of the quadratus lumborum during inspiration. The posterior fibres of the quadratus lumborum have no direct attachment to the 12th rib, instead attaching to the transverse processes of L1 to L4 vertebra. The anterior fibres of the quadratus lumborum do attach to the 12th rib although Park et al. (2012) found there was no significant change in the anterior fibres of the quadratus lumborum during respiration. This differed from Phillips et al.'s (2008) proposal where no explanation was offered as to why the posterior fibres increased in activity during

inspiration and why the anterior fibres did not. Breathing pattern mechanics were not observed as part of this study so it could be that participants with DB patterns were involved. Park et al. (2012) had twelve participants, whilst Phillips et al. (2008) used six participants in their respective study. As the sample sizes were small for these two studies, their findings should be accepted with caution. Measuring the activity of these muscles during respiration in participants with DB patterns before comparing the results with individuals with normal breathing mechanics could provide further clarity. The effect of the shared connections between the quadratus lumborum muscles and the diaphragm also needs further exploration to determine the role of the quadratus lumborum in respiration.

When the diaphragm is functioning normally, moving in a caudal and anterior direction during concentric contraction, other structures within the trunk also move and function normally. For example, the pelvic floor moves in tandem with the diaphragm (Talaszi et al., 2011). Talaszi et al. (2011) concluded that, due to their fascial connections, the diaphragm and pelvic floor move correspondingly. It can be hypothesised that DB which results in dysfunction of the diaphragm has the potential to affect the ability of the pelvic floor to function normally and complete its actions.

The thoracolumbar fascia, which surrounds the psoas major, also involves the latissimus dorsi, the trapezius, the external obliques, and the gluteus maximus, as well as the iliosacral ligaments (Bordoni and Zanier, 2014). If the diaphragm were to be found to influence the psoas major, and prevent it from functioning as expected, then it could be hypothesised that these structures can also be indirectly affected by DB. Research to determine the effect of dysfunction within the thoracolumbar fascial chain is required. Furthermore, the scalene muscles and the rectus abdominis are connected to the diaphragm via the fascia transversalis as a continuation of the endothoracic fascia (Bordoni and Zanier, 2014). It remains unclear to what extent DB could affect the condition and functionality of the scalene muscles and the rectus abdominis muscles.

Bordoni and Zanier (2015) indicated that the diaphragm is anatomically connected to the pelvic floor, tongue, the thoracic outlet, and the tentorium of the cerebellum; these (including the diaphragm muscle) are referred to as “the five diaphragms” (Bordoni, 2020). These anatomical areas/structures are linked by the thoracolumbar fascia (Bordoni, 2020). Moreover, they suggest that dysfunction in the diaphragm (or DB) can have a causal relationship with symptoms or dysfunction in any of the above mentioned “five diaphragms.”

3.2 Biomechanical Effects of DB on the MSK System

Within this section the biomechanical impact of DB on the MSK system will be explored. Additionally, breathing pattern dysfunctions will be reviewed in an attempt to clarify the potential effects these dysfunctions could have on the MSK system. Normal breathing mechanics were described in Chapter One.

Breathing pattern dysfunction has been demonstrated to have a negative effect on functional movement screening (FMS) scores. Bradley and Esformes (2014) hypothesised that the reasons for their results were multifactorial. They assessed thirty-four healthy individuals' breathing using breath hold time, the Hi-Lo assessment, respiratory rate, end tidal CO₂ and the Nijmegen questionnaire whilst also assessing their movement using the FMS protocol. They found that 75% of participants who scored ≤ 14 on the FMS scoring were assessed to have a breathing pattern disorder, whilst only 33.4% in comparison, had a breathing pattern disorder in the group which scored ≥ 15 . They suggested that DB could lead to physiological adaptations during functional movements such as decreased postural stability due to a decrease in diaphragmatic excursion. They concluded that diaphragmatic breathing, over thoracic breathing, was important for increased success and efficiency of movement during FMS. Kiesel et al. (2017) also found better FMS scores in patients without DB (averaging a score of 16) as opposed to with DB (averaging a score of 13.5), using the Hi-Lo breathing assessment tool to indicate the presence of DB. Furthermore, Cowen (2010) showed that, when they prescribed a 6-week yoga programme with elements focusing on diaphragmatic breathing and breath control techniques, FMS scores improved by 16%. The mean score of the FMS increased from 13.25

pre-yoga to 16.55 post-yoga programme. Additionally, a significant improvement (26.46cm pre-yoga to 28.06cm post yoga) in the sit and reach test was reported. These FMS improvements may also have been influenced by the exercises included in the yoga programme as the programme focused on pranayama (breathing techniques), asana (postural exercises) and savasana (relaxation techniques).

Previously, it has been suggested that individuals may have difficulty in dissociating respiratory diaphragm function and implementing core stability during activity (McGill et al., 1995). Assessing eight healthy males lifting and holding loads of 73kg to 95kg, McGill et al. (1995) found that most participants (six out of eight) demoted the responsibility to breathe effectively in preference of stabilising the trunk with large muscle forces. This study is dated and uses a small sample size, however to this researcher's knowledge, no further studies have been conducted since exploring the same concept. Furthermore, using anal and vaginal EMG during repetitive arm movements designed to effect core stability, Hodges et al. (2007) concluded that participants found it difficult to dissociate pelvic floor muscle activity between a repetitive arm movement and respiration, particularly expiration, demonstrating the pelvic floor muscles could be involved in active respiration, in an attempt to maintain intraabdominal pressure, supporting McGill et al.'s (1995) findings.

The cylinder theory of maintaining intra-abdominal pressure to provide stability to the lumbar spine includes diaphragm function and control (McGill and Norman, 1987). This theory suggests the pelvic floor muscles and abdominal muscles work together, with the abdominals and multifidus, to provide a rigid cylinder during physical activity to stabilise the lumbar spine. Talasz et al. (2011) studies eight healthy nulliparous women using real-time dynamic magnetic resonance imaging (MRI) and concluded that the diaphragm and pelvic floor muscles share a cranio-caudal parallel relationship, meaning if one is moving inferiorly whilst contracting then so does the other, to maintain appropriate intra-abdominal pressure. Therefore, the diaphragm must be considered as part of the cylinder theory of maintaining stability in the lumbar spine.

Linking back to McGill et al. (1995) and Hodges et al.'s (1997) findings, the reduced efficiency of

breathing during loading of the upper limb may be due to the diaphragm's involvement as a trunk stabiliser, as opposed to a prime muscle of respiration in this action. This would further suggest that if DB was present, and the diaphragm could not be used to match the action of the pelvic floor during loading, then lumbar (trunk) stability could be compromised. This would likely be due to the inability to maintain the same intra-abdominal pressure throughout the action.

Coulombe et al. (2017) found that increased core stability strength decreased patient's pain and increased function in patients with lower back pain within the first three months as the mean difference of score on a visual analogue scale or numeric rating scale was -1.29 and functional status improved by a mean difference score of -7.14 on the Oswestry Disability Index or the Roland-Morris Disability Questionnaire. As there is little research available at the time of submitting this dissertation, this researcher has found no evidence that explores the role of breathing mechanics on core stability strength. It remains undetermined what effect DB may have on core stability strength, and subsequently its effect on the symptoms of lower back pain.

The onset of diaphragm contraction coincides with contraction of the transversus abdominis, often thought of as a prime muscle in trunk stability, as well as a prime muscle in forced expulsion of the abdominal and thoracic cavity (in actions such as vomiting and coughing) (Hodges et al., 1997). This could potentially explain the difficulty in dissociating breathing mechanics with lumbar stability mechanics that McGill et al. (1995) found. However, referring back to the anatomical connections of the diaphragm, abdominals and pelvic floor, another reason could exist for this lack of ability to dissociate and breath effectively during loading, such as their role in stabilising the lumbar spine.

Vostatek et al. (2013) conducted a postural analysis of the function of the diaphragm in seventeen participants suffering from chronic lower back pain, diagnosed with a structural spine disorder, and a control group of sixteen healthy subjects. Both groups were tasked with resisting a force applied to the lower limb against flexion of the hips. The study concluded that the breathing rate increased significantly ($p=0.01$), and the breath depth decreased significantly ($p=0.001$) during loading in the pathological group but not in the control group, in both situations.

It is unclear whether the lower back pain or structural spine disorder influenced the changes in breathing or whether the changes in breathing mechanics are the cause of the chronic lower back pain and spinal disorders of the participants. The study also reported that changes in diaphragm posture and function were significantly slower, better balanced and bigger in size in the control group, suggesting there is more diaphragmatic control when pain or MSK dysfunction is not present.

Previous conceptions around breathing suggested that expiration during rest was considered a passive process of exhalation of air by elastic recoil of the respiratory organs and relaxation of the inspiratory muscles (Soames and Palastanga, 2019) but as summarised in Kocjan et al.'s (2017) literature review the abdominals are active during respiration. During inspiration as opposed to expiration, individuals performing an isometric trunk loading task in one of eight randomised directions noted a significant increase in the activity of the internal obliques, despite the internal oblique's primary role in respiration being in expiration (Park et al. 2012). Park et al. (2012) hypothesises that the increase of activity in the internal obliques during inspiration could be the abdominal muscles controlling the length tension relationship of the diaphragm, supporting De Troyer's (1997) earlier work.

From a large cross-sectional study of three-hundred and six child 'mouth breathers' versus one-hundred and twenty-four 'nose breathers' it was found that severe postural stability issues were more prominent in those children with mouth breathing syndrome; 9.63% of mouth breathers had severe postural problems compared to 0.83% of nasal breathers being assessed as having severe postural problems (Conti et al., 2011). More specifically, this study linked mouth breathing to increases in cervical lordosis, thoracic kyphosis, head and shoulder protrusion and head tilting. This indicates a need for early treatment of DB or breathing education for children and adolescents who mouth breathe. Further exploration of the impact of mouth breathing on postural stability issues is required in the adult population, and links to alternative forms of DB could be identified.

Thoracic dominant breathing was identified as a form of DB (Boulding et al., 2016). During

thoracic dominant breathing, accessory breathing muscles begin to activate more than in normal breathing (Gutiérrez et al., 2014). On forty healthy males Gutiérrez et al. (2014) found the external intercostal muscles showed a significantly higher EMG activity in the upper costal breathing type than in the costo-diaphragmatic breathing type. Hruska (1997) suggested that thoracic dominant breathing results in hypertonicity of the accessory breathing muscles, such as the SCM and the scalenes, and this can prevent the diaphragm from returning to its optimal resting condition. It could be hypothesised that over time, this change in breathing style can increase the workload of the sternocleidomastoid, scalenes and intercostal muscles and consequently increase the likelihood of injury.

Periodic deep sighing was identified by Boulding et al. (2016, pg. 292) as a type of DB and defined as “frequent sighing with an irregular breathing pattern”. There are few studies that have attempted to assess the effects of periodic deep sighing on the MSK system. Li and Yackle (2017, pg.89) provided an overview of sighing, defining it as a “long, deep breath that is often viewed as an expression of stress, sadness, exhaustion or relief.” In addition, they argued that typically a sigh occurs as a larger inspiration following an initial normal inspiration, which is ultimately preceded by a respiratory pause known as a post-sigh apnoea. This respiratory pause is likely to mean a pause in mechanical movement of the diaphragm and other respiratory muscles, which in certain circumstances such as when moving or in standing, can potentially influence the static and dynamic postures of individuals and their ability to move efficiently.

Further research is necessary to determine the extent of the biomechanical effects of DB. Specifically, investigation of the different types or classifications of DB is needed to allow for practicing clinicians to be able to assess and diagnose an individual's DB and its impact more accurately. Specific biomechanical functions should be investigated in relation to DB, highlighted within this subchapter, such as abdominal function, core/trunk stability, specific functional movements and the ability to perform physical activity. Special consideration should also be made in relation to further research exploring the importance of nasal breathing on the development of children and adolescents, and if this impacts adulthood and the body's ability to

function appropriately once development has ceased.

3.3 Physiological Effects of DB on the MSK System

Hyperventilation syndrome has been identified by Boulding et al. (2016) as a type of DB. Using a sample of 8 men LeBlanc et al. (2002) found that, when voluntary hyperventilation is present, there was a greater lactate (2.4mM at rest to 5.3mM after 14 minutes exercise in the voluntary hyperventilation group, in comparison to 1.2mM and increased to 3.7mM in the control group) accumulation in the muscles during the transition from rest to exercise. Whilst these results indicate there could be a greater lactate accumulation as a result of DB they are not generalisable to women or the wider public due to the small sample size used. Powers et al. (2021) suggested that greater lactate accumulation will contribute to surpassing the lactate threshold of the muscular system leading to greater muscle fatigue. Despite the small sample size it could be hypothesised that hyperventilation syndrome could lead to greater muscle fatigue. To investigate this further, a study measuring the effects of HVS or DB on muscle fatigue, measured by EMG, should be conducted.

Research into the physiological effects of alternate types of DB has yet to be conducted. Studies to explore the effects of DB on issues such as oxygen deficit at rest or during exercise, and whether this impacts the MSK system should be conducted. It is hypothesised by this author that if DB were to result in an oxygen deficit being present at rest or during exercise, then this would have significant implications for the performance of the MSK system, particularly during exercise.

Studies considering the effect of exercise on breathing (Forster et al., 2012; Cross et al., 2021) have been conducted, but there are yet studies considering the effect of DB, specifically and in isolation, on an individual's ability to exercise efficiently.

3.4 Neurological Effects of DB on the MSK System

The diaphragm is innervated by the phrenic nerve which arises bilaterally from the levels of C3 to C5 in the cervical spine (Kocjan et al., 2017; Soames and Palastanga, 2019).

The supraclavicular nerves also originate from this section of the spine and sensory innervate the shoulder region (Kocjan et al., 2017). Kocjan et al. (2017) proposes that dysfunction of the diaphragm (and therefore DB) can result in referred pain in the shoulder region if the phrenic nerve is overstimulated.

Reflex sympathetic activation is a function of the autonomic nervous system and is often instigated during physical activity to maintain homeostasis (Seals and Victor, 1991). St Croix et al. (2000) set out to test the hypothesis that fatigued inspiratory muscles can cause reflex sympathetic activation. Muscle sympathetic nerve activity (MSNA) was measured using intraneural electrodes in the right peroneal nerve of the leg whilst participants were instructed to complete a breathing protocol which has previously shown to reduce blood flow and cause fatigue in the diaphragm. St Croix et al. (2000) concluded that an increase in MSNA was present because of fatiguing respiratory muscles. They proposed the time dependent increase could be as a result of a reflex triggered by an accumulation of metabolic end products and compromised blood flow which has been more recently supported by Katayama et al. (2012). Derchak et al. (2002) conducted a similar study to St Croix et al. (2000) but in this instance measured MSNA in expiration. They similarly found a time dependent increase in MSNA coinciding with fatigue of expiration muscles. These findings would suggest that a DB breathing pattern can cause reflex sympathetic activation. If MSNA increases throughout the body during the type of DB used in St. Croix et al.'s (2000) study, then should an individual adopt those breathing mechanics as their norm, this may have the potential to cause a chronic increase in MSNA activity. Chronic sympathetic hyperactivity has been linked with increased muscle stiffness, muscle tone and dystonia, amongst other whole-body conditions (Blackman et al., 2004).

Diaphragmatic breathing is often thought as an essential part of meditation practices within martial arts and yoga practices (Hamasaki, 2020). Conducting a meta-analysis, Zou et al. (2018) found that practices such as yoga and tai chi have shown a reduction in levels of perceived stress in individuals and hypothesise this is due to the regulation of the sympathetic-vagal balance, through the use of breathing exercises. It is unclear how much breathing control alone is responsible for the reduction in stress. It could be hypothesised, taking into

consideration St Croix et al. (2000), Derchak et al. (2002) and Katayama et al.'s (2012) findings, that DB can be a direct cause of increased MSNA, upsetting the sympathetic-vagal balance and therefore contributing to an individual's feeling of negative emotion or high stress.

It remains unclear to what extent DB can affect the autonomic and skeletal nervous systems and subsequently the MSK system, but it is important that this is established in future research.

3.5 Conclusion

Several anatomical impacts have been identified in the literature with more impacts hypothesised warranting further research. Likewise, biomechanical impacts have been discussed with some preliminary studies having been conducted to support the theory that DB can affect the MSK system. There remains scope for further research to be conducted in the investigation of certain potential biomechanical effects. There is little evidence exploring the physiological implications of DB on the MSK system, however this does not mean that this area is irrelevant in the assessment of DB and its impacts on an individual's MSK health. There is a base of knowledge to suggest that DB can have neurological impacts on the MSK system, but these also require further investigation.

To summarise this chapter, the majority of the research into DB and the effects on the MSK system have thus far focused on the anatomical and biomechanical implications. A mixture of narrative and primary data collection studies have determined that DB does have the potential to affect several elements of the MSK system and its ability to perform appropriately in different environments and activities. It is yet to be determined what the scope of the effect is that DB can have on the MSK system. This area needs an abundance of exploration and further investigation to determine the significance of the effect of DB on the MSK system, now that it has been established it is possible it can have an effect at all.

This review has identified multiple potential effects on the MSK system as a result of DB. However, little is known about the clinical reasoning behind breathing assessment and intervention in relation to improving an individual's MSK health. Therefore, the study of this dissertation is designed to explore the beliefs and opinions of practicing MSK therapists whom

may or may not use breathing interventions as part of their practice. Findings from such a study may potentially identify further effects that would benefit from further exploration whilst also contextualising the findings presented in this review from a clinician's perspective.

4.0 The Relevance of Dysfunctional Breathing in Musculoskeletal Practice

At present, it is not known what musculoskeletal (MSK) clinician's understanding of dysfunctional breathing (DB) is and whether they are considering DB as a cause of pathology or as a symptom during their assessment and management of their patient's conditions. This study will aim to explore MSK clinician's perceptions of DB and the effects it has on the MSK system.

4.1 Study Design

This study used a qualitative study design using a focus group interview and an individual interview to collate the perspectives of clinicians on DB and its use in MSK practice. Using a focus group modality provided an informal environment for clinicians to share their opinions and allowed for group discussion which may have prompted some opinions from participants they otherwise may not have considered disclosing (Guest et al., 2017). Focus groups are said to increase the depth of the information that is unveiled and to raise data which may otherwise be overlooked in an individual interview (Freeman et al., 2001; Lambert and Loiselle, 2008). This method was preferred to encourage participants to share their beliefs, regardless of how evidence-based their beliefs were. If other participants were sharing similar opinions then participants may be more forthcoming. Whilst it can be argued in an individual interview setting a participant may be more likely to share as their fear of judgement would be less, they may also be less inclined to share their belief with the one researcher, without being prompted by others.

From a relativist ontological perspective, this study was designed to explore the classification and association of DB within MSK practices, according to those practicing in MSK healthcare. As the aim of this study was to explore the opinions of professionals working within healthcare the sampling method chosen was both purposive and voluntary response sampling.

This study used an interpretive paradigm due to the anticipated knowledge of participants being relative to their particular experiences and be open to their own, individual interpretations (Varpio and MacLeod, 2020).

4.1.1 Research Ethics

This study was submitted for Stage 1 and 2 ethics approval at Leeds Beckett University and gained approval from the Leeds Beckett University Ethics Committee on Thursday 27th January 2022 (see Appendix 12).

This study followed and complied with the four ethical pillars as determined by Beauchamp and Childress (2001) namely being respectful of autonomy, non-maleficence, beneficence and justice.

Each participant was provided with a participant information sheet and must agree and sign an informed consent document. This ensures autonomy, non-maleficence and justice. As this study is exploring the beliefs of practitioners, it is identifying direction for future research to ensure that current practice within MSK health remains up-to-date and optimal for patient's being treated in circumstances where DB is being assessed, ensuring the ethical pillar of beneficence is met also. The ground rules of the focus group were designed to enable an equal voice from all participants, ensuring the final ethical pillar of justice.

4.1.2 Participant Information Sheet

To ensure autonomy, all prospective participants were provided with a participant information sheet, which outlined the details of the study, what is expected of each participant and how their results and data were to be used and protected. This document also included inclusion and exclusion criteria so participants could self-exclude themselves from the study if they met any of the exclusion criteria, designed to warrant the study was conducted fairly and in a balanced manner. The participants were able to withdraw from the study at any time, ensuring they had autonomy of their participation. See Appendix 5 for the full document.

4.1.3 Informed Consent Form

All participants were informed of the risk of the study and how their results will be used after their participation had ended. They were provided with an informed consent sheet which included statements of confirmation that were agreed to for each participant to continue in the study. Participants anonymity was upheld throughout the study through the use of pseudonyms, and the participants given clear instructions on how to communicate within the interviews to avoid conflict therefore ensuring non-maleficence. See Appendix 6 for the full informed consent form document.

4.1.4 Data Storage

Records of the transcriptions were kept in the form of Microsoft Word documents which were saved on a password protected personal computer. Video and audio recordings of the focus group interviews were saved on the same device.

4.2 Population

The population of this study were health professionals working within musculoskeletal practice who also have experience of working with patients who suffer from DB. These participants were to be based in the United Kingdom and work within public or private healthcare.

Participants were asked to participate voluntarily. Social media posts, specifically on Twitter and LinkedIn were used to recruit participants. Snowball sampling was also used, as participants were asked to help recruit other participants they thought may have an interest in DB in MSK practice. The principal investigators email correspondence was provided to such parties, for prospective participants to register their interest. This method was used to bring together MSK therapists who held an interest in this topic area. To ensure a wide range of opinions were explored, the participants were selected from volunteers based on their professional background and their level of expertise. If the voluntary sample predominantly consisted of one profession, for example, physiotherapists, then purposive sampling was used to identify a broader sample using the inclusion and exclusion criteria set out below in Table 6.

Inclusion Criteria	Exclusion Criteria
Experience working within a MSK environment.	Limited or no experience working within MSK environment.
Experience of working with patients with DB.	No experience of working with patients with DB.
Employed in current practice at the time of focus group interview.	Unemployed/Retired
Participant's opinions and beliefs not known to each other or to facilitator.	Participant's opinions and beliefs known to facilitator or other participants.
Over 18 years old	Under 18 years old

Table 6 shows the inclusion and exclusion criteria used on participants in this study

Participants were to have experience of working in musculoskeletal environments; this is essential to understand how dysfunctional breathing is assessed and treated and to gauge what bearing it might have on musculoskeletal health.

All participants were to have some experience of working with patients who suffer with dysfunctional breathing; this does not mean participants must assess and treat dysfunctional breathing, but they recognise that some patients do suffer from dysfunctional breathing. These participants were included in the study as it is equally important to understand why a clinician might not assess and treat dysfunctional breathing as part of a musculoskeletal health service.

It was important to the researcher that every participant was still in current practice/employment in a musculoskeletal health capacity, as this study was aiming to identify current practices and the latest uses in musculoskeletal practice, as opposed to techniques which are not commonly used in present day practice. Participants who were unemployed or retired were excluded from the study.

It was also of importance that participants in each focus group interview were unfamiliar with the other participants in the group, to reduce social pressures and prompt authentic discussion, rather than adapting their views or restricting their disclosure of their opinions so as

not to damage any current relationships between participants.

To meet the above criteria, all participants were to be aged above 18 years old.

4.2.1 Participant enrolment

Participants were provided with a participant information sheet (see Appendix 5), detailing the study design, risks and benefits and inclusion criteria. Participants were also asked to complete a consent form (see Appendix 6) prior to commencement in the study.

Participants were asked to complete a pre-screening questionnaire (see Appendix 7) so basic data was collected and could be analysed for specific themes which might arise between individuals of the same profession or between different professions/standards of education.

4.3 Pilot Study

A pilot study using convenience sampling was conducted four weeks prior to the main study in order to refine the study parameters and questioning and to identify any potential issues that participants may experience. All participants found questions relating to Boulding et al.'s (2016) DB classifications to be confusing, and after attempts to explain each classification were made by the facilitator, participants were still unsure on what was meant by each classification and so this question was removed from the focus group interview questioning. The order of questioning was also adapted to encourage a better flow to the interview. Questioning was split in to three sub sections: exploring DB, DB assessment techniques and DB interventions. During the pilot study, it was identified that the questioning was going back and forth between assessment and intervention and so became confusing for participants also. Clarification was also needed on questioning relating to how practitioners assess DB, as opposed to how practitioners assess the effects of DB on the MSK system; due to their being some crossover between these two lines of questioning, the questions were further defined for the focus group interview using prompt words. The pilot study lasted 90 minutes initially, which had been predetermined as too long a time to be questioning the participants, as there was a risk of losing the attention and availability of individuals during the focus group.

4.4 Focus groups and data collection

Within the focus groups, a constructivism view was used as this allowed for participants of different backgrounds and educations to express their individual views and experiences as a healthcare worker. This allowed participants to express their opinions using their own words, without the need for structured terminology or repetition of results from previous studies which have explored dysfunctional breathing (Vrasidas, 2000).

One focus group was conducted lasting approximately 80 minutes. The focus group interview took place on Microsoft Teams for greater convenience for participants, to minimise logistical challenges, such as travel, allocating time towards participating, etc, and to provide a neutral venue for hosting. Four people met the inclusion criteria and were allocated to the focus group interview following the participants screening process. One other participant volunteered to participate in the focus group interview but was not available on the date arranged. As such, a separate individual interview was undertaken to ensure all interested individuals could share their views. The individual interview lasted approximately 40 minutes, via Microsoft Teams, using identical questioning as the focus group interview.

The principal investigator facilitated both interviews and encouraged participants to share their views openly and without judgement, whilst using prompts and questions to ensure the discussion points were covered. Prior to any questioning, some ground rules were presented to participants. All participants were expected to listen when others shared their opinion without interrupting, to respect each other's background, profession, and opinions, to avoid talking over each other and to maintain confidentiality after the interview had concluded. Participants were instructed to use the raise hand function on Microsoft Teams if they had something to add to answering the relevant question and would be given chance to speak in due course. Participants were also discouraged from discussing COVID-19 where possible, unless they deemed it was relevant to the topic of discussion at the time. It is important confidentiality was maintained to improve cohesiveness between participants and to ensure the participants felt comfortable about sharing their opinions (Pope and Mays, 2006).

Once all participants had been briefed on the ground rules for the interview, and were happy to proceed, the questioning began.

There were eleven questions presented to participants (Appendix 8), divided in to three types of questioning; one engagement question, nine exploration questions and one exit question. The questioning was left as open as possible to minimise participant bias and produce meaningful responses.

4.5 Data Analysis

The focus group and individual interviews were video and audio recorded on Microsoft Teams and transcribed by the same individual to provide a record of the content of the interview. A thematic analysis approach was then taken to clarify common opinions shared within the interviews (Braun and Clarke, 2022). Analysis of how the identified themes are interconnected took place also, to identify any relationships between individuals of the same profession, education, or employer. A coding table was used to firstly identify the codes from the data with regards to DB and its place in MSK practice (see Appendix 13). Each code was defined, and an example provided for clarity, once identified. These codes were then grouped into initial themes before refinement took place. Consultation of the current literature surrounding each initial theme took place to support the generation of codes and refined themes. Following Braun and Clarke's (2022) thematic approach the transcriptions were read many times in conjunction with the video and/or audio recordings. This developed familiarity with the content enabling the generation of codes and refining of subsequent themes. The data analysis took place manually and did not use any automatic software to analyse the focus group interview or the individual interview data, as Maher et al. (2018) suggested the sole use of software could lead to data being overlooked. According to Nowell et al. (2017) the criteria for trustworthiness in qualitative research hinges on the credibility, transferability, dependability, confirmability, audit trails and reflexivity of the thematic analysis. Prolonged engagement and persistent observation methods were used throughout to enhance the credibility of this study. Quotation example of each code was sourced from the original data in attempt to strengthen the transferability of this study's

findings. The research process has been clearly documented in this thesis to increase the dependability of this study, and readers can determine whether the process is logical and traceable from this. Justifications of each theme identified, along with the quotation examples, will enhance the confirmability of this study, should it be determined by the reader that credibility, transferability and dependability have all been confirmed (Nowell et al., 2017). Records of the transcripts and coding table have been provided (see appendix 9 and 13) to create an audit trail for other researchers to follow and determine the overall trustworthiness of this study design.

In this study, as an aim of this project was to identify the potential effects of DB on the MSK system, focus was given to individual point of view. This was by design to try and identify what clinicians thought the effects of DB were on the MSK system as opposed to only identifying the effects on the MSK system which are founded in evidence. If individuals who were interviewed had only cited research and the effects they propose, then there would have been no need to conduct the focus group interviews. This study was looking to explore those beliefs which may not yet be founded in evidence also, so that direction on future research can be given.

4.6 Resources

The focus group interviews were conducted on Microsoft Teams so access to this software and a computer was necessary to conduct the focus group and individual interviews. Each participant needed access to Microsoft Teams software and a personal computer. The participants joined the focus group interview via the hyperlink emailed to their email address prior to the focus group or individual interviews; this allowed for each participant to follow the hyperlink into the meeting without the requirement for a Microsoft Teams account or downloading any software.

4.7 Work Plan

A workplan was provided for the timeframe of the study. See Appendix 4.

5.0 Findings

In total five participants working within MSK health settings met the inclusion criteria and were available to participate. Four participants took part in a single focus group interview. Additionally, one participant who could not attend the focus group interview and met the inclusion criteria, was offered an individual interview. The focus group lasted for ninety minutes, and the individual interview lasted for forty minutes. These durations were indicated to be a reasonable timeframe considering the participants being interviewed (Krueger and Casey, 2015).

The participants fulfilled the inclusion criteria and were made up of two sports and exercise therapists, one osteopath, one yoga instructor, and one Chinese acupuncturist. Below is Table 7, containing the pseudonyms, professional details and level of education relating to each participant, to help provide context to the results of this study.

<i>Participant Pseudonym</i>	<i>Profession</i>	<i>Highest Qualification</i>
<i>“Jasmine”</i>	<i>Osteopath and Equine Therapist</i>	<i>Master of Science Degree</i>
<i>“Steven”</i>	<i>Graduate Sports Therapist and Lecturer</i>	<i>Master of Science degree</i>
<i>“Martin”</i>	<i>Chinese Acupuncturist</i>	<i>Bachelor of Science Degree</i>
<i>“Violet”</i>	<i>Graduate Sports Therapist</i>	<i>Master of Science Degree</i>
<i>“Fred”</i>	<i>Yoga Instructor</i>	<i>Diploma in Neuromuscular Physical Therapy</i>

Table 7 introduces the pseudonyms of the participants with some detail on their professional background and their level of education

Several themes were identified from the interviews. It was identified during the interviews that

all practitioners assessed and intervened with an individual's DB during their work within MSK health. However, there was varying frequency of usage across participants. The participants confirmed that they used assessment and intervention techniques for DB as they believed there to be a cause-and-effect relationship between DB and other systems within the body that relate to their work. Specific MSK structures which were affected by DB were named and explained loosely by participants, although it was clear that participants lacked confidence in their responses to this question as they were unsure of the specific evidence which existed relating to DB and its effects on the MSK system. Throughout the interviews, fourteen specific effects on the MSK system were suggested to occur directly or indirectly because of DB.

The following section aims to discuss themes that arose from the thematic analysis of the focus groups and the individual interview.

5.1 Assessing DB in MSK Practice

Various methods of assessing DB were identified by participants. Below (Figure 5) is a schematic to represent the different methods of assessing DB which were used by the participants of this study.

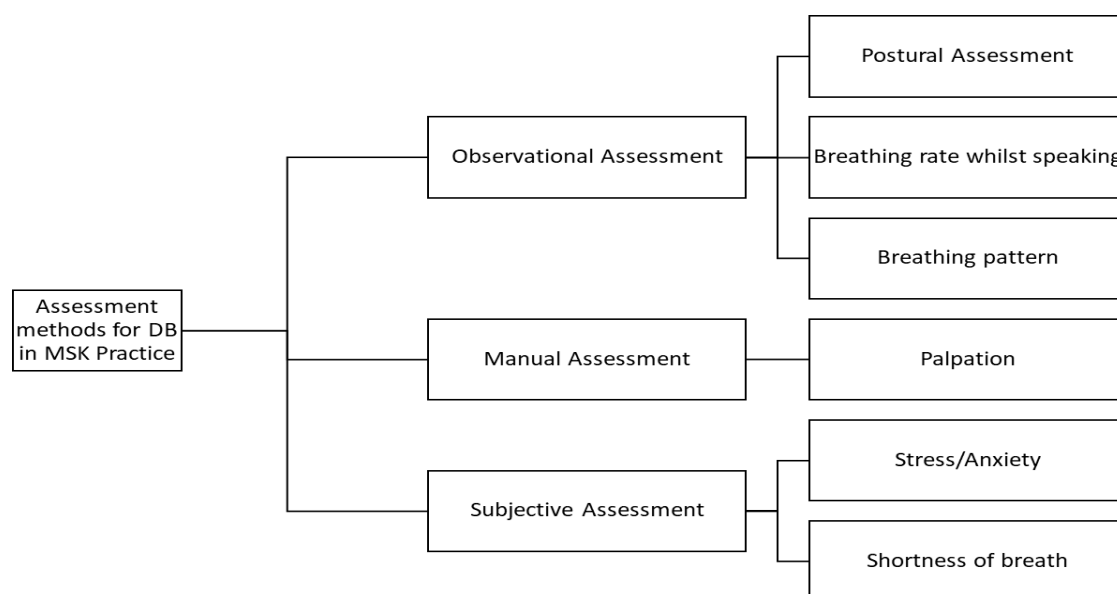


Figure 5 Schematic for Assessment Methods for DB Used in MSK Practice

Most commonly, observational or visual assessment methods were used to observe the

movement of the abdomen and the thorax during inhalation.

“Steven” (Graduate Sports Therapist, Transcription 2, line 323) said:

“...showing me how they breath and I watch them with their top off what’s happening from the back, what’s happening at the abdomen, what’s happening at the chest...”

“Jasmine” (Osteopath and Equine Therapist, Transcription 1, line 657) said: *“I guess I’m looking for things that don’t fit into what I perceive as normal”*

Speaking of a specific example involving an anxious patient, who was due to compete in a cycle event but had recently become injured, that attended this practitioner’s private clinic, “Steven” (Graduate Sports Therapist, Transcription 2, Line 59) said:

“two days to go before the 24 hour race and it’s the big... He’s been waiting for this for three years because they were all cancelled during the pandemic. And you can see his breathing’s laboured. And you know it’s partly because he’s a bit anxious about things going wrong at the last minute, but it could potentially also be because of the restriction in the neck muscles and the thoracic region.”

The participant went on to explain that, when somebody is stressed, they observed that their patient’s breathing rate and breathing pattern can change and so as part of taking their patient’s subjective history, they assess whether these changes have occurred. They also added that this could be due to or causing a restriction in the neck muscles and the thoracic region, as a result of or as opposed to being caused by stress.

Going further he said Transcription 2, Line 74):

“Subjectively when you’re talking to patients those [who have DB] whilst they’re talking, they’ll gasp or they’ll have a shortness of breath. You can normally relate that to their neck posture, shoulder elevation...”

Specifically, some participants also observe an individual’s posture for signs of DB. They stated they were looking for adaptations in posture which would indicate areas of hypertonicity/overuse during breathing.

“Fred” agreed (Yoga Instructor, Transcription 1, line 868) as he observes *“the kyphosis, forward head posture, anterior pelvic tilt, all of that.”*

Whilst “Steven” (Graduate Sports Therapist, Transcription 2, line 78) offered his explanation:

“They elevate the scapula, you can see that the scalenes, sternocleidomastoid and the upper traps all have excessive tone. And so, they’re in that fixed position where they’re lifting the shoulder, they’re elevating the scapula but you can see that their posture isn’t relaxed.”

(and Transcription 2, line 311):

“...posture observation, look at neck position, forward the chin-poke, thoracic kyphosis, look at muscle tone and it goes from the foot all the way to the head obviously, but you know particularly in the thoracic region and the neck region.”

As well as a visual assessment, the participants regularly used manual assessment/palpation techniques.

When prompting the other participants on how they would assess DB, “Jasmine” (Osteopath and Equine Therapist, Transcription 1, line 637) said:

“With hands, feeling, not much in terms of measurements I don’t do it in that kind of quantitative way, but assessing springing of ribs, diaphragm, hypertonicity, how far the rib cage goes in and out when they’re breathing in. Whether the diaphragm actually comes down at all. Again, shoulders going up as I said earlier, tension around shoulders. Neck muscles, are they tensed up.”

Participants highlighted/ reported using specific breathing assessments such as the breathing wave assessment and the breath-holding assessment techniques.

“Steven” (Graduate Sports Therapist, Transcription 2, line 316) uses the:

“breathing wave assessment. Where if you ask someone to breathe through their chest then you’d be looking for that kind of wave type motion.”

He also suggested the use of the breath hold time assessment (Transcription 2, line 345):

“there’s breath-holding so can you hold your breath for 25-30 seconds which

is another one and if someone's struggling to hold that."

Some participants assessed mobility, flexibility and muscle power as a method of determining if a patient has dysfunctional breathing. Several participants suggested that the most obvious change in mobility was a reduction in thoracic rotation if an individual had DB. For instance, "Fred" (Yoga Instructor, Transcription 1, line 670) would:

"check the breathing, watch how they're breathing... The thoracic rotation, thoracic springiness of ribcage, all of those things".

From Transcription 1, line 671 he would also measure hamstring flexibility, psoas major strength as a way of measuring dysfunction in the diaphragm.

"I'll do psoas [major strength] test and then I will do hamstring [flexibility test]. We know that there's common fibres with the psoas and the respiratory diaphragm. And their relationship there at the T12L1 is massive through the lumbar spine region... You see because psoas you can usually feel a significant difference immediately [post DB intervention]."

"Fred" added that he tests hamstring flexibility using the passive straight leg raise test and was prompted to further explain why they use hamstring flexibility as part of an assessment for DB.

"Hamstring [flexibility] is just something I learnt it was just a way of seeing whether the breath would affect the backline of the fascia once you did a passive test you could see it could go from 60 [degrees of movement] to 90 [degrees of movement] quite easily [post DB intervention]."

Other participants in the group, in particular "Jasmine" (Osteopath and Equine Therapist) found this interesting and could understand the theory behind the psoas but questioned the underpinning theory behind the hamstring flexibility testing.

In addition to Jasmine, Fred and Steven's method of assessment "Martin" (Acupuncturist, Transcription 1, line 725) would also use the distal radial pulse to assess for DB:

"I wouldn't do any differently to... feeling for hypertonicity and observing the expansion and contraction of breath. The only other thing is I might actually rely a little bit on the pulse because the distal pulse is the lung pulse in Chinese medicine..."

When asked to explain, the response was:

“So, it’s less to do with mechanical breathing, but quality of the pulse changes often depending on whether there’s tightness constricting it or whether there’s actually something in the lung. So... the pulse will feel bigger basically if there’s actually something going on in the lung. Very often anyway. And if there’s more likely to be muscular constriction somewhere the pulse will feel more tight.” (Transcription 1, line 737).

5.2 DB Interventions in MSK practice

Three main types of interventions for DB were identified from the interviews conducted: breathing re-education, breathing exercises and manual therapy techniques. The following schematic (Figure 6) offers a breakdown of the specific intervention methods that were suggested by the participants.

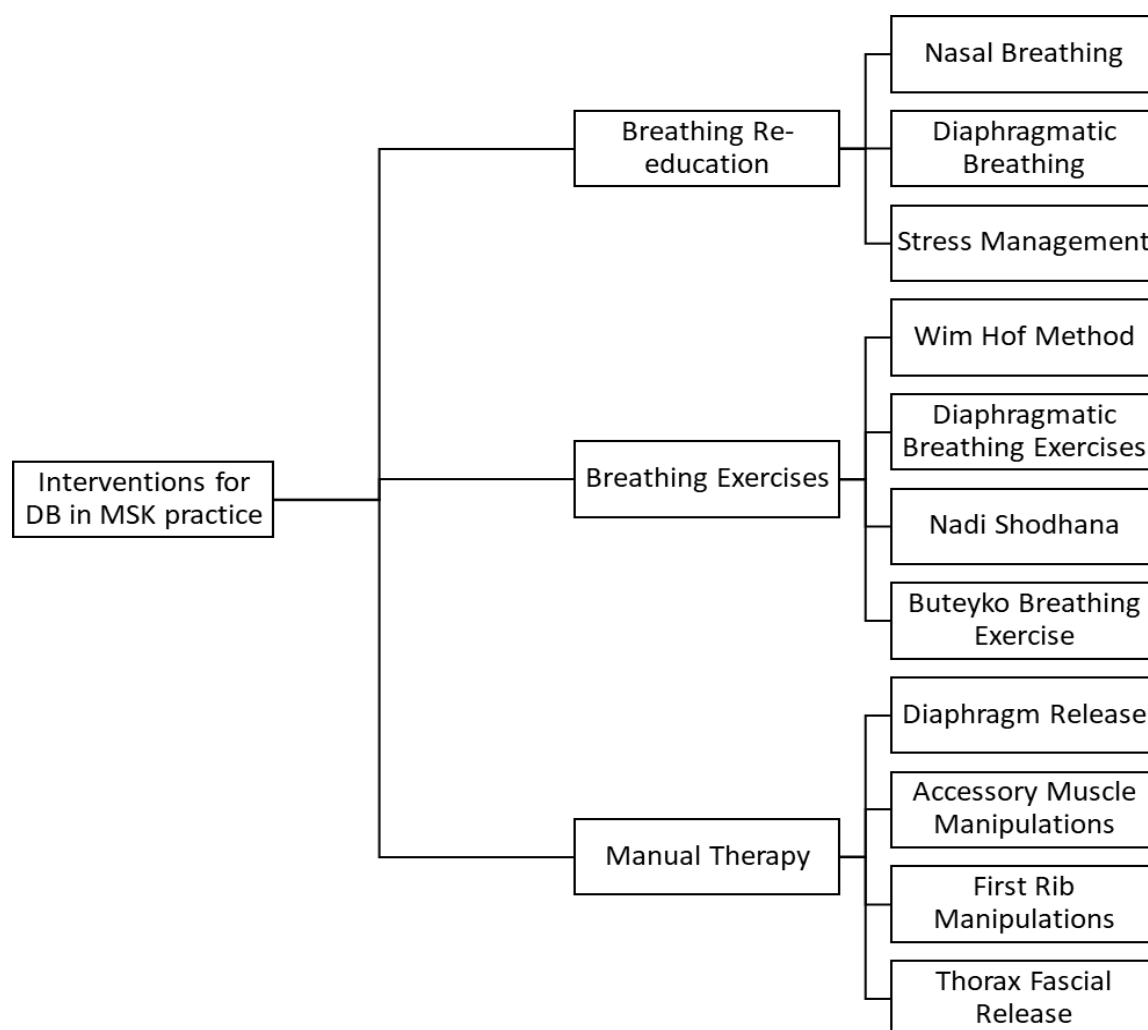


Figure 6 Schematic for Interventions for DB in MSK Practice

All participants used some form of breathing re-education. This mostly revolved around making the patient aware or conscious of their breath to intervene with the dysfunctional aspects of their breathing.

One example given by “Steven” (Graduate Sports Therapist and Lecturer, Transcription 2, line 282) was for a patient who was struggling to breath whilst cycling:

“the prescription would be... to encourage diaphragmatic breathing and focus on that whilst he’s holding the position during interval training when he’s on a turbo trainer.”

Another example of a breathing re-education was suggested by “Fred” (Yoga Instructor, Transcription 1, line 242):

“Working on the exhale for them has been the best thing for them because it’s more controlled if you count to four or five or six or if you get them to hum on the way out then that can control the outbreath and we find that they’re not struggling to take the inbreath then.”

Generally, though, all participants would describe and get their patients to practice diaphragmatic breathing as a breathing re-education tool.

“Jasmine” (Osteopath and Equine Therapist, Transcription 1, line 495) explained:

“I like to give diaphragmatic breathing exercises almost regardless of whatever they come in with because it’s so beneficial for so many things...”

She went on to add (transcription 1, line 575):

“it just affects everything. We use quite a lot of work with different diaphragms in the body. So we talk about the main diaphragm, the pelvic diaphragm, fascia, like membranes in the brain, so it all links with every single section.”

“Fred” (Yoga Instructor, Transcription 1, line 563) attempted to offer a justification to support Jasmine’s initial statement by saying:

“breath affects every single cell in your body so if you get the breath right you’ve got a better chance of the body healing.”

Multiple participants also encouraged nasal breathing as a breathing re-education tool. “Steven” (Graduate Sports Therapist and Lecturer, Transcription 2, line 108):

“[make sure] what they’re always trying to do is keep the body as calm as possible by breathing through their nose.”

“Fred” (Yoga Instructor, Transcription 1, line 927) agrees:

“I want you to breathe in through your nose and breathe out through a straw or hum and do that 10 times and just see how that makes you feel. So it’s really nice and gentle, yeah. Nadi shodhana is the alternate nostril breathing I would use with my clients...”

Some participants identified the Buteyko breathing exercise (Cowie et al., 2008) and lung (breath) packing (Schipke et al., 2015) as an intervention for DB, but one participant suggested that breathing exercises were potentially too advanced for a patient with DB.

“Fred” (Yoga Instructor, Transcription 1, line 79):

“if you don’t have good diaphragm control in the first place you can’t add technique, you’re just adding poor pattern onto another poor pattern... what you need to do is to connect with your breath properly before you could actually ask it mechanically to do something extra.”

In general, most of the manual therapy techniques explained by participants were similar.

“Jasmine” (Osteopath and Equine Therapist, transcription 1, line 942) said:

“Working anteriorly, posteriorly, diaphragm, so I go up and around first rib to release, fascia work around there. You know anterior neck especially. And Pec muscles I was going to say as well just bring those guys in just getting them really stretched, really working on them.”

Differing to “Jasmine”, “Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 294) said he would use the following manual therapy techniques to treat DB:

“mobilise the [cervical and thoracic vertebral] joints and release the tension within the [cervical and thoracic] muscles and address the length-tension relationships [of the thoracic region and shoulder girdle] ...”

One of the manual therapy techniques used by “Fred” (Yoga Instructor, transcription 1, line 678) was a diaphragm release technique. This is the same participant who would test the psoas major strength and the hamstring flexibility as part of their breathing assessment.

“[after assessment] I will do an active release on the diaphragm. So, some fascia we’re releasing [into the sternum], some getting manually into the diaphragm, bringing it down, creating space around the stomach, the pancreas and the spleen and the liver. And then I would get them to do some five inhales/exhales and then retest.”

Fred (Transcription 1, line 885) added to this:

“I use the releasing of the tissue through the SC joint and then down the sternum and then into the ribs as they come down... I do a cough reflex just underneath the ribs where you just hold [the ribs] and they cough and that can really help to release some of that tissue... I also use visceral massage technique, so I’ll go right in into the diaphragm and sort of release the diaphragm manually as well... release anything around the serratus anterior which can also lockdown the shoulder at the rib there.”

5.3 DB effects on MSK system

Fourteen effects of DB on the MSK system were suggested, described or explained during the interviews conducted. A schematic (Figure 7) was produced to display the suggested effects on the MSK system; these effects were categorised in to four superordinate themes: muscular adaptations, anatomical impacts, coordination and mobility restrictions and postural adaptations.

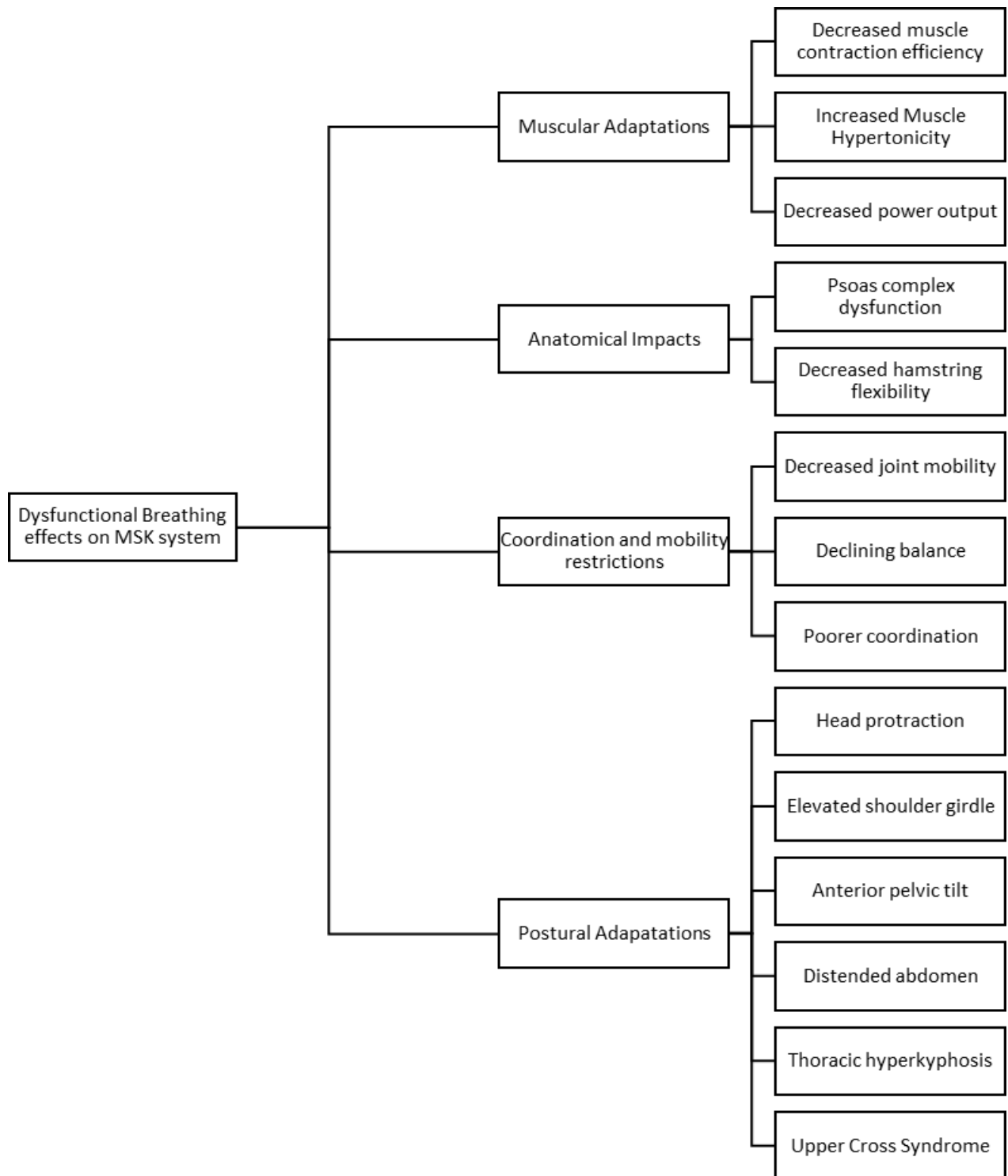


Figure 7 Schematic of the proposed effects of DB on the MSK system

5.3.1 Muscular Adaptations

In this section are the results and direct quotes which have provided the basis for the category of muscular adaptations in the results schematic above.

Decreased Muscle Contraction Efficiency

“Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 365) suggested that if a patient presents with DB this can lead to a decline in how efficiently a muscle can contract.

“I think that if you’re reducing oxygenated blood supply to the muscles then the muscles aren’t going to lengthen and shorten the way they should. So [they] don’t really contract the way they should. Then the function of the muscles relative to posture or sport performance is going to be inhibited.”

Increased Hypertonicity

When the participants were prompted for specific muscles they feel could be affected by DB they replied with:

“Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 382):

“I think in particular the scalenes, sternocleidomastoid, the traps, these are mentioned within the literature, but actually I would say the levator scapulae is often a big issue too.”

“Fred” (Yoga Instructor, transcription 1, line 777) added that they would expect to see *“tight shoulders, tight neck, [and] jaw.”*

Generally, the accessory breathing muscles were identified as being of increased tone when a patient presents with DB.

“Fred” (Yoga Instructor, transcription 1, line 588) shared a personal, intimate story which involved his pelvic floor being in a hypertonic state and suffering from incontinence for some time, until he eventually attempted to release the diaphragm and practiced diaphragmatic breathing, and his pelvic floor issues resolved themselves.

“I was in a road traffic accident... I had a pelvis injury where I was left incontinent and even though I’d been practicing yoga and been very fit all my life I couldn’t touch my knees or anything like that... I had some work done on my diaphragm to release it and at that moment my pelvic floor reset and I could touch the floor. And I hadn’t been able to do that for about four years. So for me there was an absolute profound moment in my recovery and health that came from one simple diaphragmatic release...”

Decreased Power Output

“Fred” (Yoga Instructor, transcription 1, line 569) suggested they use muscle testing as a measure of the effects of DB on the MSK system.

“from a musculoskeletal perspective you can do muscle testing before and after breath and it changes.”

He said further (Transcription 1, line 829):

“muscle testing to see where the compensations are but muscle testing around mindset. You can see how that’s affecting their whole skeletal system get them to take five breaths and they can change that.”

Multiple participants suggested they may encounter “a loss of function” but did not indicate whether this was in relation to power, flexibility, coordination, etc. or whether referring to an overall loss of function.

5.3.2 Anatomical Impacts

This section includes the results from the focus group interview which indicate specific anatomical impacts of DB on the MSK system.

Psoas Complex Dysfunction

“Fred” (Yoga Instructor, transcription 1, line 695) suggested the psoas muscle complex could be dysfunctional because of the pattern of breathing that a

patient is using. They went on to suggest that through subjective muscle testing of hip flexion a significant change can be detected before and after breathing intervention in the strength of hip flexion.

“psoas you can usually feel a significant difference immediately [after breathing intervention].”

“Fred” (transcription 1, line 673) also suggested that there is a potential anatomical link between the two which could cause a direct influence between DB and psoas complex dysfunction.

“We know that there’s common fibres with the psoas and the respiratory diaphragm.”

Decreased Hamstring Flexibility

“Fred” (Transcription 1, line 675) suggested that hamstring flexibility could be indirectly influenced by DB.

“Hamstring [flexibility testing] is just something I learnt it was just a way of seeing whether the breath would affect the backline of the fascia once you did a passive [straight leg raise] test you could see it could go from 60 to 90 quite easily [after breathing intervention].”

5.3.3 Coordination and Mobility Issues

In this section specific the focus group interview data offers additional background to the proposed coordination and mobility issues that DB can cause with the MSK system.

Decreased Joint Mobility

Multiple anatomical regions were suggested to be affected by DB in terms of their mobility, in particular the thoracic spine.

“Fred” (Yoga Instructor, transcription 1, line 809) said he often encountered patients with DB who were *“really tight in the thoracic spine.”*

“Jasmine” (Osteopath and Equine Therapist, transcription 1, line 845) agreed:

“like thoracic rotations, always a massive one and you can almost always improve that through working [manual therapy] through ribcage”

“Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 313) also agreed:

“particularly in the thoracic region and the neck region whether or not there is any tension there, any loss of function, range of motion, strength deficits”

Specific joint ranges of motion which were mentioned to be potentially impacted by DB were also listed by “Steven” (transcription 2, line 401):

“you can test range of motion... so you’ve got lateral flexion, rotation, flexion, extension for the neck, elevation, depression, protraction, retraction, for the scapula. And then your six shoulder movements, plus your scaption.”

Declining Balance and Coordination

A participant suggested that balance and coordination of movement was also something which could be affected by DB based solely on “Fred’s” (Yoga Instructor, transcription 1, line 780) own experiences as a practitioner.

“What else? Flexibility, movement, balance.”

Other participants tended to agree that they had also experienced similar changes in their practices and suggested that as DB becomes more functional, they see an improvement to their patient’s balance and coordination.

5.3.4 Postural Adaptations

All patients agreed that posture was adapted in patients with DB.

“Fred” (Yoga Instructor, transcription 1, line 787) stated:

“see what’s going on with your hamstrings and they’re usually very tight. Anterior pelvic tilt often, some of the things. There’s a complete disconnect between the rib and the pelvis, distended abdomen.”

“Fred” continued (transcription 1, line 868) to describe some specific postural adaptation they have seen in their practice:

“Look at the kyphosis, forward head posture, anterior pelvic tilt, all of that.”

“Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 79) added:

“so they’re in that fixed position where they’re lifting the shoulder, they’re elevating the scapula but you can see that they’re the posture isn’t relaxed.”

and at lines 281:

“it could be interrelated to the neck posture... he develops more tension within the thoracic region around the shoulder girdle and so his muscles are having to adapt to new levels of stress and what you find is that stiffness develops within the thoracic region, the cervical region, but he says ‘I feel like I can’t breath as efficiently.’”

Upper Cross Syndrome

A participant suggested that DB was involved with upper cross syndrome too but did not specify whether they thought it was caused by or a cause of DB.

“Steven” (Graduate Sports Therapist and Lecturer, transcription 2, line 415):

“see upper cross syndrome is interrelated with breathing dysfunction too. So if we claim to restore muscle function and postural alignment then I find that breathing improves.”

5.4 Additional Findings

Some additional results were uncovered when discussing DB in MSK practice during the interviews. These additional results were deemed too valuable to discard from this research dissertation and have been included briefly below.

There was an agreement between participants of what they perceived “normal breathing” to be. However, there was a lack of standardised terminology used across the different professions when describing the process and the specific mechanics of breathing. All participants agreed with the proposed definition of dysfunctional breathing (DB) put forward by Barker and Everard (2015) (refer to Appendix 8, question 3).

All participants agreed that the role of DB within musculoskeletal practice was complex and not easily explained or demonstrated. It was highlighted by participants that there was often a feeling of a lack of social acceptance for discussing DB with patients and peers and its role in an individual's MSK health. All participants agreed that DB was prevalent in the populations they treat daily. Participants suggested that breathing and its relationship with the MSK system was something which seemed to be overlooked by their healthcare education providers.

5.5 Discussion

The aim of this study was to explore and gain an understanding of various MSK clinicians' beliefs on the effects of DB on the MSK system. In addition to this it aimed to identify if, why, and how DB should be assessed in MSK practice and explore the current methods of intervention in treating DB in a MSK health setting. To the author's knowledge this is the first study to explore the views of MSK therapists on the assessment, treatment and relevance of DB in their practice.

Overall, this study revealed three methods of assessment of DB that these participants used in their MSK practice: observational assessment, manual assessment and subjective assessment. Multiple interventions were identified. As such, these interventions have been classified in to three groups: breathing re-education, breathing exercises and manual therapy. Additionally, the findings from this study from a variety of MSK practitioners indicated that there are multiple perceived effects of DB on the MSK system. These effects can be grouped in to four super-ordinate themes: muscular adaptations, anatomical impacts, coordination and mobility restrictions, and postural adaptations. This identifies four areas where DB could be considered as relevant in influencing the MSK system, and therefore should be included as part of an MSK assessment.

5.5.1 DB assessment

The majority of participants used a form of observational assessment to determine whether their patients had DB. Whilst they did not name it this investigator suggests that participants were describing the Manual Assessment of Respiratory Motion (MARM) which aligns with Boulding et al.'s (2016) suggestions of assessment methods. Courtney et al. (2008) concluded that MARM was a reliable tool for assessing a patient's breathing pattern and identifying DB patterns when compared with respiratory induction plethysmography (RIP). In Courtney et al.'s (2008) study, the measures observed during the MARM assessment, and subsequent DB identification, correlated with the diagnoses of DB from using the RIP. The MARM is however based around subjective opinion and estimation, whereas RIP is a measurement of pulmonary

function. In Courtney et al.'s (2008) study, only twelve participants were assessed and only two examiners were compared. Courtney et al.'s (2008) study showed that the MARM was valid for assessing DB across these twelve participants, but caution should be used when attempted to justify its validity in use across the general population. Courtney et al. (2009) found that fifty-six osteopaths and osteopathic students preferred using the MARM to the Hi- Lo breathing assessment. Todd et al. (2017) identified a new method of assessment for breathing pattern disorders specifically; the Breathing Pattern Assessment Tool (BPAT). This tool was developed in an attempt to rectify the subjectivity of the MARM, which is seen as a limitation. Using a sample of sixty-five patients suffering with post-COVID breathlessness, Hylton et al. (2022) validated the BPAT (see Appendix 11) which was found to have a sensitivity of 89.5% and specificity of 78.3% when assessing and diagnosing BPD. If participants are using the MARM then it is important that this be considered as one of the assessment techniques for identifying DB, however its validity and reliability needs testing further. Alternatively, the BPAT has been identified as a tool that is reliable for identifying breathing pattern disorders, classed as biomechanical thoracic DB and could be adopted as an assessment tool for DB. The BPAT itself, has limitations, however. Some scoring of the BPAT remains subjective to what the assessor observes, and so can be observed differently between assessors. Assessors are expected to observe an individual's breathing for one minute, following five minutes of rest in sitting. There are seven elements to be observed during the BPAT, which could prove challenging to a novice practitioner attempting to use this tool. Two of those elements are the inspiratory and expiratory flow which are to be given a rating of silent, audible and loud, which are not measured in decibels but individually interpreted by each assessor. The breathing rhythm is also expected to be observed as rhythmical or erratic, which has the potential to be interpreted differently by assessors or even change during the one minute of breathing observation. In conclusion, it is important for an inter-rater and intra-rater reliability study to be completed for the BPAT, to assess whether these potentially subjective assessments show any variation in outcome.

Boulding et al. (2016) stated that the most common method of diagnosing DB was reliant upon a positive Nijmegen Questionnaire, however this was not mentioned by participants in the present study. Van Dixhoorn and Folgering (2015) questioned the validity of using the Nijmegen questionnaire to diagnose DB. They highlighted three factors which would affect the outcome of a Nijmegen questionnaire when attempting to diagnose DB: a specific syndrome cannot be diagnosed from an elevated score on the Nijmegen questionnaire, it reflects only a subjective aspect of DB and normalisation of the score can occur after breathing regulation. As a standalone assessment it has not yet been validated for DB. Van Dixhoorn and Folgering (2015) proposed a multifactorial assessment should be conducted to try to diagnose DB.

Other methods of assessment said to be used by Boulding et al. (2016) but were not mentioned in this study by the MSK practitioners were the Self Evaluation of Breathing Questionnaire (SEBQ), end-tidal carbon dioxide measurement (capnography) and optoelectronic plethysmography. This could be because the SEB-Q and Nijmegen Questionnaire take some time to complete when practitioners could observe a patient's breathing using the MARM technique and determine a DB pattern much more time efficiently. End-tidal carbon dioxide measurements using capnography may also fall outside of the scope of practice of many, if not all, of the participants in the present study, and so they may not have been aware of, have access to or not be competent in assessing breathing using this technique.

Methods of assessment which were said to be used by practitioners but were not discussed in Boulding et al. (2016) were breathing rate whilst speaking, postural assessment, palpation nor measuring an individual's level of stress/anxiety. As these were all presented as methods of assessment by practicing MSK therapists it is important that these methods are validated and explored further to determine their use in future MSK practice.

Postural adaptations are evidently an important assessment technique when it comes to assessing DB however Boulding et al. (2016) did not include this in their review. Perhaps this is because a postural assessment can be highly subjective to the therapist assessing, and

there can be multiple explanations as to why an individual's posture may present in the way that it does (Paillard et al., 2007; Delafontaine et al., 2017; Johnson et al., 2019; Kaewmanee et al., 2022). As it is a highly multifactorial assessment method postural assessment alone is likely not to be a reliable nor valid tool to use to assess DB. DB should be an important consideration when assessing individuals who are deemed to have a poor posture and are symptomatic as a result of this, as DB could be one of multiple influencing factors on that individual's posture. Postural assessment for diagnosing DB should therefore not be discounted entirely, but it would be better deployed as part of a cluster of tests, that could be shown to be reliable and valid in diagnosing DB, as opposed to a stand-alone method of assessment of DB.

It was proposed that stress and anxiety can affect an individual's breathing and cause it to become dysfunctional. Steven said (transcription 2, line 59): *"you can see his breathing's laboured. And you know it's partly because he's a bit anxious about things going wrong at the last minute."* It is unclear how practitioners would know that a patient's altered breathing is as a direct result of increased anxiety or not. Considered with a thorough subjective history, covering lifestyle, occupation, support networks, could give a practitioner an indication that they may be suffering from anxiety, or a patient may have been previously diagnosed by their general practitioner. However, it would be difficult to directly attribute all changes in breathing mechanics to just anxiety related adaptations.

Based on the findings of this study it is suggested that a cluster of assessment methods are used to diagnose DB. Hagman et al. (2011) suggested the use of a criterion list (Appendix 3); each participant had to have at least five out of the ten criterion to be diagnosed by a physician with DB.

It could be argued that a combined use of the MARM and SEB-Q could be a valid measurement of an individual's DB. Further research needs to be conducted to assess the validity of these measurements in diagnosing DB.

Breathing dysfunction as a result of an underlying condition was not discussed. It is important that any recommendation of an assessment method in future research is specific to DB as a result of poor breathing mechanics and can exclude or identify the need for assessment of possible underlying health conditions.

5.5.2 DB interventions

Various specific methods of intervention were identified by the participants. These methods were divided in to three classifications: breathing re-education, breathing exercises and manual therapy.

Breathing Re-education

Breathing re-education seemed to be a particularly important tool used by participants in this study. Participants suggested that discussing and explaining diaphragmatic breathing and how breathing can positively impact a patient's DB was important to a sustained improvement. It could be an effective technique as it contributes to the development of a functional breathing pattern which is sufficient to maintain a good quality of breath, like the Papworth Method (Holloway and West, 2007). The Papworth method (Cluff, 1984; Holloway and West, 2007) of breathing re-education was described (but not named) by participants in relation to attempting to treat DB. Therefore, it can be suggested that the Papworth Method may continue to be used as an intervention for DB by some MSK practitioners in modern day healthcare although not necessarily named or identified as such (Holloway and West, 2007). It is not however being implemented in its totality, as practitioners are likely using individual components of the Papworth Method to individualise their treatment to their patient's needs. Whether this is as effective as applying the entire Papworth Method components as a treatment for DB is still to be determined.

The Papworth Method also covers the education of stress response management techniques, and encourages nasal breathing over mouth breathing, which are the two remaining methods of breathing re-education techniques that the participants in this study identified as potential interventions (Holloway and West, 2007). These two methods were also highlighted by Boulding et al. (2016) as tools to be used in DB intervention. Generic stress management breathing techniques (such as deep breaths) were mentioned as a method of re-educating a patient on their breathing also, as a mechanism of reintroducing control of breathing.

Breathing Exercises

The Buteyko method of breathing (Cowie et al., 2008) was also identified as an intervention tool by participants in the present study. This has been classified as a breathing exercise as opposed to a breathing re-education tool. This is based on the suggestion from participants that a patient may struggle to breath using something as complex as the Buteyko method if they do not have a basic control over the function of their diaphragm. Hence, the Papworth method remains a tool of re-education, whilst the Buteyko method is classified as a breathing exercise.

Other breathing exercises which were indicated in this study were diaphragmatic breathing exercises, derived from the Papworth Method (Cluff, 1984; Holloway and West, 2007) (as previously discussed).

Jasmine stated that she prescribed diaphragmatic breathing exercises to her patients, regardless of what MSK condition they present with, justifying this by stating “it’s so beneficial for so many things,” (transcription 1, line 496). Jasmine didn’t elaborate on her answer, so it is unclear as to what these things were.

Retrospective searching of evidence found a study by Hagman et al. (2011) which showed that when DB is treated with diaphragmatic breathing exercises then the quality of life, number of emergency room visits, symptoms associated with DB, and impairment during daily life and

exercise had all improved five years after the breathing intervention was first introduced. Hagman et al. (2011) compared asthmatics with individuals with DB and implemented a breathing retraining programme for the DB group only, finding that on a five year follow up the patients with DB had a better quality of life. The study conducted by Hagman et al. (2011) used an unvalidated criterion list to diagnose DB, however. The design of their study also meant that the improvements that were measured in the DB group could be down to the intervention they used, or to other factors such as a spontaneous improvement of symptoms or effects from being involved in the trial.

Other breathing exercises which were identified by participants were Nadi Shodhana breathing (Hakke, 2017; Sheela, 2021) and the Wim Hof method of breathing (Petraskova Tousekova et al., 2022).

Nadi Shodhana Pranayama breathing is more commonly known as 'alternate nasal breathing' and is a form of yogic breathing. Sheela (2021) and Hakke (2017) found that Nadi Shodhana breathing was beneficial to improving respiratory function. Thus far, there are very few published papers on Nadi Shodhana, and, to the authors' knowledge, no studies have been identified that measure the impact of Nadi Shodhana Pranayama breathing on the MSK system. Sheela (2021) used only menopausal women as participants, and so the effectiveness of this breathing method in alternate populations may be different.

The Wim Hof Method of breathing has become increasingly known over the last few years within popular culture leading to a greater recognition and awareness of DB from practitioners and patients alike. By implementing an 8-week training programme consisting of the Wim Hof Method breathing exercises, cold exposure, and meditation, it has been shown to reduce stress responses and cortisol levels over an extended period (Petraskova Tousekova et al., 2022) but specific long-term breathing adaptations have not been documented after use of this technique. It is also unclear, how much effect each section of the 8-week training programme had what impact, or whether they need to be conducted as a three in order to be effective. Furthermore, Marko et al. (2022) conducted a study into the effects of the Wim Hof

method of breathing, on breathing economy during exercise, and concluded that there was no effect after a four-week breathing intervention. Illidi et al. (2023) conducted a review in aim of distinguishing different respiratory interventions that were founded in science or in pseudoscience. The review concluded that techniques similar to the Wim-Hof method of breathing lacked plausible scientific explanation and were therefore mostly founded in pseudoscience. This is supported by evidence on cold water immersion which suggests that it slows down recovery post exercises, contrary to what the Wim-Hof method of breathing claims (Roberts et al., 2015; Fuchs et al., 2020; Malta et al., 2021).

Manual Therapy Interventions

The third classification of breathing intervention identified was manual therapy interventions. The most used manual therapy intervention by the participants in this study were accessory breathing muscle manipulations or soft tissue therapy in the form of sports massage or passive stretching. The efficacy of massage has been well documented over the past few decades and it is still unknown whether massage can be an effective long-term solution to increased muscle tension (Xiong et al., 2015; Ling et al., 2013; Ernst, 1999). Massage use as a long-term intervention in treating DB is therefore also disputed. Lee et al. (2009) argued that massage could be used as a manual therapy technique to provide short term symptom relief to allow for better breathing mechanics. This might allow for a normal breathing pattern to resume. However, this needs to be explored further in research. In conjunction with other interventions, however, massage could be a useful tool in improving a patient's breathing mechanics. Harris and Richards (2010) showed that massage can improve relaxation of an individual, thus detracting from anxiety and stress levels. The participants in this study alluded to this being important for restoration of normal breathing mechanics and so, massage alongside breathing re-education, for example, could be a useful tool for eliminating DB. Further research is needed to explore this hypothesis.

Participants commented on specific manual therapy techniques such as a diaphragm release technique and thorax fascial release techniques. Both techniques are understood to be forms of

myofascial release techniques (Carey et al., 2001). Marizeiro et al. (2018) found that diaphragmatic myofascial release improves the chest wall mobility, posterior chain flexibility and improves extension and lateral flexion in the lumbar spine, supporting the use of this technique in MSK practice. It does not go as far as to suggest that DB can be improved using this technique, however. Long term effects of using this technique are also disputed and need to be explored further. As Marizeiro et al. (2018) used two myofascial release techniques in the experimental group it is difficult to know which technique had the greatest effect and whether each technique individually would be beneficial. Ajimsha et al. (2015) conducted a systematic review into the effectiveness of myofascial release and concluded that the treatment strategy had the potential to be considered an effective treatment modality. None of the studies included in this review were based on diaphragm release interventions. It is important that further research to explore specific diaphragmatic myofascial release methods and their impact on DB is conducted, to establish whether myofascial release techniques are a viable intervention for DB.

It was also suggested by participants that the first rib should be considered for mobilisation in patients with DB. This was poorly explored and explained in the interview, but it is assumed that a hypo-mobile first rib could be as a result of DB mechanics. As such, the assumption would be that restoring movement of the first rib could improve breathing mechanics. This is very speculative at present. More research is needed to investigate whether first rib hypo- mobility effects an individual's breathing mechanics and how much of an impact this has on breathing efficiency.

5.5.3 DB effects on the MSK System

The findings from this study propose that muscular adaptations due to DB are classified as changes to general (whole body) muscle performance and/or changes to the condition of muscles. Analysis of the interviews conducted in this study suggested that practitioners considered muscle tension to increase, muscle contraction efficiency to decrease, and muscle power output to decrease in patients with DB. It is well-established that an oxygen deficit whilst

exercising can negatively impact the performance of the MSK system with fatigue onset being quicker when there is a limited supply of oxygen (Hepple, 2002). If an individual has DB then it may be conceivable to assume that they will also be suffering with an associated level of oxygen deficit. This may lead to changes in the performance of the overall MSK system. At the time of submission, there have been no studies found that test this hypothesis.

The participants of this study consider this to be an important factor in their assessments and interventions with regards to injury, health and wellbeing. Currently no research has investigated how much of an impact DB can have on the effectiveness of a muscle during movement. Research exploring the effectiveness of the MSK system during different types of breathing should be conducted to determine if DB can influence the muscular system.

There were some anatomical connections with the respiratory muscles and other skeletal muscles identified by participants in the present study as potentially affecting one another. These were categorised as anatomical impacts of DB. Psoas complex dysfunction was identified as a possible result of DB by the participants who speculated that the anatomical connections between the diaphragm and psoas is how the diaphragm can impede the psoas major. Tufo et al. (2012) stated that the diaphragm has the potential to cause dysfunction within the psoas muscle complex due to the fascial connections between the psoas major and the internal crus of the diaphragm. This is based on the anatomical connections of the diaphragm and the psoas muscle complex. No evidence has been found that tests for a direct relationship between psoas function and breathing mechanics to support the hypothesis that DB could cause psoas complex dysfunction. There was no consensus from participants on this theory, but once suggested, participants seemed to be able to understand the potential relationship. Further research is necessary to explore this proposition in greater detail.

Another anatomical impact which was suggested by one of the participants was a decrease in hamstring flexibility, but limited explanation was given to this concept when the participant was prompted to explain. This could be due to a lack of knowledge of the scientific evidence to support this proposal, lack of confidence in front of other participants or based on anecdotal evidence they have experienced within their own practice. There are no known direct muscular

connections between the respiratory muscles and the hamstrings muscles group. However, this concept could potentially be explained through an indirect anatomical link. It is already known that the diaphragm and the pelvic floor share a cranio-caudal relationship when moving (Talas et al., 2011; Bordoni and Zanier, 2015). Why this relationship exists however, is still unclear. Sajko and Stuber (2009) suggested the psoas major muscle's inferomedial fascia is a continuation of the deep fascia of the pelvic floor. So, it is plausible to suggest that the craniocaudal relationship between the diaphragm and the pelvic floor is facilitated by the psoas major (Siccardi et al., 2021). How this impacts the hamstring flexibility could therefore be linked with pelvic floor activity and the postural positioning of the pelvis when testing hamstring flexibility (Sullivan et al., 1992). Sullivan et al. (1992) demonstrated that an anterior pelvic tilt position whilst testing hamstring flexibility resulted in a greater range of motion through an active knee extension test (for hamstring flexibility). If the cranio-caudal relationship between the diaphragm and pelvic floor, facilitated by the psoas major, results in an anterior pelvic tilt when breathing functionally, then this could explain why practitioners may notice an increase in hamstring flexibility when normal breathing mechanics are restored. More research is needed to explore the links between hamstring flexibility and poor breathing mechanics.

The findings of this study suggests that an individual's coordination and mobility could be affected by DB. Participants believed that joint mobility could be restricted by DB, coordination of movement could deteriorate, and balance could worsen if DB was present. Thoracic spine mobility was indicated as being affected by DB and the participants' explanations of this effect is less anecdotal and more based on scientific research (Rahimi et al., 2020).

Clavel et al. (2017) discovered that breathing through a spirometer disturbed an individual's balance indicating that there may be some credibility to the participant's suggestions that balance improved with more functional breathing and declines with DB. As Clavel et al. (2017) compared spirometer testing to normal breathing this may not be the most reliable way of testing the effects of DB on balance and coordination, and so further research is required to explore whether balance is affected or not in individuals with DB.

According to the participants' responses when questioned about postural adaptations, there appears to be an acceptance that there will be some postural adaptations to DB in most if not all cases. Specific adaptations which were mentioned multiple times were forward head postures, thoracic kyphosis and an anterior pelvic tilt. Chambi-Rocha et al. (2018) found that there were differences in facial development in relation to breathing types but found there was no statistically significant difference in head postures between individuals with different breathing mechanics. This contradicts the opinions of the practitioners in this study, in relation to postural adaptations as a result of DB. Chambi-Rocha et al. (2018) compared nasal vs oral breathing as opposed to DB vs diaphragmatic breathing and so a forward head posture could still be a sign of DB. Further research is required to explore this. A forward head posture could be accounted for if individuals are often using mouth breathing, as opposed to nasal breathing, as this has been shown to be associated with a forward head posture (Neiva et al., 2009). Yet, it has not been defined whether mouth breathing is a functional method of breathing or whether it is dysfunctional. Therefore, conclusions cannot be made as to whether a forward head posture is related to DB or not.

5.5.4 Study Limitations

Despite attempts for widespread recruitment via social media and an email campaign a limited number of volunteers showed an interest in participating in this study. This could be due to a lack of interest from MSK practitioners in respiration and its role in their practice, a lack of exposure when advertising for participants or a hesitancy from potential participants to discuss their practice in the absence of evidence-based practice. Advertisement of this study was made through social media primarily and so the reach of the study's exposure to potential participants was restricted to that of the primary investigator's social media followers and those who interacted with the study advertisement posts.

As a result, it transpired that there were fewer participants willing to be identified and willing to be recruited based on the inclusion and exclusion criteria. This led to a smaller sample than expected and desired by this researcher. As such the fewer voices impacts upon the data analysis and thus, potentially, the transferability of the study's findings. Because snowball

sampling was also used, this potentially meant that like-minded participants were recruited, leading to a one-sided outcome in the findings.

Saturation was not able to be reached as no further participants were forthcoming after the initial round of interviews. In addition to this, the time constraints of completing this study as part of a Master of Research postgraduate degree award has also limited this study's ability to reach saturation. Otherwise, more time could have been afforded to recruiting participants expanding the variety of professions and experience of the participants to increase the likelihood of data saturation. Nevertheless, this study has been able to offer some initial insights that could open new avenues for future research in this area.

Some participants evidently were not comfortable sharing their knowledge and opinions of the subject as they did not contribute to the focus group discussion as much as other participants. This is a common criticism of focus group interviews, and even with experienced moderators, it cannot be excluded from influencing the outcome of the focus group (Kreuger and Casey, 2015). It is evident from the findings of this study that participants like "Fred", "Jasmine" and "Steven" contributed more effectively to the discussion than "Martin" and "Violet".

A multi methods approach was used to interview participants. This was determined by individuals' availability to participate in one of the scheduled focus groups. It is unclear as to what data was excluded by interviewing one participant individually as opposed to part of a focus group and vice versa. Some participants may have divulged more information in an individual interview as they may have felt more willing to discuss their opinions without judgement of their peers. However, some participants may have presented an opinion which they may not otherwise have shared, had it not been for prompt or discussion with other members of the focus group interview. Alternatively, the participant of the individual interview would not have participated, and so valuable insight would not have been gathered.

These interviews were conducted online, electronically, which increased the availability of the participants but did have its drawbacks (Kreuger and Casey, 2015). It was, at times during the interviews, difficult to control participants from speaking over each other, although for the most

part this was not an issue, and generally led to more in-depth discussion. This may have been easier to control during an in-person interview. Some participants had issues with their microphones and audio during the interviews. This affected the flow of the discussion and could have resulted in omitted data which could have proven valuable to the outcome of this study.

By allowing participants from all backgrounds in MSK health, this study has attempted to limit any cultural bias. However, due to the lack of participation in this study, only a small group of professions working within MSK health have been interviewed. Other professions, such as MSK physiotherapists, particularly with respiratory experience/background, may have been useful to offer a different insight into how DB is assessed and used within MSK practice, if at all. As they are a large workforce, particularly within the NHS in the UK, their beliefs on this topic may have been valuable to the findings of this study. There may be some cultural bias involved in this dissertation through the analysis of this study's findings. This researcher's background is in western medicine and is trained in the United Kingdom, with minimal exposure to other cultural practices of medicine. Their understanding of other cultural beliefs is limited, and so exploration of DB in other cultural practices is limited also. Therefore, when analysing the findings of this study, some beliefs or values grounded in non-western medicine may have been overlooked. However, this data analysis was conducted in an exhaustive, consistent and precise manner, using a coding table (appendix 13) and the data was recorded systematically using the same transcriber and then reviewed by this researcher for errors in spelling and grammar (Nowell et al., 2017). Every opinion and belief was coded within the coding table and coded using previously published research which supports the participants belief, to increase the credibility and confirmability of the analysis. Those beliefs that were not founded in evidence were still coded but were coded to accurately represent what the participant said, rather than this researcher attempting to interpret what the participant may have meant and apply their own opinion bias to the coding. Trustworthiness could have been increased in this study if this researcher had completed some form of data collection triangulation or researcher triangulation, through peer debriefing, through member checking the findings with the participants themselves and through keeping a reflexive journal throughout to demonstrate reflexivity (Nowell et al.,

2017).

6.0 Discussion

During an initial scoping search at the outset of this dissertation, it was unclear whether dysfunctional breathing is consistently considered as part of a MSK examination/assessment. Moreover, it is unclear in current research how MSK therapists believe DB and breathing pattern disorders should be assessed and why they assess and/or intervene with DB as part of their practice as an MSK therapist. Therefore, the aims of this dissertation were:

- to explore MSK practitioner's beliefs on the causes and effects of DB on the MSK system.
- to identify if, why and how DB should be assessed in MSK practice and explore the current methods of intervention in treating DB in an MSK health setting.

Initial searching revealed that DB had already been defined by Barker and Everard (2015) but did not include all of the proposed elements of DB, such as biopsychosocial DB and biochemical DB, as well as biomechanical DB (Courtney, 2009; Kiesel et al., 2017; Vidotto et al., 2019). DB needed defining further, to provide clarity for any subsequent reviews or studies which followed. Chapter Two of this dissertation set out to provide a critical review of current research in DB to contribute to a clearer understanding of DB. From the review conducted it was revealed DB should be considered an overarching umbrella term potentially covering a wide range of breathing abnormalities: from breathing pattern disorders to vocal cord dysfunction. This review included details on how DB is currently assessed according to research. It identified multiple methods of assessment, but no specific methods that were proven to be specific to DB in its totality. Therefore, it was recommended a battery or cluster of assessment methods be developed to determine the presence of DB.

Chapter Three sought to review the literature which considered the relationship DB may have with the MSK system. In this narrative review, it was discovered that DB can influence the MSK system: anatomically, biomechanically, neurologically and physiologically. However, to date, most of the research has been conducted on the biomechanical and anatomical elements of the MSK system. Furthermore, research studies have mainly explored the effects of the MSK

system on breathing, as opposed to the effects of DB on the MSK system.

To explore the current thoughts and opinions surrounding the impact that DB may have on the MSK system, a focus group interview (and one individual interview) was conducted in Chapter Four. From a sample of five practising MSK therapists who frequently assessed breathing for MSK injury, fourteen potential effects were identified by five practicing MSK therapists as part of this dissertation's study. Of the effects proposed by the participants, only five of these effects were found to be supported by evidence in the narrative review outlined in Chapter Three: psoas dysfunction, increased muscle hypertonicity (specifically the accessory muscles and abdominals) and three postural adaptations.

6.1 A New Model of DB

Based on the conclusion of Chapter Two, and less so the findings from the focus group and interview study in Chapter Four, a new suggested model of DB has been developed (Figure 8). This new model is an expansion of the adapted model proposed in Chapter Two. This new model includes the psychophysiological and biochemical types of DB and uses alternative terminology to Barker and Everard's (2015) model to provide more clarity specific to the biomechanical branch of DB. It represents more clearly the different elements of DB and addresses some of the potential relationships between the different elements of DB. It is acknowledged by this researcher, however, that this is a limited view of DB and is ultimately one that has been formed through the researchers understanding of DB. As this researcher has less of an understanding of the biochemical and psychophysiological aspects of DB, these areas have not been explored or expanded upon in great detail, and so this is represented in the model. This model of DB is intended as a starting point to lead into a discussion of what a more detailed model of DB should look like. It is proposed by this researcher that a clear, agreed definition of DB is necessary to develop an understanding of the prevalence, aetiology and epidemiology of DB. Once this has been agreed, further iterations of an accurate model of DB can be produced.

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 purely define biomechanical DB. At

present, there are no formal definitions for the psychophysiological and biochemical DB.

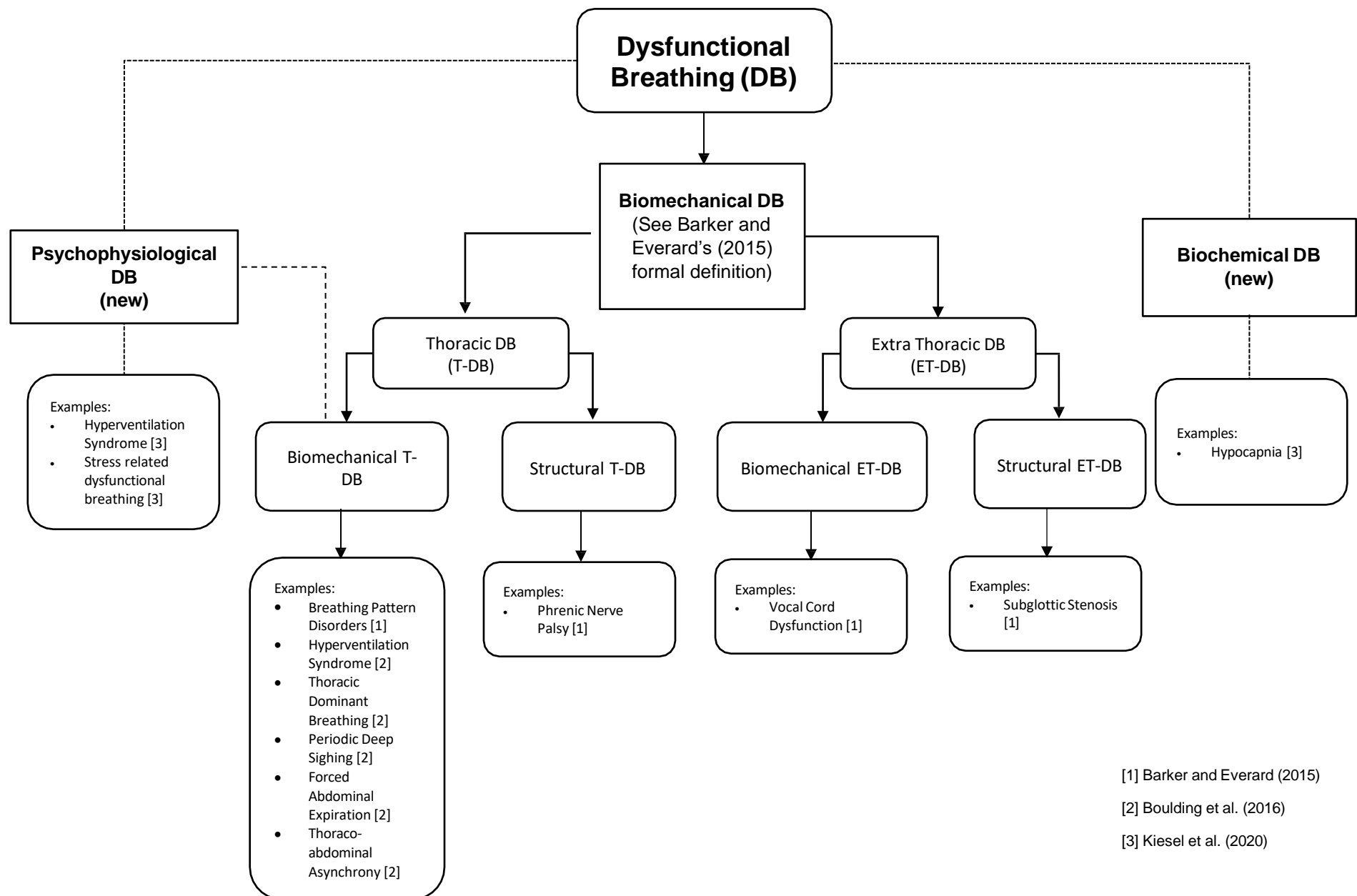


Figure 8 Proposed model of DB. Solid arrows showing the relationships that have been explored and supported with evidence. The dotted lines connect elements which need further exploration.

This model of DB provides some clarity of the different types of DB and how they interact with one another, based on the conclusion from the critical review in this project primarily. It is divided in to three categories, as suggested by Courtney (2009), Vidotto et al. (2019) and Kiesel et al. (2020). Barker and Everard's (2015) model has been included as part of this adapted model, representing the biomechanical aspect of DB. However, due to the findings reported in the critical review presented in Chapter Two the terminology used by Barker and Everard has been amended to provide more clarity in the language used to describe biomechanical DB. As this dissertation has focussed mostly on the biomechanical aspect of DB, this model has been developed further in biomechanical DB, than in psychophysiological DB or biochemical DB. The psychophysiological DB and biochemical DB branches of this model is an expansion and a direct contribution as a result of this study.

Further research is required to add to the psychophysiological wing and the biochemical elements this model. Exploration of the relationships between each category is also recommended as there may be crossovers between categories. 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.

6.2 Direction for Future Research

In section 6.1, a new model of DB has been proposed. To validate and further understand this model, research exploring the psychophysiological and biochemical elements are required. A Delphi study could be conducted in attempt to specify and reach a consensus on the definition of DB and its signs and symptoms, and the model of DB proposed in this study. It is important

that definitive lists be developed of the signs and symptoms of DB and categorised within this study's proposed model of DB. This will provide further clarity for researchers and health professionals when assessing DB.

From the collection of studies included in this dissertation it is apparent that there is an absence of understanding on the different assessment methods that can be used to accurately diagnose and monitor DB. Before assessment of DB can be developed, a clear and agreed definition of DB is needed. Without this understanding of DB there is no clear direction for further development of assessment techniques for DB. Therefore, only when a definitive formal definition has been agreed, should a future study be needed to formulate a cluster of assessment methods. These clusters could differ between biomechanical DB, biochemical DB and psychophysiological DB, making the assessment of DB more streamlined for each. A special interest group or a further Delphi study could be conducted to determine the appropriate methods to be used to assess DB.

Questionnaires, such as the Nijmegen questionnaire (Thomas et al. 2005; Grammatopoulou et al., 2014), subjective assessment and observations of breathing rate (Vostatek et al., 2013) could be an element of the assessment method for the psychophysiological branch of DB, amongst other techniques. Biomechanical DB might be able to be assessed using the Hi-Lo and/or the MARM breathing assessment tool (Courtney et al., 2008; Courtney et al., 2009), or alternatively the BPAT (Todd et al., 2017; Hylton et al., 2022) together with a subjective assessment. Additionally, the biochemical arm of DB could be assessed using capnography (Courtney and Cohen, 2008; Boulding et al., 2016) amongst other assessment tools. As there is, at the time of submission of this study, no gold standard assessment method of DB a validation study cannot be conducted where this is compared with the suggested measures of DB. Should a definitive list of signs and symptoms of DB be established then a study to assess the specificity and sensitivity of each of the assessment methods identified can be conducted to determine the most accurate methods of individual assessment for these signs and symptoms. From this, different methods can be combined and measured against other assessment method combinations to identify which clusters of testing are the most specific

and sensitive to DB.

7.0 Conclusion

Collectively, this dissertation has found DB does not have an accepted formal definition, as yet, but general agreement between researchers suggests its use as an umbrella term to cover the broad topic of DB. The relevance of DB to MSK practice has been established through this dissertation's review of the effects of DB on the MSK system. It has also identified that DB is presently assessed and treated within MSK therapy however limited evidence is available on how best to accurately assess, diagnose and intervene with DB specifically. There is a need for a clear and agreed definition of DB, in order to develop a wider understanding of DB within both MSK and wider healthcare. A consensus on a definition would provide the platform to begin developing an understanding of the prevalence of DB, and guide further studies into developing a method of assessing DB. It would also contribute to further iterations of the proposed model of DB suggested in this study.

Multiple methods of DB assessment have been identified that are currently used within MSK practice. At present, there is no consensus on the most effective method of assessing DB according to MSK practitioners. It is proposed that a cluster of assessment methods could be the most reliable method of diagnosing biomechanical DB, and so further research to identify these methods and their validity is required. Researchers of this study have identified that some MSK practitioners are using three methods of assessment: observational assessment, manual assessment and subjective assessment of DB. Three superordinate themes have been identified in relation to DB interventions that are presently being used by some MSK practitioners: breathing re-education, breathing exercises and manual therapy interventions.

This study has also identified that the use of DB in MSK practice is partly based on anecdotal evidence, and in part based on empirical evidence. This is because such studies to explore the experiences of these MSK practitioners have not yet been conducted. At the time of submission, the evidence to support their anecdotal experiences is limited. Nevertheless, there is some evidence to support some of the claims practitioners made within this research dissertation.

Based on the outcomes of the critical review primarily, a new model of DB has been proposed to provide clarity and direction for future research. This model proposes that DB be used as an umbrella term and classified in to three categories: biomechanical DB, biochemical DB and psychophysiological DB. This proposed model contributes to the clarification of DB and can be used as a reference to develop and identify appropriate methods of assessment for each category of DB.

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Appendices

Appendix 1 – Nijmegen Questionnaire

(van Dixhoorn and Duivenvoorden, 1985; cited in Ogilvie et al., 2019 p.171).

	Never (0)	Rarely (1)	Sometimes (2)	Often (3)	Very often (4)
1. Chest pain					
2. Feeling tense					
3. Blurred vision					
4. Dizzy spells					
5. Feeling confused					
6. Faster/deeper breathing					
7. Short of breath					
8. Tight feelings in the chest					
9. Bloating feeling in the stomach					
10. Tingling fingers					
11. Unable to breathe deeply					
12. Stiff fingers or arms					
13. Tight feelings around the mouth					
14. Cold hands or feet					
15. Palpitations					
16. Feelings of anxiety					

Appendix 2 – SEBQ (Courtney and Greenwood, 2009)

Scoring this questionnaire: (0) never/not true at all; (1) occasionally/a bit true; (2) frequently/mostly true; and (3) very frequently/very true.

I get easily breathless out of proportion to my fitness.

I notice myself breathing shallowly.

I get short of breath reading and talking.

I notice myself sighing.

I notice myself yawning.

I feel I cannot get a deep or satisfying breath.

I notice that I am breathing irregularly.

My breathing feels stuck or restricted.

My rib cage feels tight and can't expand.

I notice that I am breathing quickly.

I get breathless when I am anxious.

I find myself holding my breath.

I feel breathless in association with other physical symptoms.

I have trouble coordinating my breathing when I am speaking.

I can't catch my breath.

I feel that the air is stuffy, as if not enough air in the room.

I get breathless even when I am resting.

My breath feels like it does not go in all the way.

My breath feels like it does not go out all the way.

My breathing is heavy.

I feel that I am breathing more.

My breathing requires work.

My breathing requires effort.

I find myself breathing through my mouth during the day.

I breathe through my mouth at night while I sleep.

Appendix 3 – Hagman's Criterion List

Hagman et al. (2011) criterion list:

difficult inspiratory breathing;

unable to take deep breaths;

increased breathing frequency (>16/min);

frequent sighing/yawning;

frequent need to clear the throat;

muscle and joint tenderness in the upper part of the chest (sternocostal joints and/or intercostal muscles);

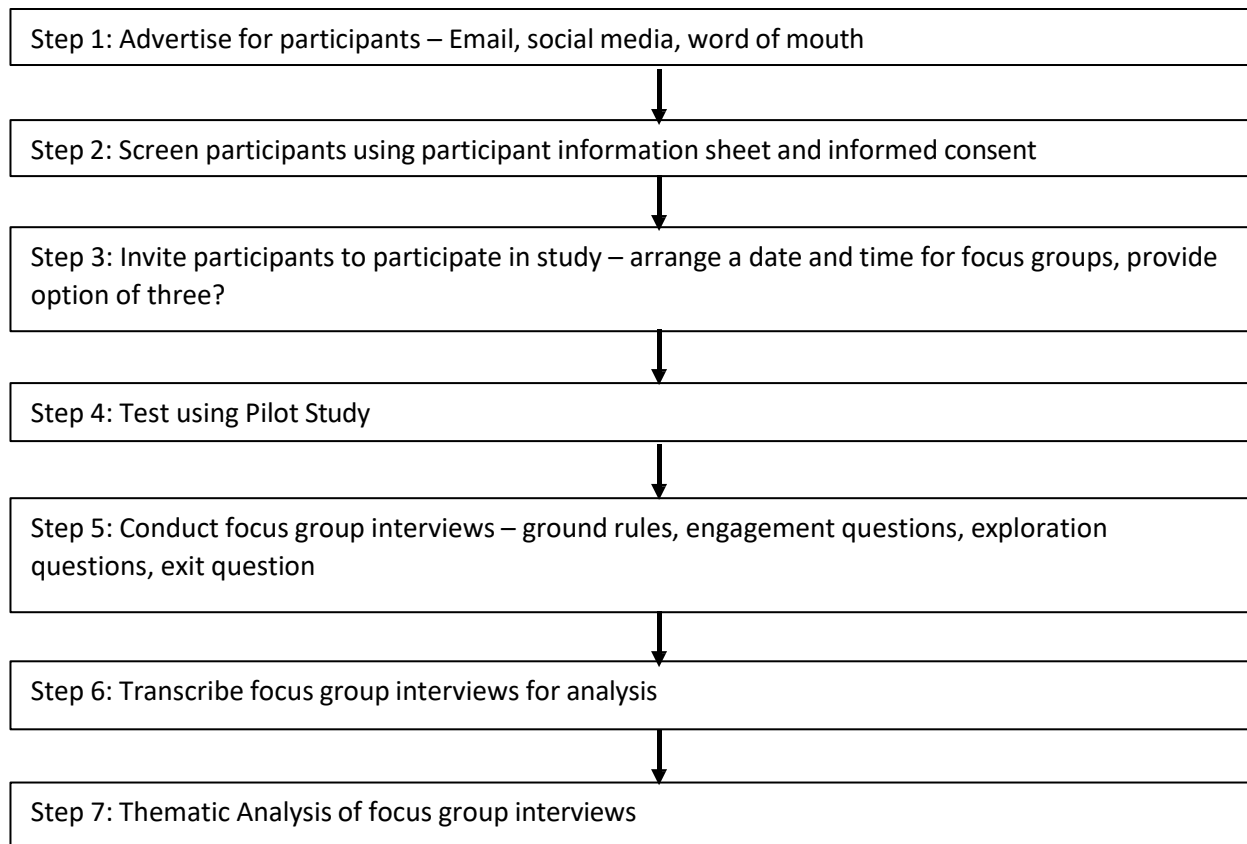
hacking cough;

chest tightness;

sensation of lump in the throat;

previous or current effects of stress.

Appendix 4 – Work Plan



Appendix 5 – Participant Information Sheet

Participant Information Sheet

Study Title: Focus Group Interview to Explore Clinician's Views on Dysfunctional Breathing in Musculoskeletal Practice

Principal Investigator: Thomas Pinder

Invitation

You are being invited to take part in our focus group study, which I (Thomas Pinder) am undertaking as part of my Master of Research postgraduate degree project. The MRes degree project is registered with Leeds Beckett University. Before you agree to participate in this study, it is important that you understand the aims of the research project, and what it will involve for you. Please take the time to read the following information carefully and ask any questions that you may have before agreeing to participate. If you do have any questions or would like more information, then please feel free to contact me using the contact number and email address at the end of this information sheet.

What is the purpose of this study?

This study is designed to explore the opinions and beliefs of musculoskeletal clinicians who work with patients who suffer from dysfunctional breathing. The prevalence of dysfunctional breathing is unknown and dysfunctional breathing can be overlooked in common musculoskeletal health practice. The aim of this study is to identify the common beliefs and opinions that musculoskeletal practitioners have of how dysfunctional breathing effects the musculoskeletal health of a patient and identify common methods of assessment and treatment used by these clinicians, to direct future research into this topic area.

Am I a suitable participant for this study?

We are seeking volunteers who are degree educated musculoskeletal health practitioners who have an interest in respiratory health and its relationship with musculoskeletal health. You must have at least 2 years post graduate experience and be currently employed in a musculoskeletal healthcare role. All participants will require access to a computer and be available to attend an online focus group interview for 1-2 hours. We will ask that you check you are eligible to participate by checking against our inclusion and exclusion criteria before the focus group interview takes place.

Do I have to take part?

No. It is your decision as to whether you take part in this study or not. If you decide to take part, you will be given this participant information sheet to keep. You will be required to sign a consent form if you decide to participate in the focus group interview, but you are free to withdraw from the study at any time. You do not have to give your reasons for withdrawal.

What will happen if I agree to take part?

We will arrange a time and date for you to participate in the focus group interview. You will be asked to declare whether you are eligible for the study by checking against our list of inclusion and exclusion criteria. If you are willing to take part, you will be asked to sign an informed consent form. Once the aforementioned documents have been read and returned completed, the focus group interview can commence. The facilitator of the focus group will introduce themselves and some ground rules for the focus group interview to follow. Approximately 10

questions will be asked during the focus group interview with each participant given an opportunity to respond how they see fit. Once all questions have been asked and the facilitator is satisfied that they have gathered as much information as possible from you, you will be free to leave the focus group interview.

What are the possible risks of taking part in the study?

The study has been ethically approved by Leeds Beckett University and these documents are available on request. We foresee no serious risks associated with this study.

What if there is a problem?

If you have a concern about any aspect of this study, you should speak with myself or any other researchers associated with this study. They will do their best to answer your questions. If you wish to complain formally about any aspect of the study, including the conduct of the investigator, you can do this through the Independent Contact Person identified at the end of this sheet.

What do I have to do before I take part in the study?

We advise you refresh your knowledge of the evidence behind dysfunctional breathing as a stand-alone topic area and refresh your knowledge of how breathing affects the MSK system. Participants can prepare any notes or information they wish and use them during the focus group interview.

What are the possible benefits of taking part in this study?

By taking part in the study, you will contribute to improving the understanding of dysfunctional breathing in clinical practice and add to the current evidence base that supports or opposes the use of dysfunctional breathing assessment and treatment in musculoskeletal practice. Any information you provide will be valuable information for the development of future studies in this topic area.

What will happen to the results of the study?

The collected information in the focus group interview will be analysed and the findings will be written up for a Master of Research Dissertation, potentially submitted for publication and may be present at scientific conferences.

Will taking part in this study be kept confidential?

All information collected about you will be kept strictly confidential, other than to those individuals who are involved directly in the study. The study is designed to collect information about your attitudes, behaviours and beliefs which could be deemed sensitive, however all information will be kept strictly confidential, and you will not be listed by personal information. We are duty bound to disclose any information that you provide that relates to criminal activity, so we encourage you not to engage the investigators in conversation about such matters. Any data gathered that leaves Leeds Beckett University will be coded to maintain your anonymity. You are free to withdraw from the study at any time and we do not require you to give your reasoning. If you do wish to withdraw before study completion, unless you object, we will keep records relating to you, as this information is still valuable to the study. The information will be always kept confidential and held securely electronically at Leeds Beckett University under the provision of the 1998 Data Protection Act.

Complaints and Independent Contact

If you have any complaints, concerns or would like more information about any aspect of the study with someone independent to the research, you should contact:

Sheila Casey (Academic Quality Support Officer)

s.a.casey@leedsbeckett.ac.uk

School of Health, Leeds Beckett University, Calverley Street, Leeds, LS1 3HE

Contact for further information

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What do I do next?

If you would like to take part in this study, then please inform the principal investigator who will arrange a date and time for you to participate in the focus group interview. You will be given a copy of this information sheet and the informed consent form to keep.

Thank you for taking the time to consider participating in this study.

Appendix 6 – Informed Consent Sheet

Informed Consent Form

Title: Focus Group Interview to Explore Clinician's Views on Dysfunctional Breathing in Musculoskeletal Practice

Statements of Confirmation

I have been informed and understand the purposes of this study.

I have been given sufficient opportunity to ask any questions, with regards to the study and the results it produces.

I understand I can withdraw from the study at any time, with no consequences to myself.

I understand that any information I disclose which may identify me, will not be published in the study findings and I will remain anonymous in the results.

I understand that any information I disclose in the study about the subject area can be analysed and published, but my anonymity will be protected.

I have read and understand the participant information sheet and have no further questions.

I agree to participate in the study as described in the participant information sheet.

Participant Name (IN CAPITALS):

Participant Signature:

Date:

Appendix 7 – Participant Pre-Screening Questionnaire

Participant Pre-Screening Questionnaire

Title: Focus Group Interview to Explore Clinician's Views on Dysfunctional Breathing in Musculoskeletal Practice

Name:

Date of Birth:

Profession:

Education/Qualifications:

Do you know any of the investigators of this study or are you aware of anybody you know who is also participating in this study?

Yes / No

If yes, give details below:

The information you disclose by completing this questionnaire will be kept in a secure place and will only be viewed by the Principal Investigator.

Appendix 8 – Interview Questions

Introduction from facilitator

Thank you all for attending this focus group exploring dysfunctional breathing and its relationship with the musculoskeletal system. I am sure this is a busy time for everyone, so it is very much appreciated that you have given your time today to participate in this study.

I am just going to clarify a few ground rules before we start. If we could refrain from talking over each other, listen to one and other's opinions without interrupting, respect each other's backgrounds, professions, and opinions, and please maintain confidentiality after this interview has concluded. If you wish to speak whilst somebody else is speaking, please use the raise hand function and you will be given chance to air your views in due course.

Could we please exclude COVID-19 where possible from any discussion.

To clarify the purpose of this focus group, we are exploring what you think are the effects breathing can have on the musculoskeletal system and not the effects of physical activity or the musculoskeletal system on an individual's breathing.

Engagement Questions

To begin, I would like to know when was the last time each of you took time to think about your own breathing?

Exploration Questions

Firstly, could we discuss as a group what we think dysfunctional breathing is as opposed to normal breathing?

Barker and Everard (2015) defined breathing as dysfunctional when “an alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may be respiratory and/or non-respiratory”. How do you feel about that definition?

Follow up: So, would you agree with the definition or not?

4. Would you say that dysfunctional breathing is the same as abnormal breathing?

Do you believe that dysfunctional breathing is common within the adult population?

Follow up: What do you base that on?

Statement. The next few questions are on the subject of breathing related to the musculoskeletal system, as opposed to viewing it from a cardiovascular perspective

Can I get a sense of who might treat or intervene with dysfunctional or abnormal breathing to benefit the musculoskeletal system?

If participants answer yes, then proceed with questions 7, 8 and 9. If they answer no, then proceed with questions 7b and 8b instead and do not ask 9.

Follow up: Why is it important to do so?

How do you assess an individual's breathing?

Follow up: Is there a method or more than one method?

7b. Why do you not assess an individual's breathing?

As a group, could you list what you believe are the potential effects of dysfunctional breathing on the musculoskeletal system?

8b. What are your thoughts on some of the beliefs practitioners might have in relation to assessing and treating breathing in a musculoskeletal health setting?

How do you assess the effects that dysfunctional breathing has on the musculoskeletal system, i.e., is there anything you observe, palpate, test?

If you treat dysfunctional or abnormal breathing, what specifically do you use to intervene and how often do you use them?

Exit Question

Is there anything we did not touch on that you feel is important to add?

Appendix 9 – Transcript 1 (Focus Group Interview)

TRANSCRIPTION PROTOCOL

Header for all transcriptions

Date transcribed	
Date started	
Transcriber Name	Transcriber 1
Audio file name	Dysfunctional breathing focus group
No. minutes taken to transcribe	2.5 +
Date complete	

Transcription specification

1. Verdana 10 point
2. **Bold for interviewer (I)**
3. Normal for participant (P)
4. Insert time [e.g. 11.37] in red where inaudible
5. Single line spacing
6. Double spacing between speakers
7. Page numbers in footer

I: So, thanks everyone for attending I'm just going to give you a few ground rules before we start, but yeah before I do do that thank you because I'm sure it's a busy time for everyone. So it's much appreciated. So, a few ground rules, if we could try and refrain from talking over each other and try and listen to each other's opinions without interrupting. If you do have anything to say at any point whilst somebody is speaking try and use the hand up function and then I'll come to you once that person who is currently speaking is finished and we'll give you a chance to air your views and opinions and responses then. Try and respect each other's background professions and opinions even if you don't agree with them. Try and maintain confidentiality after the interview is concluded as well. Can we try and exclude any Covid-19 chat where possible? It's obviously a very hot topic at the minute but let's try and exclude that if we can. And to just clarify before we start with questions to explore what you guys think about what effect breathing can have on the musculoskeletal system as opposed to what effects the musculoskeletal system or physical activity can have on somebody's breathing. So it's how breathing affects the body rather than the other way around ok?

So, to begin with I'd like to know when was the last time each of you took time to think about your own breathing?

FRED: Today

I: Today? In what context?

41 JASMINE: On the way back from my friend's.

42

43 FRED: I'm a yogi as well, so I would start everyday with breathwork and have
44 done for many years so.

45 **I: What were you going to say?**

46

47 JASMINE: I was just going to say on the way back driving back, thinking
48 about what we were going to talk about today. It made me do some breathing.

49

50 **I: Cool**

51

52 VIOLET: Probably in the exercise class I did earlier because I finish every
53 class with breathing techniques for people to manage their pain.

54

55 **I: OK cool**

56

57 MARTIN: Most days for me because I practice a lot of Qi Gong so but also
58 because I'm actually conscious of tightness in my own body and how it really
59 helps me to get my lungs functioning and opening everything up so. Yeah most
60 days. I haven't done any today though.

61

62 **I: OK perfect.**

63

64 VIOLET: Can I just go open the door? My sister's waiting to be let in. I'm
65 ever so sorry.

66

67 **I: Yeah.**

68

69 **I'd be keen to know if there's anything in particular that you guys think**
70 **about your breathing? With regards to when would you choose to do it**
71 **for example? When would you choose to do your breathing and not?**
72 **Obviously [M] you said you do it daily is there a particular reason why**
73 **you would start your day with a bit of breathing?**

74

75 FRED: Yeah I had a lot of allergies growing up and I started practicing yoga at
76 quite a young age and what I did which a lot of yogis do is you go into a lot of
77 these very complex technical breaths patterns or exercise thinking that they're
78 going to be saviour. And what I've realised over the years is that if you don't
79 have good diaphragm control in the first place you can't add technique, you're
80 just adding poor pattern onto another poor pattern. So because of that because I
81 can get into bad breathing pattern quite easily and I just start my morning with a
82 very simple breathwork. So obviously I've worked with Douglas Heel for years so
83 I use the diaphragm release that he does. Not always because there's other ones
84 that I use that are also good. And I just start my morning with that every
85 morning and I do five minutes of conscious breathing work. And then I went to
86 the gym again at 11 so I got really out of breath doing that because I'm really
87 unfit right now. so then I had to come on and do another five / 10 minutes of
88 conscious breathing. I think I've probably practised or studied every breath
89 technique that's on the planet. Particularly in the last two years because
90 everyone's got very interested in breath and I don't know about you [M], for me
91 being from a yogi background. I couldn't have given breath exercises to my
92 students three years ago, they weren't interested. They were like 'no we want
93 asana' 'no we want this' and they weren't that interested in the what conscious
94 connection with the diaphragm and now because of all the I'd say the trends now
95 the books that have been written over the last few years James Nestor is Breath's
96 and Dan Buglio's work. People are more interested now in what breath does
97 they're getting a bit more developing an understanding about it. For me it's just

something that I have to do because like I said life I live in the city centre in Dublin it's busy. And I've been travelling a good bit the last few weeks. And been with family and you know you always need to catch a breath when you're in those situations don't you?

MARTIN: You know I really understand what [FRED] is saying although I think actually is the majority of people who come into my classes are actually looking more for they're not thinking about breath very much still they're very much wanting just to relax. So although we're doing a lot of exercises that are focussing on the breath it's often much more focussed on allowing yourself to let go of muscle tightness and so on and not really focussing on the what's actually happening in diaphragm and when you're doing those exercises. But the basic purpose of what I'm doing is you need to open everything up and try and create space for your lungs to expand and allow all the muscles to function properly so it's kind of the same basic idea. Certainly in terms of doing the exercises myself. I'm not as disciplined as Ben so and I'm really shocking in the morning. So I'm sort of the motivation part in the window in the morning. But I do my exercises pretty most days I would say and they usually end up being in the evenings. So I put some time to one side every most days and say 97% of the time. And I'm very conscious of how it actually helps me to kind of feel more into my lungs. It sounds strange but it almost feels like I can actually feel the blood circulating better in my lungs and in my torso and this whole portion all over me. I tend to particularly get tight around the upper chest. And that's the bit where if I do some exercises. So at the start of exercises I'm conscious of tightness here at the end of doing exercises I'm not conscious of anything in particular. It's just my lungs are functioning. And I was a smoker for a while when I was younger. And I'm pretty sure that's had a significant impact on blood function and it's one of the reasons why I've ended up doing lots of lung exercises myself because it's not just what it does to your lungs but it's what it does to the muscles around your torso and your diaphragm and all that sort of mechanically. So yeah.

I: Thanks for that right so, we're getting into go on FRED

FRED: Sorry I was going to say I got into breathwork obviously because of yoga was the initial thing but when I started to really understand breath was I think it was in my late 20s when I had I was having lots of breathing issues and I was a runner at the time. And I kept getting asthma induced running every time I went for a run I'd feel like I was really struggling always. So I did a course in the Buteyko never know how to say that Buteyko breathing. And I found that that made me really understand the context of over-breathing and what you needed to do to connect with your breath properly before you could actually ask it mechanically to do something extra. So that was the beginning of my real big journey of teaching breath properly. I'm not saying I get it right all the time, but you know it's definitely it's complex. It's very complex.

I: Cool. So I'm going to try and get into some of the complexities around assessing and treating breathing in a little while. But first I'd like us to discuss as a group what we think dysfunctional breathing is as opposed to normal breathing.

JASMINE: Dysfunctional breathing it's so common these days isn't it? Like almost all my patients probably come with some form of difficulty breathing unless they've done something like Qi Gong like yoga, they've already started to go down that path. So many times I find that people just aren't using diaphragmatic breathing and it's all up here and you just put your hands on their shoulder and ask them to breath and it's fff-ahhh and it's just you know and it's

155 amazing when you ask them especially some people to then diaphragmatic breath
156 and you're trying to teach them. And I don't know all these different types of
157 breathwork I know a few but not massive, but just trying to get them to use their
158 diaphragm can be so challenging, so difficult. So I know that a lot of my patients
159 have dysfunction. I think that's what I notice the most is the upper rib breathing
160 more than anything.

161
162 FRED: I mean I would say dysfunctional breathing is anything where you're
163 getting out of breath by doing normal activities. I know there's a lot of theories
164 about whether it's hyperventilation or whether there's a lot of categories where it
165 sits in. so for me my clinic patients come in and they can't give me a sentence
166 without hrrr this or the, and I go 'take five breaths let's have a look at how you're
167 breathing now' and like JASMINE says they're straight up there in the apical
168 senses and they're using the collateral muscles rather than the respiratory
169 diaphragm to do the work. And also this like this obviously a lot of people be
170 doing Wim Hoff breaths and I think the breath is amazing, but the Wim Hoff
171 breath is an active breath it's not a breath that is relaxing. And like again I said if
172 you don't have diaphragm function then you're using a complex breath like that
173 breath then you're adding more. My personal view, I've seen a lot more of my
174 clients who come in give me a breath and they're going 'heee' and they're doing
175 this very intense breathwork. And I think to be clear I think Wim Hoff's work is
176 quite profound but you've got to really understand what you're doing first. It's
177 very intense breath and for me it's not where you start. I don't want to stay
178 anything bad. I do it too.

179
180 **I: How do we view dysfunctional as opposed to normal then? What**
181 **specifically would we be sort of assuming normal is to therefore work out**
182 **what dysfunctional is?**

183
184 FRED: OK that's good. So I'd say normal breath is the ability to move about your
185 day without breath-holding or getting breathless. I'm talking about just generally
186 walking about, doing household chores, walking up the stairs and having a very if
187 you do something like that then you have good recovery. So there's a lot of
188 aspects in it for me, how quickly do you recover from exertion as well?

189
190 **I: OK.**

191
192 FRED: Anyone else? I can talk so I'm going to stop now.

193
194 MARTIN: I was going to say you could maybe think that there were shades
195 of there are kind of shades to this and that actually lots of people are going about
196 their everyday lives without breath problems. But actually they're not doing
197 anything that really exists, places any kind of demand on their bodies and as
198 soon as they actually try to run 20 metres then they're a bit out of breath. So I'd
199 say I agree with what's been said so far, but I think maybe there's lots of people
200 who aren't necessarily conscious of it because they're just not really doing
201 anything to really test whether they've got it or not.

202
203 **I: So to that end do you think that it's circumstantial? Do we think**
204 **that it's contextual and it's not as black and white as what is normal and**
205 **what is dysfunctional or abnormal?**

206
207 FRED: A lot of my patients say they find it hard to take a breath in. they're
208 struggling to get a breath in and my go-to at that point is 'well let's look at your
209 breath out' because that will trigger a proper in-breath if you get that right. I
210 don't think it's simple I think it's very complex. I think because of our lifestyle,
211 the daily stresses the bombardment that we get from news data updates on your

computer you're constantly in a fight/flight response you're constantly in that slightly vigilant if not hypervigilant state and that's definitely going to affect the way you're breathing and then the impact upon the cells and the tissues in your body, the way you move is going to be affected just by that.

MARTIN: Interesting you say that about the fight or flight response. In Chinese medicine your kidneys are responsible for your inbreath and your lungs are responsible for your outbreath. So you might actually say, one of the ways that I think you think about some of these older ideas is that actually if your adrenals are overworked or if effectively your driving resources in that direction you're depriving possibly the diaphragm or areas that are actually responsible for the functional breathing of resources. So I think you're constantly doing that you can end up with more chronic conditions but yeah I'm afraid I can't elaborate more on that but that's kind of yeah the inbreath out breath thing is an interesting way of thinking about it.

FRED: Well again from the yogi point of view the outbreath is getting rid of the waste, getting rid of the toxicity, helps the lymphatic system to clean. The inbreath is you're going to take an inbreath no matter how bad it is you're just primed to breath in, but if you can get the outbreath to work better we're jumping ahead here Tom so I don't want to.

I: Keep going.

FRED: So for me if I can get the outbreath and get the lung outbreath then we're tapping into that adrenal response we're going to slow down the release of the carbon dioxide so that's going to help with the gaseous exchange in the body and then it's going to help to alkalise the system. I also work with a group of people with MS so I work a lot with a group called 'MS to Success' so they often have lesions on the brain and on the spine, so working on the exhale for them has been the best thing for them because it's more controlled if you count to four or five or six or if you get them to hum on the way out then that can control the outbreath and we find that they're not struggling to take the inbreath then.

I: OK anybody else have anything to offer on that one or shall we move on?

OK I'm going to post in the chat so this should be a chat button at the top of your screens and it should pop up anyway when I send it through. I'm going to post a proposed formal definition of dysfunctional breathing, which was proposed by Barker and Everard in 2015 and I'd just like to get your thoughts on whether you think it's accurate, whether you think it needs tweaking, whether you think it's a load of BS? So they defined dysfunctional breathing 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.'

So this is for dysfunctional breathing, not normal breathing.

MARTIN: Do they then define the normal biomechanical patterns of breathing? How does?

I: So yeah they've actually created a model which I haven't got to show you guys, but they've created a model of what they would define as normal breathing. And within that what they would define as

dysfunctional they've categorised it to four different categories as well, so they've got (let me get this right): biomechanical thoracic dysfunctional breathing, biomechanical extra-thoracic dysfunctional breathing, and then physiological thoracic, physiological extra-thoracic dysfunctional breathing.

FRED: OK

I: What were your initial thoughts on reading that, what was the first thing that popped into your head?

FRED: Well what is normal biomechanical pattern of breath? How what was the baseline of that? What was the yeah process behind that? And then

MARTIN: I was going to say the next step for me would probably be how would you track that in that that is what is causing the intermittent or chronic symptoms, which may or may not be respiratory because that actually could be a huge range of different things. So they're kind of covering a lot of ground with that definitely.

I: Yeah

JASMINE: Yeah similar thing it's quite broad, but then I was glad to see that they did put such a broad thing in as well. Because it does take into account pretty much everything without being too specific. So that's kind of a good thing as well. I'm not sure.

MARTIN: Can I get this is me being woo-woo, but can I get a bit woo-woo?

I: Yeah

MARTIN: OK so again my reference points are all kind of Chinese medicines. So in Chinese medicine the lungs rules the Qi of the entire body. They're like the prime minister of the body and if they're not functioning things just don't move properly. So in theory you can actually relate it to just a huge range of things. I mean the things that I'm most conscious of are often actually gut-mobility, like what's actually happening in the gut? Peristalsis, kind of normal movement, and then obviously the actual breathing itself, they're the two things I'm thinking of usually if I'm tracking how breathing might be affecting the wider body.

I: Can I play devil's advocate a little bit? Just to try and prompt some more stuff out of you? Breathing being such an important thing for our bodies to be able to do, does it not make sense that it could potentially affect near enough everything?

FRED: It does.

MARTIN: Yeah yeah

FRED: The biomechanics of your body are relying on the energy the ATP, the gasses exchange in your body. So we can go down the road of yogic and Chinese medicine which is fascinating, amazing, we are so far away from what their knowledge was and their methods are explaining it didn't have the same scientific background doesn't mean that they're any less valuable because I think that's where we're all going. We know that they knew we're just going 'how?' and the latest research around breath's like alternate nostril breathing, we now know that the left nostril uses a different part of the brain to the right nostril which is

326 why one is more relaxed than the other. But biomechanically nothing everything
327 is reliant on the ATP in the cell. Everything.

328

329 **I: JASMINE have you still got something to say or is your hand up**
330 **from earlier?**

331

332 JASMINE: No that's down sorry.

333

334 I like woo-woo M so wrap it in.

335

336 MARTIN: I have to admit I am not I feel often when I say these things I'm
337 being woo-woo but I actually don't consider myself to be very woo-woo generally.
338 You know,

339

340 JASMINE: I'm glad it was you first and not me.

341

342 MARTIN: But I mean for me it's just a different it's a linguistic umbrella to
343 cover everything with. Do you know what I mean? It's not actually that it
344 shouldn't contradict anything that modern science tells us really.

345

346 FRED: I think it's the other way I think modern science is trying to figure out
347 what trying to support what the ancients do. Sorry I did talk over you then.

348

349 MARTIN: No it's cool. I think a lot of the time you're right, but I do also think
350 that it doesn't always happen hat way round. But this is kind of yeah broader
351 state I suppose.

352

353 **I: So I'm going to again devil's advocate. I'd like you to either agree**
354 **or disagree with that definition if you can.**

355

356 JASMINE: Oh gosh.

357

358 MARTIN: I would find it hard not to disagree with it.

359

360 JASMINE: Yeah I was going to say it's an agree.

361

362 VIOLET: it's so vague I feel like you have to.

363

364 **I: Yep OK.**

365

366 **So, moving onto next question I've got for you. Would you guys say that**
367 **dysfunctional breathing is the same as abnormal breathing?**

368

369 FRED: No.

370

371 **I: Why not FRED?**

372

373 FRED: Because dysfunctional could be from a disease, a chronic airway
374 destruction 'destruction' I need coffee! Chronic airway disorder, where the other
375 is something that could have been introduced by poor patterns. In my mind that's
376 why I'm looking at it. Same question again.

377

378 **I: Is dysfunctional breathing the same as abnormal breathing?**

379

380 FRED: No I think for me abnormal breathing indicates that there's a conscious
381 interference with the breath and they got it wrong. I'm not saying it's right but
382 that's what I'm thinking here.

I: There are no right or wrong answers.

MARTIN: I would understand abnormal to be a pattern. I mean if we assume that there is a normal pattern of breathing that if we were all in perfect health and everything was functioning absolutely correctly that we would all be using that pattern of breathing. Abnormal is just not using that normal pattern of breathing whatever that is. Whereas dysfunctional breathing is actually that there is a problem which is coming from breathing. Do you see what I mean? That's certainly how I understand it.

JASMINE: Yeah

MARTIN: Like it's not functioning anymore, so then the there's going to be some kind of an upshot like a lack of oxygen.

I: I know what you mean. JASMINE?

JASMINE: I'm not sure whether I can answer the question but in osteopathy one of our things is that structure governs function, so when I hear function I'm thinking of like the structure of the body. So maybe that's causing dysfunction instead of like abnormal breathing being more. I don't know I'm losing my train of thought. But yeah abnormal being more to do with learned behaviours rather than structure I think I think that's what I was trying to get at there. Does that make sense?

I: Yeah

MARTIN: I think that probably aligns a bit with what Ben said as well doesn't it?

JASMINE: Yeah

FRED: So I've got something to add there or I've followed a lot of free diver called Stig Severinsen and he does something called 'breath packing', that's abnormal. That there's nothing normal about that breathing. So he can create this he can create a way of breathing for 20 minutes so that he oxygenates all of his cells gets massive ATP then he can go under the water hold his breath for 22 minutes. So that's not dysfunctional that's a very different way of looking at yeah.

JASMINE: That's a good example that helps.

I: VIOLET?

VIOLET: I would say when I look at the people in my class like in my cardiac class or pulmonary class. I know they all have dysfunctional breathing and I think that's because of their medical conditions causing that. But I know the difference between their dysfunctional breathing and when they've got abnormal breathing. And I know I should worry when I can notice they're breathing abnormally to when they're just breathing in their dysfunctional way of breathing. So I would say there's a different.

I: So are you saying, again going back to what we were saying before, it's circumstantial, it's depending on what's happening at that moment in time as to whether it's normal or abnormal vs?

VIOLET: yeah I think it definitely is circumstantial because I know a lot of them have dysfunctional breathing and that's all the time. But circumstantial to their medical condition. But then obviously it's completely separate to me to abnormal breathing because that's not circum it is circumstantial if there was something that was going on that was worse than in. So if one of my people with COPD they obviously have dysfunctional breathing because they've got COPD, but I know that if they're breathing in an abnormal way to their normal dysfunctional breathing that something worse going on. If that makes sense?

I: Anybody else want to add anything?

MARTIN: I was just going to say that's interesting actually what VIOLET is saying there because that's suggesting that normality is actually what people are used to or what people are doing normally rather than there is a normal state we should all be following or so yeah. But that makes sense as well, that's like the nature of language in this.

I: I'm going to play devil's advocate again. I'm going to say that somebody's normal breathing could be dysfunctional so their breathing that they would normally do might be dysfunctional and if you was to show them functional breathing that might be perceived as abnormal to that individual as well. So we can come at it from a circumstantial point of view. We could look at it from a point of view of when somebody's running you expect their breathing rate to go up for example, you expect them to start breathing in a particular way. Is that normal? Is it dysfunctional? It's certainly dysfunctional if they was to breath that way for the rest of the year for example, do you know what I mean? But in that circumstance at that moment in time it's not dysfunctional but it would be an alteration in the normal biomechanical patterns of breathing.

MARTIN: Are you sure you're not doing a Philosophy PhD?

[laughter]

I: Oh. So we've already kind of touched on this one. Let me just talk about it in a little bit more detail. Do you believe that dysfunctional breathing is common in the adult population? And if so what do you base that on?

FRED: I say yes it's common. It's more common since we're not supposed to talk about disease, but it's more common. Yeah the history people give me in clinic. When I ask them about their day what happens when they how they go about their energy levels how quickly they recover, so that's what I base that on.

I: OK. Anyone else? Is it common? Is it not common? No idea?

JASMINE: Yeah I think it's very common. Because and I based that on just everybody I see in clinic every single day. I try to look at brief breathwork with most of my patients because it affects the whole body which we've slightly touched on. so I do think it's an important part to bring into a treatment plan. Maybe not that day, but it's something that I do like to try to touch on with everyone and most patients are stressed as well they're being stressed freezing and all of that. It's I like to give diaphragmatic breathing exercises almost regardless of whatever they come in with because it's so beneficial for so many things I do see it a lot.

497

498 **I: Hold that thought.**

499

500 JASMINE: OK.

501

502 FRED: Yeah the same as JASMINE. I start all my sessions with breathwork. I
503 don't do any musculoskeletal work anymore until I've got them to understand
504 where their diaphragm is and to see that there's been a change in a way their
505 exhalation is going. So I don't move onto anything else and I do an assessment
506 on hamstring length pre and post diaphragm release.

507

508 **I: Hold that thought. VIOLET?**

509

510 VIOLET: Yes

511

512 **I: Yep. OK.**

513

514 MARTIN: I'd say it's very common although I am saying in practice I actually
515 don't treat that much. I mean I see people who've got breathing problems but
516 actually just in the way that I work I've not really ended up looking at the breath
517 very much which is kind of weird because I'm dealing with it all the time for
518 myself. But now I'm thinking I should. Every patient now I'm going to be working
519 with the diaphragm. But yeah but I do think actually what I said earlier is all
520 these also true just anecdotally that a lot of people have don't realise that they
521 have what we might call kind of some level of dysfunction in their breathing. And
522 don't really test it as well. But I mean I actually treat quite a lot of elderly people
523 and so a lot of them actually probably are quiet commonly getting out of breath
524 doing fairly simple tasks, but it's like I say I'm not analysing the breathing very
525 much which is this whole conversation is very interesting. I'm thinking I should.

526

527 **I: OK. So, the next few questions are on the subject of breathing**
528 **related to the musculoskeletal system and how it might affect the**
529 **musculoskeletal system if you think it does as opposed to viewing it from**
530 **a cardiovascular perspective. So any sort of talk of carbon dioxide,**
531 **oxygen all that sort of stuff, can we put that to one side and just focus on**
532 **the musculoskeletal aspect? So we've already mentioned accessory**
533 **muscles, respiratory muscles how they might be affected, that sort of**
534 **thing. So, bit of a dud questions because I already have a bit of an idea**
535 **now. but can I get a sense of who might treat dysfunctional or abnormal**
536 **breathing? Or intervene with dysfunctional or abnormal breathing to**
537 **benefit the musculoskeletal system.**

538

539 JASMINE: Me

540

541 FRED: Yep

542

543 MARTIN: I don't want to give the idea that I wouldn't do that it's just that I
544 don't seem to end up doing it very much. I mean actually I have done today. So
545 it's one of those things that drops into my clinic every so often but I can't say I
546 do it every time you know.

547

548 **I: OK. VIOLET you?**

549

550 VIOLET: I probably don't use it as much now as I did when I worked in clinic
551 because I don't have the time and the one to ones with people to be able to fully
552 explain how their breathing is dysfunctional and how they could better it. But I try

553 and include breathing at the beginning and the end of every class I do including
554 my musculoskeletal class.

555

556 **I: OK I would say that counts.**

557

558 VIOLET: Yeah

559

560 **I: OK. Why do you guys think that it's important to do so?**

561

562 FRED: Because breath affects every single cell in your body so if you get the
563 breath right you've got a better chance of the body healing. From my point of
564 view if the body if they're in apical breathing then there's a stress pattern, a
565 breath stress pattern, high cortisol, ok we're not doing that, but then if you've got
566 cortisol in your body then your tissues are going to be less flexible, less
567 malleable, less able, the cell wall is going to be yeah it's not as strong. So and
568 you can from a musculoskeletal perspective you can do muscle testing before and
569 after breath and it changes.

570

571 **I: OK**

572

573 JASMINE: Yeah I feel like this answer could go on and on and on really
574 because it just affects everything. We use quite a lot of work with different
575 diaphragms in the body. So we talk about the main diaphragm, the pelvic
576 diaphragm, fascia, like membranes in the brain, so it all links with every single
577 section. And then there's like rotations when you're breathing. So everything
578 pretty much I feel like I could link it to every patient, somehow I use it a lot.

579

580 FRED: So it's a personal thing so you can delete this if it's not required., but
581 years ago I was in a road traffic accident and

582

583 **I: Hang on FRED**

584

585 MARTIN: You've muted yourself FRED

586

587 FRED: Ah didn't touch anything. Ok so years ago I was in a road traffic accident,
588 so first of all I said if this is irrelevant you can get rid of it. So I was carrying to
589 JASMINE who was saying about all the diaphragm. So I had a pelvis injury where
590 iw as left incontinent and even though I'd been practicing yoga and been very fit
591 all my life I couldn't touch my knees or anything like that and that was going on.
592 and I had some work done on my diaphragm to release it and at that moment my
593 pelvic floor reset and I could touch the floor. And I hadn't been able to do that for
594 about four years. So for me there was an absolute profound moment in my
595 recovery and health that came from one simple diaphragmatic release because I
596 had gone into spasm and I had been compensating and managing in my
597 dysfunctional way of breathing and managing pretty well, not really, but everyone
598 said 'you're doing well' and you know years of treatment and amazing therapists
599 supporting me. It was the one thing that changed it for me and the pelvic floor
600 reset I was no longer incontinent I didn't have any pain in the pelvis and my
601 breathing just kind of reset and also my eyesight got better. And for me it was
602 like 'what the just happened there?'. So a bit of hallelujah moment for me. So
603 from that moment on I then started to look at people who were working with the
604 diaphragm in different ways. That's how I found Doug Heel's work. And everyone
605 else like Patrick McEwan I studied all of them after that to find out what happens
606 when your change your breath properly. When biomechanically it changes, what
607 can it do in your entire body? And for me just rest me. So.

608

609 JASMINE: That's awesome. That's amazing isn't it?

FRED: Yeah and I've had good results with other people. Since I've because I've had a better understanding and it wasn't now just a academic piece of work or a breath, I had sat there and done breath work forever. You know I practiced pranayama's and I was more interested in that kind of work. But even though I was doing all the breathing, my respiratory diaphragm wasn't able it wasn't well. So until that actually got released and neurologically came back on it was like I was only using one lung. You know? And it was the left lung so it was around the heart as well so it was the fascia around the heart and everything that got constricted. I mean tell me if we talk about how it works on a musculoskeletal level. You know the fascia is reliant on what is happening from the inside out. We can release as much connective tissue as we like but until you get the body congruent from the centre out the fascia is stuck down to do a job, to stabilise and support something. So if we release it to early then you're going to have other issues further down the line. From my perspective, like I'm neuromuscular therapy so we work with the nervous system to muscle, rather than musculoskeletal.

I: OK so. Let' get stuck into the nitty gritty, you can take as long as you want with these answers or you can just skim over them, I might poke and probe a little bit if you say something that I want in a little bit more detail. But how do you assess somebody's breathing?

FRED: I've talked a lot does somebody else want to go?

JASMINE: I'll happily go. It's a lot to do with as I say for a lot of osteopaths it's to do with hands, feeling, not much in terms of measurements I don't do it in that kind of quantitative way, but assessing springing of ribs, diaphragm, hypertensivity, how far the rib cage goes in and out when they're breathing in. whether the diaphragm actually comes down at all. Again, shoulders going up as I said earlier, tension around shoulders. Neck muscles, are they tense up. Yeah and trying to think if there are any other major things. I mean there are others because everything links doesn't it? Like soas and you could go further into hip musclesbut yeah I think if we were to go very basic probably I would look at upper ribs, lower ribs, diaphragm, springing, thoracic rotation, all of that, everything.

I: What would you be expecting to see? What would you be looking for versus finding? Going back to what we were saying earlier on about normal breathing now. So what would you be looking for in assessment of that, what would you be expecting to see?

JASMINE: Yeah. If I was looking for the perfect model in my eyes I would be looking for diaphragm to be coming down both sides equally, rib cage equally in the bottom expanding out, the kind of shoulders they're not meant to be deep breathing like running a marathon so staying down. Not really inhaling quickly, a lot of people will do that as well when you ask them to deep breath they [breathing sound] and you know you're not looking for that. So I guess I'm looking for things that don't fit into what I perceive as normal which you're probably going to ask me aren't you? Because we've already talked about it we don't need to go there. Yeah I think that I'm trying to avoid.

I: OK.

FRED: Anyone else? I can come in now because I have some specific measurements. I do an active soas test and a passive hamstring test.

I: OK why?

FRED: Why? Because it's baseline so I'll check the breathing, watch how they're breathing, watch for all the things JASMINE has said. The thoracic rotation, thoracic springiness of ribcage, all of those things. And then I'll do soas test and then I will do hamstring. We know that there's common fibres with the soas and the respiratory diaphragm. And their relationship there at the T12L1 is massive through the lumbar spine region. Hamstring is just something I learnt it was just a way of seeing whether the breath would affect the backline of the fascia once you did a passive test you could see it could go from 60 to 90 quite easily. So I do the assessment, the breathing, I do the muscle testing and then I will do an active release on the diaphragm. So some fascia were releasing, some getting manually into the diaphragm, bringing it down, creating space around the stomach, the pancreas and the spleen and the liver. And then I would get them to do some five inhales/exhales and then retest. And you've got a really strong specific measure and sometimes it's that much of a change people are really shocked and that's the buy-in that's how powerful your breath is when it's right so. It's a pretty clear way I'm not saying I don't there's no evidence behind why it should do that but it's I can muscle test activate, muscle test is great. I got that thing so.

JASMINE: FRED, can I ask you how often that works, does it work every time? I'm quite intrigued by that I've never heard of that.

FRED: You can always feel a change, particularly with the soas, the hamstring is always a little bit because it's how good am I at testing? How good are they at using the quad? How good are they at cheating? So if I could get a real good passive test on the hamstring then yeah. You see because soas you can usually feel a significant difference immediately.

JASMINE: That's really interesting. Yeah the soas I can really understand but the hamstring one was a surprise for me.

I: Working in the same building as me, Gail and Jess, I'm surprised you'd say you've never seen that before JASMINE.

FRED: Yeah I've never seen that before, no. it's massive because you've got to be really clear about the passive test. Because otherwise you can be, it's not that straightforward is it Tom? I mean you use but the change is phenomenal. I'd say eight out of 10 you can see a very clear change, a very significant more than 10 degrees increase in hamstring length.

JASMINE: It's something I need to look into I need to try that.

FRED: Ask Tom as you're in the same building as him go and.

JASMINE: Yeah.

I: Tuesday if we've got a bit of time.

VIOLET. M, do you assess it in any different way to that? Would you assess it in any other way? Do you fairly similar?

VIOLET: End say probably fairly similar. Obviously from the doing the training with at the clinic that would probably be exactly how I would do it if I was still working in a clinic at the moment.

MARTIN: Yeah I'd say I do it. If I was to do it I wouldn't do any differently to what JASMINE was suggesting which is actually feeling for hypertenisisity and observing the expansion and contraction of breath. The only other thing is I might actually rely a little bit on the pulse because the distal post is lung pulse in Chinese medicine so you're kind of feeling how yeah but that's the completely other kind of paradigm, different way of thinking about what's going on I think.

I: So would you be taking the pulse reading as they're breathing in a particular way or would it be just a case of?

MARTIN: No so I'm not good enough at reading the pulse to be able to detect subtle change well I can so things I can detect on the pulse much more about whether there's actually any congestion in the lungs for example. So it's less to do with mechanical breathing, but quality of the pulse changes often depending on whether there's tightness constricting it or whether there's actually something in the lung. So you'd be more like the pulse will feel bigger basically if there's actually something going on in the lung. Very often anyway. And if there's more likely to be muscular constriction somewhere the pulse will feel more tight. Almost like tight or wiry so yeah, those are the kind of qualities I'd be looking for.

I: OK FRED?

FRED: Yeah it's another thing that's come up lately and I was working with a group of people with diabetes and they were type 1 diabetes so they were on the monitors and the diaphragm release struck their blood sugar levels and stabilised a couple of them had been stressed for a long period of time and hadn't been able to manage their, were taking more medicine than normal and when we released the diaphragm you could see it coming down and it stabilised so that was something I've had feedback from from three individuals who were type 1 diabetic. So I mean that's blood gasses so I guess that's not muscular, sorry, jump in there.

I: It's all relevant.

FRED: It's hard to keep us all controlled huh?

MARTIN: I was going to see one of the things I don't really have anything to add to on this, but certainly you can sometimes feel the, I don't know if anyone else might have anything to contribute to this, but actually aorta of the aortic pulse, whether that changes, because sometimes it can feel changes in the pulse, depending on what's going on specifically in this area. But again it's not something that I've ever that I haven't really done enough in tandem with checking breathing to know whether there's a consistent alteration.

I: OK cool.

Moving onto let's say the more anecdotal things that we might look at. I'd like us to try and list as a group what we believe the potential effects of dysfunctional breathing are on the musculoskeletal system. So what do you think happens? What are the effects to the musculoskeletal system if somebody presents with dysfunctional breathing?

FRED: Tight shoulders, tight neck, jaw using their jaw a lot so it may be find often need a TMJ release. Shallow breaths, noisy breaths, colour in the hands, you know like a little [53:10 thianosis ?] around the lips if you're really good at it. What else? Flexibility, movement, balance,

I: Flexibility in general? Movement in general? Or

FRED: Yeah in general. Because I'm a yogi so I'm looking at people from all that, my clinic is in a yoga hall so I'd say 60 per cent of my clients come from that. So my 'show us your downward dog' 'show us your [53:49 gapad?] or whatever it is you know. Anything with an extension and you will see what's going on with your hamstrings and they're usually very tight. Anterior pelvic tilt often, some of the things. There's a complete disconnect between the rib and the pelvis, distended abdomen,

I: And you mentioned hamstring flexibility improving when you intervene earlier.

FRED: Yeah

I: So I and we right in sort of flipping it on its head and flipping the coin and saying if somebody's breathing is affected then hamstring is reducing flexibility.

FRED: Yeah

I: OK, just clarifying for the tape.

FRED: Studies, you've got to make sense of all of this.

I: Any other things that we might look for?

FRED: Thoracic spine, often really tight in the thoracic spine, I mean that's we know that the sympathetic branch of the nervous system is coming through there so it's going to be affected you know. Blood sugar levels, that's definitely, and your cortisol levels are up, blood sugar levels are you know you're going into the acidic range of the blood so. Lymphatic system is cloggy, it's everything isn't it? How can we I could just go like musculoskeletal, breath is the beginning of everything. With yoga say your first breath is the one in the last breath is the end of your life, so everything is what you do inbetween. And if you do that well, if you breathe well you've got a chance of moving well and living well and making good decisions because you're not running from that cortisol based fight/flight response. I would say also that people who don't breathe well tend to I would say it's anecdotal but can often be quite snappy and irritable not always but you know, I'm tired, I'm not getting enough oxygen in my cells, I'm tired I'm narky, and nothing you do is going to help me but I'm here anyway. It's from that point of view.

I: I've seen that a few times.

FRED: I know 'I've been sent to you but I don't believe in it it's not going to help me' 'OK'. No that's where someone's really really not well and then you can usually see from their testing the not just the muscle testing to see where the compensations are but muscle testing around mindset. You can see how that's affecting their whole skeletal system get them to take five breaths and they can change that.

I: So how might we assess some of the affects that we think are happening due to dysfunctional breathing? So we've talked about how we assess dysfunctional breathing, but how might you assess some of the affects that are happening? So, FRED you obviously mentioned doing the straight leg raise testing for the hamstring. Is there anything else

that you guys might observe or palpate or test that you've specific look for or assess looking for the effects of dysfunctional breathing, rather than just in general?

JASMINE: I guess I just it is a bit general but I do retest what I tested before. Especially the ones that especially the ones that patients really notice as well, like thoracic rotations always a massive one and you can almost always improve that through working through ribcage and all of that what we've discussed. And yes, I guess pain as well as an indicator. You go back and test those points that were painful and that's always a great indicator.

FRED: I mean you can get I guess like the work we do Tom you know the walk test, just get them to walk around or down on one leg and you can see what they've got and then when you've treated them retest all of that. That's a very simple way of them feeling their own body, you know the way we're going in the world, most of us most people are become very detached from their physical self, we're in our head a lot, just start that connection back into the main body, people they don't want to feel their pain or they've disconnected because something's too hard, it's too hard to deal with. I had a woman who said 'I have amputated this arm because it's just not worth being' mentally in her had 'I've amputated it, it's just not useful to me anymore' and that was a lot of work getting her back into. Why would you want to connect with something that you've actually mindfully, consciously gone 'this is so painful I'm going to just cut it dead'. Luckily we did get some work done and did help a lot.

I: What about would you guys ever look at somebody's posture in relation to breathing and expect something to have changed? If so, what might you look for? What might you observe? What might you see?

FRED: Look at the kyphosis, forward head posture, anterior pelvic tilt, all of that. That's another marker I do, I usually take it before and after photograph just of the side back profile and we just look at that. I don't always show the photograph again after I've done the breathwork, but I might actually start doing that just to see how the breath actually does change the posture before I go into any of the musculoskeletal stuff, that's actually worth doing actually.

I: OK cool. If you guys do treat and I'm assuming still that you do treat. If you guys do treat or intervene with dysfunctional breathing or abnormal breathing, do you use anything specifically and how often do you use it?

FRED: Yeah it's me again. I'm sorry does anybody else want to because i'm quite happy to?

I: Go for it FRED.

FRED: So I use two things specifically. I use the releasing of the tissue through the SC joint and then down the sternum and then into the just the ribs as they come down. So I'll use that release, but if it's too painful I do a cough reflex just underneath the ribs where you just hold and they [cough] and that can really help to release some of that tissue. And then I would also, so three techniques really, the one is just to clear the sticky tissue, and then I also use visceral massage technique, so I'll go right in into the diaphragm and sort of release the diaphragm manually as well.

I: OK. Are the release techniques myofascial release techniques?

FRED: I guess so yeah they would be. I sort of [1:02:10 neuromuscle but if it all Leanne Cheeto's?] work around the diaphragm releasing through fasc. I guess it is fascia I never really questioned it it's just you go underneath you get them to breathe in and then you push up and pull down and you just hold it there for a little while and then suddenly they go 'ah' and then I also do some intercostal releasing, getting the thumb into the intercostals and do some lateral inflection away from the thumb and that's going to open up the space in the intercostals and release anything around [1:02:42] anterior which can also lockdown the shoulder at the rib there. So they're quite easy releases and they have the biggest impact there, but if someone's really sensitive because they've got chostochondritis or something like that I'm not going to do the rib, the external rib release, I'm going to go into the underneath the diaphragm and do it underneath there so.

I: OK. You also mentioned breathing exercises earlier on. Do you use them as a way of intervening with breathing or?

FRED: Yes. I get them to hum so they can get a longer outbreath. So it's just a breathe in, I don't even give them a count, I just say 'breathe in and count how long. Just take a normal inbreathe and then as you're breathing out hum and just see how far you get without losing your breathe'. So it just like inhale, exhale. And I can once they get used to the breathing the gentle breathing, then I can introduce yogic breaths like 'vriti' it's called which is now called the box breathe, which is like four, four, four, four that's pretty good for getting people to check, but it's also it's too mechanical sometimes and that can cause stress because you can't get the count right. So it depends it's one of those it really is the chicken and egg. How well they've released, did they release well often you don't need to give many much because they're just easy they can just go 'oh my god I can breathe!'. You don't really need me to coach it then. But then I go 'do you like this feeling?' 'do you like feeling like this?' 'ok you've got to maintain this, so what I want you to do every morning is this diaphragm release' or whatever which one working there and I want you to breathe in through your nose and breathe out through a straw or hum and do that 10 times and just see how that makes you feel. So it's really nice and gentle, yeah. Nadi shodhan is which the alternate nostril breathing I would use with my clients who are also yogis because they get they're also learning about the nervous system, the feminine, the masculine side of the yin the yang of their body. So that would be the left side energy system is considered to be the sympathetic branch of the nervous system where the right side is the sympathetic. Did I say the other way? Parasympathetic left, sympathetic right. So, there's lots of different breaths I would use. I tend not to use any of the hyperventilations when I'm teaching breath work. That would be four breath technique and they can only learn that once they've got the diaphragm working well. For me anyway.

I: Cool. Any other interventions or treatments? Anyone else?

JASMINE: Mine are very similar to what FRED said. Working anteriorly, posteriorly, diaphragm, so I go up and around first rib to release, fascia work around there. You know anterior neck especially. And Pec muscles I was going to say as well just bring those guys in just getting them really stretch really working on them. Really helps people feel like, lifting pec they're lifting diaphragm it all just makes people feel like they want to do that. They feel really good from that. And similarly I do give breathing exercises but I think because I don't know enough about them and I tend to stick to the diaphragmatic ones. Occasionally I'll being in a fun one just because I think the patient might engage with it a little bit more because I'm just lying and doing diaphragms and breathing exercises a lot of people they say their head is too busy and they can't concentrate so I might

get them to do something a little bit more fun. Like a buzzing breath, buzzing bee or something like that just to drown out the noise almost of their own head. But mostly it's just really thinking about getting that diaphragmatic breathing exercise.

I: OK

MARTIN: If I give people breathing exercises they often involve physical movement of the upper body as well. Often the upper body. I would like to get people more using the lower body as well because I quite like exercise, the breathing exercises where you can coordinate your movement both the upper and the lower. So kind of moving through diaphragm and the soas getting everything moving at the same time. But I think it's much easier to give people exercises that are just very simple ones, like actually breathing in and lifting up kind of things. So trying to open up the rib cage and actually open everything up a bit. So very often the kind of thing I'm giving people and more my personal experience as well is that so from doing quite a lot of meditation when you follow the, I personally found it a lot easier to follow the breathe if I'm coordinating it with a physical movement as well. You know sitting in meditation and following your breathing or really trying to feel inwardly certainly for some people can be quite difficult. Particularly if things are kind of locked up and so on so that tends to be. If someone can do that then I'm very happy to give them that. Very often I find myself giving them exercises that are going to open everything up where they're more happy to engage with the external [1:08:28 arms?]. People who often think with their hands don't really connect very much with their lower bodies.

FRED: I'm going to come in again. I'd also do some thoracic extensions as well just over a bolster, a soft bolster just to get them to lift into the chest and also TNJ releases because that can release the floor of the nose let's say so the palette can also help to lift that area and drain the sinuses which just gives them that sense of space there.

VIOLET: I was just going to say yeah I agree in clinic I would do the diaphragm release, but now in my classes I obviously they've got such complex medical conditions I can't do anything to extreme to adapt their breathing. So it would probably be like M said just getting them to breathe and lifting their arms up in the arm just so that they can follow the breath and then slowly release it because obviously I don't want my cardiac patients and the pulmonary patients doing too deep a breaths especially the ones with oxygen tanks on their back and so yeah just guiding them through the breaths nice and slowly is probably what I mainly do now.

I: OK. Good stuff. Last question is there anything else that you guys feel important to add to anything that we've discussed that we haven't touched on?

FRED: From an education point of view I remember when I was studying that diaphragm and breath came something like month nine into my education. It should be one. it should be the first thing you learn.

JASMINE: I agree

FRED: I believe it should be the first thing that we work with with all of our clients in classes and in even with complex I know VIOLET you've got some very complex patients. And I used to be a nurse so appreciate where you're coming from. I've worked for a bit with people with fibrous lungs and working with their

diaphragm and getting their SATs on them you can see a change in oxygen levels as well. But that has to be on a one-to-one and in a I just think that we need educators to be educated first. Doctors should be educated about the breath, so many things could be changed. I mean my injury, my pelvic injury, the doctor basically said 'well Bev now you're age' I was about 43 at the time. 'With your age now I know that's kind of going to happen', I'm was like 'no I wasn't incontinent before I fell off my bike. I also believe and this is just anecdotal but I believe because we I was also Pilates mad as well at one point and the style of Pilates was zip up your abs and lock them down and do everything with locked abdominal area. So I believe when I fell off the bike I was so tight that I just the elastic band that snapped on me. And until my diaphragm got released I wasn't healing and I had osteo, physio, chiro for years, for years and it was Doug Heel he stuck his thumb in my chest and said 'until you get that sorted out none of that is going to change, whatever you've done to your hip, your knee your' and he listed my injuries it was like 'what is this man' it was like [noises] and literally did like five minutes on the floor in the London Excel and I was a wreck for three days because I didn't realise how stuck down I was. And it was like three days later when I realised actually I feel the best I've felt in years. And for me it was huge. And from my personal point of view yes I taught I teach yoga I teach people to become yoga teachers and I teach all this amazing technique, but if the biomechanics are not right their diaphragm then it's not going to work. So I don't teach it out I go 'you've got to learn your diaphragm and if you don't get your diaphragm right you can sit in your diaphragm breathing for the next year and until you get that right you haven't earned the right to use technique yet'. That's that yogi bossy perspective. So it's actually respecting your body and what it's capable of doing right now before you give it something more complex. So I love that you said that JASMINE that the diaphragm breath and the humming bee breath they're fun breaths and they're nice breaths as well. That's all I would add that education-wise breath needs to be up there properly. And we should look at all the different breaths that have come through. The oxygen advantage, Patrick McEwan the take home method, he uses that a lot to look at [1:33:33Wim's?] breath, we should look at them in context of what they actually do and how wonderful they can be, but what are the other sides of them for people who are not in their diaphragm yet?

I: Cool anything else?

JASMINE: I was just going to say yep agree with all of that in terms of education I would definitely agree. I did not learn much about even just a simple as the ribs during my uni degree and it's a really major part for me now. I just like to really enjoy learning about the connection between all of the diaphragms particularly pelvic floor and the diaphragm diaphragm, so that's quite an interesting one and I thought I really find it interesting to compare children's breathing and adult breathing. Because that's what is almost optimum children's breathing. I'm not saying it always is but you know their stomachs are out it's great and I like to tell patients about that. And you know everyone can picture a kid in their head and be kind of 'oh yeah I get that' and that can be quite useful.

FRED: I mean from an osteopathic point of view the first breath is the most important breath and what if the first breath was stressful and it never got reset.

JASMINE: Yeah

FRED: There's a lot of I work in a clinic there's an osteo who is next door to me and he works a lot with paediatrics and resetting their diaphragm. He's very very cool. He doesn't use the same techniques as me but he's like 'get this baby breathing properly'.

1066
1067 JASMINE: Yeah oh yeah I bet that's really interesting.
1068
1069 FRED: Yeah it's very cool.
1070
1071 JASMINE: Scary.
1072
1073 FRED: It's actually if you guys are interested in you've probably done more of
1074 this but Tom Myers and a guy called Tod Garcia who has this enlightened
1075 anatomy practice they've got a really good dissection camera straight over and
1076 it's called 'Every breath you take' so it's from nose to pyramidalis. And the
1077 camera is right over the body all the way through it so you don't miss a bit.
1078 Normally when you're in dissections you're like having to go out a bit to get away
1079 from it or get the smelling salts out. I found that was really useful as well to look
1080 at the complexities of breathing and how far biomechanically it goes so.
1081
1082 **I: Anything else from anyone?**
1083
1084 VIOLET: I would agree I think education-wise it wasn't.
1085
1086 **I: OK**
1087
1088 VIOLET: Every other lecturer but you it wasn't made clear the importance of
1089 breathing and the diaphragm and I think even talking to the people that come to
1090 my classes you know recovering from different either musculoskeletal conditions
1091 fibromyalgia the people with COPD, cardiac issues, they're never taught the
1092 importance of breathing after these events occur. Or even to manage their
1093 condition because I mean a lot of my patients in the pulmonary class have a lot of
1094 musculoskeletal issues as well which does affect their ability to exercise. Not just
1095 because they've got COPD and they get breathless so quickly but because their
1096 body can't physically do the exercise. But none of them are taught how to breath
1097 what we would say would be normally or properly for them. And none of them are
1098 taught about the importance of the diaphragm if you ask them they just don't
1099 have a clue what you're talking about. So maybe it should be part of the rehab
1100 process like in a clinic we would assess even especially if you've got an injury we
1101 would assess that and that would be part of the rehab. But when it's like a
1102 medical condition it's not a factor that's discussed. Like doing my cardiac rehab
1103 qualification there's nothing on breathing at all. Nothing whatsoever like obviously
1104 I would be limited at what I would do for a diaphragm release on someone with
1105 these medical conditions but there's nothing on breathing they don't expect you
1106 to include it in the class. They don't expect you to talk about it, nothing.
1107
1108 FRED: It changes the blood gasses which are going to help everything in the
1109 boyd shift so it's.
1110
1111 VIOLET: It's not anything in the qualification.
1112
1113 FRED: It's just such a stark area just it's almost like and I can say this with love
1114 because I did work for the National Health Service for a long time. But it's almost
1115 like everyone's become a micro-expert and no one's heart. So I've got a patient
1116 right now who's fallen and broken her ribs and I've had to work with her remotely
1117 she's not been able to come in. and when I finally got my hands on her ribs are
1118 like a corset she is so tight everywhere no wonder the ribs went there's nowhere
1119 for them to go when she fell. She's young and the bone one of the ribs isn't
1120 healing so I said 'you need to go to orthopaedics and find out what's going on
1121 with that bone' and cardiothoracics have said 'well if you go to them we're going
1122 to discharge you because it's too close to your lungs and we're not going to take

responsibility' and I'm like 'how about you guys having a chat together and that's frustrating from a practitioner like me on the ground floor dealing with this because now she's saying 'well I'm afraid of you doing this release because this guy said that and that guy said that' and I just said 'ok well why don't we just take it slowly and see what happens'.

I: We're getting political now so stop recording.

FRED: Yeah for you to do that but it is about the education and that's really what drove that yeah.

I: OK so if there's nothing else to add to that last question I'm just going to stop recording and then I'm just going to hang around a little bit afterwards to answer any questions or anything that you guys might have.

[end of recording]

Appendix 10 – Transcript 2 (Individual Interview)

TRANSCRIPTION PROTOCOL

Header for all transcriptions

Date transcribed	14.06.22
Date started	13.06.22
Transcriber Name	Transcriber 1
Audio file name	Dysfunctional breathing interview 2
No. minutes taken to transcribe	240
Date complete	14.06.22

Transcription specification

1. Verdana 10 point
2. **Bold for interviewer (I)**
3. Normal for participant (P)
4. Insert time [e.g. 11.37] in red where inaudible
5. Single line spacing
6. Double spacing between speakers
7. Page numbers in footer

I: So first question, when was the last time you took the time to think about your own breathing?

STEVEN: It was probably yesterday when I was running.

I: Yeah

STEVEN: Yeah.

I: In what context in the sense of just trying to get your breath going whilst you were running or?

STEVEN Well, I think yeah I'm always conscious that, particularly when I've been competing on a bike or running of diaphragmatic breathing. So that your controlling how regular you're breathing but also helps the control your thought process as well. So I've always kind of felt something that I developed over 25 years races is just that in order to focus more on composure you need to control your breathing from your diaphragm. So then consciously feel this wave effect coming from your abdomen which is your diaphragmatic breathing. It's almost like an S shape. That S shape rhythm then starts to regulate your breathing. Because once your breathing starts to become rapid then you're not supplying the muscles with sufficient oxygen. So you're losing your composure and then you start to lose your mechanical efficiency. So I've always seen the connection between the two and these are the sort of thought processes that always used to go through my head in races where people would attack. So if your main competitor's attacking it's are you in control or are you out of control, because if

you're out of control you're going to blow and then the elastic will snap. So a lot of it's that kind of mind connection with your breathing.

I: Is it something that you think about regularly then?

STEVEN No, I think that because I knew that we were going to have a chat today I was more conscious of it yesterday when I was running, but some I think because of being running more it's been sporadic, been busy with work so it's been sporadic times when I can run, so then sometimes you sort of think 'right, ok I'll just run a bit faster today' and then you're actually 'actually, I'm breathing really hard, am I going to be able to make it to the end at this pace?'. So then you start to become a bit more conscious of it. But then I always started to think about how I would relate that to the types of advices I give to patients. Because the majority of my patients are endurance athletes so they're cyclists, triathletes, runners, some of them are maybe less experienced or I had a patient last night whose got the 24 hour world champs this weekend and on Friday but he's looked after his bike, he's looked after everything apart from his own body. And so then all of sudden he just started developing a neural pain in his hands and neck and he can barely move his neck and so many what two days to go before the 24 hour race and it's the big. He's been waiting for this for three years because they were all cancelled during the pandemic. And you can see his breathing's laboured. And you know it's partly because he's a bit anxious about things going wrong at the last minute, but it could potentially also be because of the restriction in the neck muscles and the thoracic region. So yeah I think you start to consider how it's affecting others as well as yourself.

I: OK cool. What do you think dysfunctional breathing is then as opposed to normal breathing? So what would you quantify as normal breathing? What would you quantify as functional breathing? And what do you think dysfunctional is?

STEVEN I think that what you sometimes see is that patients or whoever you're talking to but if I'm relating it more specifically to patients from an MSK point of view and subjectively when you're talking to patients those whilst they're talking they'll gasp or they'll have a shortness of breath. You can normally relate that to their neck posture, shoulder elevation, because a lot of these athletes because I live in at the edge of the North York Moors they do a lot of ultra-running and they elevate the scapula, you can see that the scalenes, sternocleidomastoid and the upper traps are all have excessive tone. And so they're in that fixed position where they're lifting the shoulder, they're elevating the scapula but you can see that they're the posture isn't relaxed. And that seems to reflect in the way that they speak. So sometimes they speak fast with short breath and they're not aware of it. I often ask questions around whether or not they're asthmatic the standard questions that you would ask, but it's yes sometimes it can be quite subtle. There can be the odd wheeze, so we often have if I detect that I'll ask if there are any difficulties with breathing and talk about breathing and sometimes it's actually during the treatment. So once they start to convey information about their competitive events I'll say 'have you considered a breathing strategy?' and some have and some haven't. Some would like to discuss it, I think it's just all part of a more holistic approach to manage. But yeah it's quite a I know it's a very generic term dysfunctional breathing, but I would say if I was to summarise it they're not relaxed when they're talking and they're not relaxed when they're breathing, seem to be holding tension, that shortness of breath.

I: What would you say is normal breathing then? How would you describe normal breathing?

98
99 STEVEN Yeah it's a relaxed form of conversation and a relaxed intake of
100 breath through the nose and out through the mouth. What we there was a fad a
101 couple of years ago actually where in fact it was during the pandemic because a
102 lot of people were training indoors and cyclists are very obsessive I could see a
103 lot coming up on social media about cyclists saying 'I've just managed to pedal at
104 this number of watts and this heart rate but only breathing through my nose. And
105 so then you know obviously the autonomic nervous system responds. I think
106 what some cyclists were believing was 'what I do is try and suppress my stress
107 on my body whilst I pedal at a very high intensity' because we know that that's
108 the objective is to try and train your utilisation and fat as a fuel. But actually what
109 they're always trying to do is keep the body as calm as possible by breathing
110 through their nose. But certainly when I've worked with professional cyclists,
111 they're instructed by their coaches to breathe through the nose and out through
112 the mouth, which is something that I would do in races. And then you know that
113 when you're making a really high intensity effort that goes out the window, so
114 you kind of breathing in through your mouth and your nose at the same time to
115 try and get as much air in. Usually your mouth's open. So, yeah in normal
116 circumstances it's someone's very relaxed when they're talking, relaxed with their
117 breathing and in through the nose and out through their mouth. But sometimes I
118 think about it as whether it's upper respiratory or lower respiratory so if it's upper
119 respiratory then it's short and laboured. And when someone's under stress and
120 there's, when I've talked to the psychiatrists, psychologists, colleagues of mine,
121 we'll often talk about people who are suffering from stress in their normal life, the
122 background that they have. And because I live near Middlesbrough and I've got
123 quite a few colleagues who work in Medicine within James Cooke they say that
124 some people you can tell when they've got a very stressful life because when
125 they come in they talk fast and breath fast and usually breath out their mouth. So
126 they're and you know they say, one of my Anaesthetist friends say 'can you just
127 stop talking and can you just calm down' and they don't know how to because
128 they're used to being fast, talking fast, so everything's elevated and everything's
129 just short. So the intake of breath is very short, and that doesn't then supply, we
130 talk about this where you're not then supplying the brain with the oxygenated
131 blood because you're not getting enough air into lungs and so then this may
132 develop from childhood. You know, in that case where you may have had very
133 stressful upbringing and a low socioeconomic area and actually what that's
134 created. So sometimes you'll have a family that will come in to a shop and they're
135 all shouting and talking fast and all eating with their mouth open and you think,
136 'actually is this as educational as nutrition?' And I find that really interesting and I
137 think that part of the issue and these low socioeconomic areas and the medical
138 staff that are working with patients is they can't get the patients to relax and
139 breath and think. So they're trying to give them advice, but they're not thinking
140 about the advice, they're not interpreting the advice, because they're in that high
141 state of stress. So I think that's all interrelated with the breathing as well. So,
142 yeah, I don't know if that answers your questions or not.

143
144 **I: It does, it gives a lot of detail. And like you say it's funny it's not as**
145 **simple as normal breathing is it, versus so dysfunctional breathing, it's**
146 **not an easy question to answer even though it's an easy question to ask,**
147 **do you know what I mean?**

148
149 **So on that note, Barker and Everard in 2015 suggested a formal**
150 **definition of dysfunctional breathing, which today hasn't necessarily**
151 **been recognised by everybody performing research into dysfunctional**
152 **breathing. I'm going to share with you in the chat the definition and I**
153 **just want to get your thoughts on it as to whether you, well, what you**

think about it to start with and whether or not you would agree with it or disagree with it.

So they've suggested the formal definition as 'an alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may or may not be respiratory'.

STEVEN I would agree with that. It's I think if we consider it from our neuromusculoskeletal point of view with us assessing patients conservatively and recommendations by cardiologists within research suggesting that a more realistic approach is necessary and yeah there are biomechanical factors, posture related, the length-tension relationships within muscles, but also it can be habitual. I would say that social media and phones, phone use, use of laptops and sitting posture has had a significant effect on pressure around the neck and thoracic region. And that's a significant change socially in the last 20 years or so and so as a result of that I think that it's really important to address this. But I do think it's multifactorial, I do think it is biomechanical. But it's if so, if you could read that back out again just there was a point that he makes at the beginning. Because I can't actually see it, so

I: Yeah so it's

'an alteration in the normal biomechanical patterns of breathing that result in intermittent or chronic symptoms which may be respirator and/or non-respiratory'.

STEVEN Yeah I think that's as close as you're going to get to a definition of dysfunctional breathing. Given how multifactorial it is, I think that's a fair call.

I: OK. Would you say that that dysfunctional breathing is the same as abnormal breathing? Would you quantify the two together? Would you say that abnormal is just another way of saying dysfunctional or?

STEVEN I think that dysfunctional suggests that someone would have a normal function of breathing but it's as a result of a situation. So that could be environmental, you know running in a polluted city like London where I know that some runners have said to me that they just start retching because there's round about 5pm if you try and go out running round the parks in London on a hot day it actually forces you to start to gag. Then that's dysfunctional because you can't control your breathing because it's environmental. But actually if it's abnormal breathing then that could be as a result of you know, a non-normal situation such as asthma, where it requires more of a medical intervention rather than a. Say for example they needed reference to a clinical consultant in the NHS rather than a neuromusculoskeletal intervention which is more holistic. Which is just as a result of dysfunction. So someone could have said 'well, I used to be breathing normally, but actually, as a result of this type of activity, I'm no longer breathing normally'. Whereas if it's I don't know if that answers your question but yeah. Yeah so I mean dysfunctional so if they had a normal functional breathing then it's dysfunctional then we could intervene, whereas if it was an abnormal type of breathing as a result of asthma it might be require an inhaler. That's how I would interpret it.

I: OK so could somebody's normal breathing if you like, be dysfunctional? So let's say they've been breathing dysfunctionally for a long period of time. Like say they've had a sort of an increase in sympathetic drive for an extended period of time then could that individual potentially be breathing dysfunctionally for a long period of

time and now that's become their normal breathing if you like? That's what they're used to. And could it suddenly then see functional breathing as being abnormal because it's not what they're used to?

STEVEN Yeah I mean the paper that you or the quote that you referred to. That talks about chronic situations too. So you could change from one situation to the other. Where it goes from normal to abnormal, an abnormal situation, to a dysfunctional situation and interchangeably. I guess it depends on how serious the situation is. Because if a patient said to me they can't sleep because they're catching their breath in the middle of the night and they feel like they're choking. Then and also it's affecting normal daily function, then it requires medical intervention. Whereas in some cases it can be exercise induced or it can be something that's not they wouldn't consider to be too serious, but they just feel as if they're not breathing as smoothly and in control as they would otherwise. So I guess it's all down to severity. Whether it's dysfunctional or whether it's abnormal.

I: OK.

STEVEN Drawing those lines and the experience of the therapist or practitioner to know the point of referral.

I: Do you think that dysfunctional breathing is common within the adult population? If so how prevalent do you think it is?

STEVEN I think it's more common than we've been made to believe. Because you're exploring quite a normal topic and although it is recognised within the literature it's not, I wasn't trained to be aware of it, I've just become aware of it, but actually I've become aware of it through you know learning how to breath correctly whilst training, talking to the other athletes and coaches and then relating that to more experiences in other from patients. When they're saying that do you know someone might say to me 'is it normal to wheeze when I'm pushing myself hard in intervals because that never used to happen?'. So they recognise that as a different situation it's an abnormal situation for them, but it's only during that one type of training, it's not at any other time. So they'll say 'I'm sleeping fine, breathing fine, they appear to be breathing fine'. So yeah I do think the point I made about people who suffer from stress and anxiety, now that we have this situation with Covid and lots of people complain that they feel shortness of breath and I've experienced that myself whether I'm rock climbing or whether I'm cycling or running and it's seems to be intermittent. Others are saying that it's had a chronic effect so that's really brought this topic to the fore. Because people are thinking about their breathing a lot more because they never imagined that a pandemic would occur where it affects everyone's breathing. And also people who are high level athletes they are much more in tune and reflective. Whereas I find if it's suggested that sort of five per cent of the cycling population actually compete, then there's a lot of the cycling population that you don't know whether or not they're getting these signs and these symptoms and they would talk amongst their friendship groups. But then you've also got people within society who aren't educated about breathing, haven't competed, and just breath that way and think that's normal and if they speak to someone else they're like 'oh that's just the way you've always been' that's what the family members would say rather than actually any breathing education coming to the fore. And I think that's really suggests that the type of research you're doing is really necessary.

I: OK. So, the next few questions are going to be on the subject of breathing related to the musculoskeletal system. It's you will probably find it very easy to start talking about breathing in relation to the

cardiovascular system and stuff because obviously we know quite a lot about the links with that. But if we could try and just stick to MSK system as much as possible. If obviously you feel like it's relevant to talk about the cardiovascular system as well because it is and it's all intertwined and stuff then obviously feel free to do so.

So, my first question would be 'do you treat or intervene with dysfunctional or abnormal breathing?'. Do you educate patients for example? Do you get them to do any sort of particular interventions?

STEVEN I think the holistic view that we've already talked about very much is treat each patient as an individual if because as I say they could have intermittent breathing, patients come and see me compete anyway, so they would they may say that they've got occasionally they feel tension that I would it could be interrelated to the neck posture because for example I have a patient who's had a new bike fit but he's getting a really low aerodynamic position he retracts his chin protracts his scapula that then restricts his breathing capacity but it's a much more aerodynamic position because he'd been tested in a wind tunnel. He's also got a new bike so his bike fitter who's highly renowned said 'well you need to condition yourself to be in that new position. But he says 'I feel like I can't breath as efficiently and also my eyes are getting painful because I'm having to look straight up over looking almost vertically up'. So it when I what happens as a result of that is that he develops more tension within the thoracic region around the shoulder girdle and so his muscles are having to adapt to new levels of stress and with that and what you find is that stiffness develops within the thoracic region, the cervical region. And so the prescription would be to obviously mobilise the joints and release the tension within the muscles and address the length-tension relationships, but also to get subjective feedback from the patient as to whether his breathing's improved, but also to encourage diaphragmatic breathing and focus on that whilst he's holding the position during interval training when he's on a turbo trainer. So he's on the position turbo trainer and he can go for minute on minute off or so. But he's focussed on breathing. So yes I mean I think that I would look to address neuromusculoskeletal aspects, but the patient has self-management exercises and strategies. And then we would discuss how things are evolving. If you treat each patient as an individual the presentations very individualised and the circumstances are individualised as well. So it's just a lot of it's based on subjective and then the observations and any solutions that you can provide so it can be a modification in the bike-fit position if it's too restrictive.

I: OK. How would you normally assess somebody's breathing?

STEVEN First of all I would look obviously we standardise our assessment even when we were students we would make a posture observation, look at neck position, forward the chin-poke, thoracic kyphosis, look at muscle tone and it goes from the foot all the way to the head obviously, but you know particularly in the thoracic region and the neck region whether or not there is any tension there, any loss of function, range of motion, strength deficits. But the most basic I picked this up a while ago was the prone breathing wave assessment. Where if you ask someone to breath through their chest then you'd be looking for that kind of wave type motion. I know there's lots of other ways that you can assess, but if the patient's conveyed to me that they have a breathing dysfunction, then I would ask them to describe it and then just inhale and exhale and standing as well and also sitting on a plinth and what situation is it that's causing the breathing restriction? So they might go into that they've got aerobars on their bikes or they might simulate being in the position of the aerobars and showing me how they breath and I watch them with their top off what's happening from

the back, what's happening at the abdomen, what's happening at the chest, and then look to see if I can modify the position. So, it is very much specific because I work a lot with cyclists who have some breathing restrictions or difficulties that can be as a result of the position and the height of the handle bars or the width of the bars or they've had some modifications that it's how you get round that to or is it just that it's in standing and what I often find is through more personal situations is the patients are having breathing difficulties when during sport and when they're exerting themselves, so I'm not having patients coming to see me who are just sedentary and are struggling to breathe they wouldn't book in with a sports injury clinic. So I guess I don't have any experience of dealing with situations like that, but I'd assume that those patients would see a GP and then they would be referred if that was deemed to be necessary.

I: OK. So you mentioned the prone lying method, are there any other particular methods that you're aware of in terms of assessing breathing?

STEVEN Yeah I mean there was a good list actually on Physiopedia, and they give a good overview I think it's a good resource that we refer students to and if we're not aware ourselves as staff they've got a breathing pattern disorder assessment, the breathing [0:27:17 way?] is mentioned in there but I know that there's breath-holding so can you hold your breathe for 25-30 seconds which is another one and if someone's struggling to hold that. Because if a lot of athletes are aware of the breathing techniques that are required within yoga and often I advocate yoga and meditative breathing. And then some patients will prefer to breathe in their nose for eight and out for the mouth – and then hold for eight – and then out through the mouth for eight and then in through the nose. And others say 'I struggle, I can only do that in for four, hold for four, out for four'. And then I say 'yeah well that's fine' you just have to take it slowly try to build towards it. But can they hold their breathe for 30 seconds? Because you know because there are a lot of triathletes as well they can hold their breathe for a lot longer than I can so they're used to being in open water and storms and all sorts of things. So they cyclists tend to breathe pretty hard too.

I: OK. Could you attempt, so, you might find this difficult, you might find this easy. Could you attempt to list what you think the potential effects of dysfunctional breathing are on the musculoskeletal system? So what specifically do you think dysfunctional breathing does to musculoskeletal system?

STEVEN Specifically for muscles I mean not the circulating system more muscle function. Yes I think that if you're reducing oxygenated blood supply muscles then the muscles aren't going to lengthen and shorten the way they should. So don't really contract the way they should. Then the function of the muscles relative to posture or sport performance is going to be inhibited. So I think that shallow breathing is a kind of generic way of describing it, but then everything will feel laboured because the muscles don't get the oxygenated blood that they require. Also you're not getting that expansion of the lungs and so then the thoracic cage function and if we look at the skeletal system then the costal-vertebral joint mobility and the thoracic joint mobility it all the joints are then affected by muscle dysfunction and then stiffness occurs and then muscle weakness can occur as a result of that.

I: OK. Are there any sort of other specific muscles or muscle groups that you think are directly affected by dysfunctional breathing? So rather than it being sort of the whole body holistic sort of affects is there any specific sort of?

STEVEN Yes. I think in particular the scalenes, sternocleidomastoid, the traps, these are mentioned within the literature, but actually I would say the levator scapulae is often a big issue too. And the levator scapulae is obviously I consider it now to be the texter's muscle because with patients elevating the scapula and retracting the scapula but then with that forward head posture there's the isometric contraction on the sternocleidomastoid but then obviously you've got the support of the weight of the head, which could be 25 per cent of your body mass being supported by the scalene sternal colloidal mastoids. So the isometric contraction is a tension that occurs in and around the musculature and also from the upper traps then actually has effect on the ability for you to breath. So I think it's obviously scalene sternocleidomastoid are your inspiratory muscles, but it's going to then have an effect on respiration too.

I: OK. So how would you assess, if you were to do it, how would you assess the effects that dysfunctional breathing has on musculoskeletal systems. So not how would you assess dysfunctional breathing, but how would you assess the effects that it has so observations, palpations, any testing you'd do anything like that?

STEVEN Yeah I mean you can test range of motion because for some patients say that their neck's getting stiff when they wake up in the morning or they can't turn their neck in one particular direction so you've got lateral flexion, rotation flection, extension for the neck, elevation, depression, protraction, retraction, the scapula. And then your six shoulder movements, plus your scaption. So you're looking to see whether or not the neuromuscular timing patterns, but also head posture and the effect that head posture has, sometimes you know the types signs and symptoms that the patient has with breathing dysfunction relates to the types of exercises they're doing too. So it can create muscle imbalances from I've mentioned this sort of forward head posture, protraction, so shoulder impingement can be interrelated within overactivation of the pec-minor, they can be doing excessive bench press-ups and working on rectus abdominus the anterior muscle groups neglecting the posterior chain. And then you can see that from the posture. So they're more protracted and compressed Upper cross syndrome. So see Upper cross syndrome is interrelated with breathing dysfunction too. So if we claim to restore muscle function and postural alignment then I find that breathing improves. The ability for a patient to retrain their breathing function if they have breathing dysfunction then develops more easily because they have this open chest because they've been stretching their pecs, and pec-minor, pec-major and then strengthening the retractors and depressing the scapula and retracting the chin. So it's postural education and modification of the types of activities they're doing. Not just the treatment that you would be doing within the session.

I: OK. We've already touched on this one a little bit so if you don't have much to add to it then just say. But how would you treat that dysfunctional or abnormal breathing we were talking about earlier on? How would you intervene with them and how often would you do that? I know because obviously you said it's individual dependent and stuff but how often do you reckon?

STEVEN I think I mean my clinics are quite limited so it is during the duration of the time scales or? I mean I feel that the patient can do a lot more in self management if I educate them than I can do in any treatment session. But certainly manual therapies, so that's mobilisations, I think mobilisation of the first rib is really important and then release of trigger points and muscle tension within the scalene and sternocleidomastoid that, the upper traps, the levator scapulae, but mobilisation of the thoracic spine, mobilisation of the scapula

thoracic joint, external clavicular, acromioclavicular, AC joint if that's necessary. And then potentially longitudinals for the glenohumoral joint and any restriction or mobility that's required for any joints that are interrelated. So it could be in the upper limb. But it very much depends on what you find when you assess the patient. Because you could find that they're individual suggestion describe say that they are in a fixed position on a time trial bike in a iron man for 110 mile bike session, then they will have tension that's very unique to them. And they will have breathing restrictions that are unique to them. And I think because of the type of training they're doing, the intensity of the training, then I would just work with that. And adapt to their needs.

I: Do you use breathe work with a lot of your patients? Would you say you use it with only a handful? Would you say you use it with the majority?

STEVEN I think that there's no there's not like a I wouldn't prescribe it to more that only what I would say is that the patients who I discuss it with then I would say 'have you considered meditative breathing? Are you aware of the type of breathing that's required for yoga?'. They may not be familiar with either, so then we'll discuss that and we'll discuss the diaphragmatic breathing during exercise and breathing in through your nose and out through your mouth and if they're familiar with the real fundamentals and then they can start to progress. But you know posture, because that's interrelated and muscle imbalances are interrelated I'd also be educating them on those and why they may need to use foam rower and follow through on yoga exercises and how they would breath and position themselves in that. So then they would take videos of me demonstrating those exercises but I'd be talking about the breathing whilst I was doing them. And so then it becomes a sort of an educational interaction where you're trying to educate the patient to learn more about themselves and to be conscious of what they're doing and why they're doing it. And so then I would only do it if it was necessary. So some patients I've never discussed breathing with them because it's never been an issue.

I: OK. Final question. Is there anything that we haven't touched on that you feel would be important to add?

STEVEN I think there was something that I wanted to briefly mention. There is a narrative review by it's Hamasaki and so that narrative review actually has a very good figure which relates the autonomic nervous system with the cardiovascular system, the respiratory system and the gastrointestinal system. And I think that the gastrointestinal system we had a brief conversation about this in one of the assessments, and the fact that if what we also have we have young people who we deal with at the university who are using their phone all the time and they have poor posture, this forward head posture we talked about, they protracted, but then what they do is they go to the gym and they do loads of situps and they do lots and lots of abdominal bracing, so they're doing the plank all the time. So they do very select exercises, and what they're instructed to do is when they're doing bench press if it's the lads it's to brace your core, brace your core all the time, but that's something that people also do when they're tense and they're anxious. You know you tense your stomach up so they've got exams and everything, and it can lead to incontinence, but it can also lead to an inability to digest food. So this relationship with so your gut health and your general demeanour, the types of anxieties you have how you're dealing with stress and anxiety, and I think that we can relate now with covid stress that a lot of people have been under, but also the changes in diet that people have had too. So I think that that's something we haven't discussed but even though we're talking

495 about breathing it's just a fact that is we've been able to relate the respiratory
496 system to the gastrointestinal system and the potential

497
498 [sound quiet]

499
500 **I: I've lost you Jason can't hear what you're saying.**

501
502 STEVEN There was a call coming through so I don't know if you could hear
503 that so I've dismissed it. I'm just too popular today that's what it is.

504
505 **I: You're a man in demand. Right I'm just going to stop recording if**
506 **there's nothing else you want to add?**

507
508 [end of recording]

509

Appendix 11 – Breathing Pattern Assessment Tool (BPAT)

SUPPLEMENTARY INFORMATION

Utility of a Breathing Pattern Assessment Tool to detect Breathing Pattern Disorder in patients presenting with Refractory Asthma

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APPENDIX S1 - THE BROMPTON BPAT (BREATHING PATTERN ASSESSMENT TOOL)

Breathing Assessment at Rest

The patient should be at rest (have sat still for 5 minutes prior to assessment) in sitting with their **back rested against a seat back**.

Count respiratory rate and observe breathing pattern for **one minute**. Score features of breathing in table below.

	0	1	2
Abdominal or upper chest movement: Where is movement occurring in tidal volume breathing at rest?	Abdominal (Diaphragm level and below)	Combination (Movement in both upper chest and abdomen)	Apical (Upper chest rises and falls with each breath)
Inspiratory flow Do they have increased inspiratory flow? This would be indicated by an <u>audible</u> breath <u>IN</u> through either nose or mouth and includes any type of wheeze.	Silent	Audible	Loud
Expiratory flow Do they have increased expiratory flow? This would be indicated by an <u>audible</u> breath <u>OUT</u> through either nose or mouth and includes any type of wheeze.	Silent	Audible	Loud
Channel of inspiration and expiration	Nose	Nose and mouth	Mouth (Breathing with mouth open throughout)


Are they breathing through their; nose, mouth or a combination of both during the minute assessed?	(with their mouth closed throughout the minute assessed)	(During the minute some breaths are through their nose and some through their mouth)	
Air hunger During the minute assessed is the patient showing signs of air hunger. This includes yawning, sighing or taking a deeper breath than their tidal breaths?	None	Once per minute	Twice or more times per minute
Respiratory Rate What is their respiratory rate in the minute assessed? TOTAL RR	12 or less	13-25	25+
Rhythm Are their breaths evenly spaced throughout the minute? Do they appear regular and rhythmical?	Rhythmical		Erratic
Scoring	0	1	2
Score for each column			
		TOTAL SCORE	
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Appendix 12 – Leeds Beckett University Ethics Approval

Research Ethics



researchethics@leedsbeckett.ac.uk

To  Pinder, Thomas (Student)

 Reply  Reply All  Forward 

Thu 27/01/2022 06:58

Application Ref: 93085

Applicant Name: THOMAS PINDER

Project Title: To what extent does dysfunctional breathing within musculoskeletal therapies influence lower limb function?

Dear THOMAS PINDER, Lawrence Mayhew, the Local Research Ethics Co-ordinator, can confirm that the above research project has been given ethical approval and may commence. Please see your online application for any comments or recommendations.

This project has received research ethical approval in line with the Research Ethics Policy and Procedures of Leeds Beckett University.

Please note that if you wish to make substantial changes to the project, new ethical approval would be required.

Sent on behalf of the Local Research Ethics Co-ordinator.

[Click Here to View](#)

This email has been sent to your supervisor for information.

Appendix 13 – Coding Table

Code	Description	Example
Vital	Participant thinks it of utmost importance to practice breathing exercises on a daily basis.	"I would start everyday with breathwork"
Yoga	Implies yogi's start everyday with breathwork.	"I'm a yogi as well, so I would start everyday with breathwork"
Reminder	Participant consciously breathes when breathing is thought/talked about	"thinking about what we were going to talk about today. It made me do some breathing"
Pain	Breathing techniques are used to help patient's manage their pain levels.	" I finish every class with breathing techniques for people to manage their pain."
Qigong	Implies qigong uses breathing regularly to help coordinate body posture, movement and meditation	"Most days for me because I practice a lot of Qigong"
Fundamentals	Awareness of breathing important for normal breathing.	"if you don't have good diaphragm control in the first place you can't add technique, you're just adding poor pattern onto another poor pattern"
Manual Therapy	Use of a manual therapy technique as an intervention for dysfunctional breathing	"so I use the diaphragm release"
Public Awareness	Increasing public awareness of breathing techniques and exercises	"I couldn't have given breath exercises to my students three years ago, they weren't interested."
Overlooked	Patients and/or therapists who are overlooking breath work, or think it is irrelevant.	"majority of people who come into my classes are actually looking more for they're not thinking about breath very much still"
Relaxation	Patients and/or therapists indirectly using breath work to relax	"they're not thinking about breath very much still, they're very much wanting just to relax."
Conventional	Views or opinions which are focussed on traditional western approaches.	"often much more focussed on allowing yourself to let go of muscle tightness"

Alternate Interpretation	Similar approach, explained using different terminology	"basic purpose of what I'm doing is you need to open everything up and try and create space for your lungs to expand and allow all the muscles to function properly so it's kind of the same basic idea."
Consciousness	Slow, deep, functional breathing is a conscious action.	"I just start my morning with that every morning and I do five minutes of conscious breathing work ."
Perception	Views or opinions which are based on differing perceptions.	"feel more into my lungs."
Multifaceted	Indications there are multiple facets to breathing	"it's not just what it does to your lungs but it's what it does to the muscles around your torso and your diaphragm and all that sort of mechanically."
First-hand	Opinions based on one's own experience(s) in the past	"I started to really understand breath was I think it was in my late 20s when I had I was having lots of breathing issues"
Respiratory Pathology	Breathing became relevant to an individual's health and wellbeing only when respiratory pathology arose.	"I kept getting asthma induced running every time I went for a run I'd feel like I was really struggling always. So I did a course in the Buteyko never know how to say that Buteyko breathing."
Buteyko	Use of Buteyko Breathing Technique	"So I did a course in the Buteyko never know how to say that Buteyko breathing"
Incertitude	When one is uncertain or lacks confidence in approach or relevance	"I'm not saying I get it right all the time, but you know it's definitely it's complex. It's very complex."
Prevalent	Dysfunctional breathing is common amongst public	"Dysfunctional breathing it's so common these days isn't it"
Diaphragmatic Breathing	Opinions of diaphragmatic breathing	"people just aren't using diaphragmatic breathing and it's all up here"
Facilitation	Intervention of providing 'hands-on' stimulation to	"put your hands on their shoulder and ask them

	encourage movement in certain body parts.	to breath"
Thoracic Dominant	Breathing noted in to upper chest and rib cage.	"the upper rib breathing more than anything"
Complex	Suggested that breathing is complex and can be a difficult skill for people to understand and perform well in.	"And I think to be clear I think Wim Hoff's work is quite profound but you've got to really understand what you're doing first. It's very intense breath and for me it's not where you start."
Eupnoea	Not being breathless whilst performing normal day to day activities.	"So I'd say normal breath is the ability to move about your day without breath-holding or getting breathless"
Unaware	Patients are unaware due to lack of physical exertion or sedentary lifestyle.	"I think maybe there's lots of people who aren't necessarily conscious of it because they're just not really doing anything to really test whether they've got it or not."
Sympathetic Response	Notion that lifestyle can induce sympathetic response.	"because of our lifestyle, the daily stresses, the bombardment that we get from news data updates on your computer you're constantly in a fight/flight response you're constantly in that slightly vigilant if not hypervigilant state"
Sympathetic Breathing	Dysfunctional breathing is induced by sympathetic response.	"you're constantly in that slightly vigilant if not hypervigilant state and that's definitely going to affect the way you're breathing and then the impact upon the cells and the tissues"
Domino	When one thing leads to another thing	"The biomechanics of your body are relying on the energy the ATP, the gasses exchange in your body."
Unconventional	When practice goes against western medicine or lacks evidence to support it.	"So in Chinese medicine the lungs rules the Qi of the entire body. They're like the prime minister of the body and if they're not functioning things

		just don't move properly."
Retrospective	Modern science is looking back and attempting to prove anecdotal knowledge that has a lack of or poor evidence to support.	"I think modern science is trying to figure out what trying to support what the ancients do."
Barker & Everard	Agreement with the term and formal definition suggested by Barker & Everard (2015) of dysfunctional breathing.	"Yep, I agree with that."
Abnormal Breathing	A participant explains their interpretation of abnormal breathing.	"I think for me abnormal breathing indicates that there's a conscious interference with the breath and they got it wrong."
Dysfunctional Breathing	A participant explains their interpretation of dysfunctional breathing.	"dysfunctional breathing is actually that there is a problem which is coming from breathing."
Structural	Dysfunctional breathing is related to structure	"in osteopathy one of our things is that structure governs function, so when I hear function I'm thinking of like the structure of the body. So maybe that's causing dysfunction"
Breath Packing	Breathing technique pioneered by Stig Severinson	"called 'breath packing', that's abnormal. That there's nothing normal about that breathing. So he can create this he can create a way of breathing for 20 minutes so that he oxygenates all of his cells gets massive ATP then he can go under the water hold his breath for 22 minutes."
Circumstantial	Breathing changes depending on the circumstances the individual finds themselves in.	"suggesting that normality is actually what people are used to or what people are doing normally rather than there is a normal state we should all be following or so yeah. But that makes sense as well, that's like the nature of language in this."

Anecdotal	Theory or opinion based on the participant's own experiences	"the history people give me in clinic. When I ask them about their day what happens when they how they go about their energy levels how quickly they recover, so that's what I base that on."
Healing	Breathing improves healing	"Because breath affects every single cell in your body so if you get the breath right you've got a better chance of the body healing."
Stress	Breathing pattern changes around stress levels.	"From my point of view if the body if they're in apical breathing then there's a stress pattern."
Power	Breathing pattern can effect the power output of muscles when muscle testing with different patterns of breathing.	"So and you can from a musculoskeletal perspective you can do muscle testing before and after breath and it changes."
Pranayama	Pranayam Breathing exercises used as an intervention	"I had sat there and done breath work forever. You know I practiced pranayama's and I was more interested in that kind of work."
Manual Assessment	Manual Assessment of breathing which looks at breathing patterns.	"with hands, feeling, not much in terms of measurements I don't do it in that kind of quantitative way, but assessing springing of ribs, diaphragm, hypertonicity, how far the rib cage goes in and out when they're breathing in. whether the diaphragm actually comes down at all. Again, shoulders going up as I said earlier, tension around shoulders. Neck muscles, are they tense up."
Psoas complex	Suggestions that breathing effects the psoas complex and it's function.	"I mean there are others because everything links doesn't it? Like psoas and you could go further into hip muscles"

Normal Breathing	Descriptions of normal breathing or what participants would consider to be normal breathing.	"for diaphragm to be coming down both sides equally, rib cage equally in the bottom expanding out, the kind of shoulders they're not meant to be deep breathing like running a marathon so staying down. Not really inhaling quickly, a lot of people will do that as well when you ask them to deep breath they [breathing sound] and you know you're not looking for that"
Hamstring Flexibility	Suggestions that breathing pattern effects the hamstrings and their flexibility in passive ROM testing.	"I have some specific measurements. I do an active psoas test and a passive hamstring test."
Power Assessment	Assessment of breathing which involves muscle testing.	"So I do the assessment, the breathing, I do the muscle testing..."
Relevance	Unsure on relevance of breathing to practice/work with treating patients.	"actually just in the way that I work I've not really ended up looking at the breath very much which is kind of weird because I'm dealing with it all the time for myself"
Palpation	Participants assess breathing through palpation techniques	"actually feeling for hypertonicity"
Hypertonicity	Participants expect increase in tonicity of muscles with dysfunctional breathing	"Tight shoulders, tight neck, jaw using their jaw"
Inflexibility	Participants expect to see inflexibility generally with patient with dysfunctional breathing	"depending on whether there's tightness constricting it"
Coordination	Participants expect to see poor movement coordination generally with patients with dysfunctional breathing	"What else? Flexibility , movement , balance."
Balance	Participants expect to see poor balance control generally with patients with dysfunctional breathing	"What else? Flexibility , movement , balance."
Postural Dysfunction	Participants would expect to see changes in postural positioning	"Anterior pelvic tilt often, some of the things. There's a complete disconnect between the rib and the pelvis, distended abdomen"

Immobility	Reduction in movement due to dysfunctional breathing	"if we look at the skeletal system then the costal-vertebral joint mobility and the thoracic joint mobility it all the joints are then affected by muscle dysfunction "
Mobility	Increased mobility due to better breathing	"like thoracic rotations"
Humming	Intervention with humming exercises	"say 'breathe in and count how long. Just take a normal inbreathe and then as you're breathing out hum and just see how far you get without losing your breathe'. So it just like inhale, exhale"
Nasal Breathing	Breathing Exercises	"Nadi shodhan is which the alternate nostril breathing I would use with my clients who are also yogis"
Buzzing Bee	Breathing Exercises	"Like a buzzing breath, buzzing bee or something like that just to drown out the noise almost of their own head."
Exercise Interventions		"thoracic extensions as well just over a bolster, a soft bolster just to get them to lift into the chest"
Biomechanics	Breathing effects biomechanics/movement efficiency.	"once your breathing starts to become rapid then you're not supplying the muscles with sufficient oxygen. So you're losing your composure and then you start to lose your mechanical efficiency."
Composure	Breathing effects a person's composure.	"breathing starts to become rapid then you're not supplying the muscles with sufficient oxygen. So you're losing your composure."
Fast Talking	Breathing effects speed of speech	"seems to reflect in the way that they speak. So sometimes they speak fast with short breath and they're not aware of it."

Rushed	Notion that when somebody is breathing dysfunctionally, their speech, actions, and breathing all seem rushed.	"can you just stop talking and can you just calm down' and they don't know how to because they're used to being fast, talking fast, so everything's elevated and everything's just short."
Education	Lack of education on breathing technique can lead to dysfunctional breathing	"So sometimes you'll have a family that will come in to a shop and they're all shouting and talking fast and all eating with their mouth open and you think, 'actually is this as educational as nutrition?' "
Socioeconomic Background	Hypothesis that dysfunctional breathing may be more prevalent in individuals from a low socioeconomic background, due to poor education, nutrition, lifestyle, etc.	" this may develop from childhood. You know, in that case where you may have had very stressful upbringing and a low socioeconomic area and actually what that's created."
Social Influences	Breathing is affected by social influences.	"social media and phones, phone use, use of laptops and sitting posture has had a significant effect on pressure around the neck and thoracic region."
Necessity	There is a desire from practitioners for more research to be conducted in to breathing.	" And I think that's really suggests that the type of research you're doing is really necessary."
Breathing Re-education	Patients are taught how to breath	" encourage diaphragmatic breathing"
Mobility Assessment	Participants are assessing a patient's mobility as a way of assessing the effects of dysfunctional breathing.	"check the breathing, watch how they're breathing... The thoracic rotation, thoracic springiness of ribcage, all of those things".

Prone Breathing	Participants use the prone breathing wave assessment technique to assess for dysfunctional breathing	"was the prone breathing wave assessment."
Visual Assessment	Participants use a hands free observational assessment of breathing patterns.	"simulate being in the position of the aerobars and showing me how they breath and I watch them with their top off what's happening from the back, what's happening at the abdomen, what's happening at the chest..."
Contraction	Breathing can effect the contraction efficiency of a muscle.	
Fatigue	Breathing can effect an individuals levels of fatigue	"shallow breathing then everything will feel laboured."
Neck Mobility	Participants believe neck mobility will be reduced if a patient is breathing dysfunctionally.	"you can test range of motion because for some patients say that their neck's getting stiff when they wake up in the morning or they can't turn their neck in one particular direction so you've got lateral flexion, rotation flection, extension for the neck, elevation, depression, protraction, retraction, the scapula."
Shoulder Mobility		"you can test range of motion because for some patients say that their neck's getting stiff when they wake up in the morning or they can't turn their neck in one particular direction so you've got lateral flexion, rotation flection, extension for the neck, elevation, depression, protraction, retraction, the scapula."
Upper Cross Syndrome	Dysfunctional breathing has causal relationship with upper cross syndrome	"Upper cross syndrome is interrelated with breathing dysfunction too"

