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A Multi-Dimensional Model of Dysfunctional Breathing and Integrative Breathing Therapy - Commentary on The functions of Breathing and Its Dysfunctions and Their Relationship to Breathing Therapy

Rosalba Courtney*

School of Health and Human Sciences, Southern Cross University Avalon, Australia

Abstract

Dysfunctional breathing can be defined as breathing that does not fulfill its primary or secondary functions. It is not efficient, adaptive or appropriate for the changing needs of the individual. Dysfunctional breathing has 3 key dimensions biochemical, biomechanical and psychophysiological. This article discusses this multi-dimensional model of dysfunctional breathing, describes its evolution and application in a clinical setting.

The article titled "functions of breathing and its dysfunctions and their relationship to breathing therapy" explores biomechanical, physiological and psychological aspects of breathing. It discusses the characteristics of neuromuscular, biochemical and psychophysiological dysfunctions of breathing, identifies common causes of these and describes the impact that dysfunctional breathing has on posture and motor control, hemodynamics, function of the lymphatic system, physiological regulation and the autonomic nervous system. It also briefly reviews some of the research on using breathing as therapy.

In this commentary I will expand on the on the multi-dimensional model of dysfunctional breathing that underpins this article, describe the evolution of this model and discuss the practical application of this model in a clinical setting.

Functions and Dysfunction of Breathing - A Multidimensional Model

Breathing is fundamental to health. Breathing interacts with many body systems and has many functions beyond the uptake of oxygen and expulsion of CO_2. Recognition of the multiple primary and secondary functions of breathing and its interactions helps us to understand why dysfunctional breathing has such as a large impact on physical function as well as mental and emotional health. It also helps us to refine the therapeutic and clinical applications of breathing.

Primary Functions and Dysfunctions of Breathing

Breathing serves two primary functions in the body which for practical purposes can be categorised as biochemical and biomechanical functions.

Biochemical

The biochemical function of breathing is to regulate oxygen, carbon dioxide and pH. The lungs, under the direction of the central nervous system, work together with the circulatory system and the kidneys to maintain homeostatic levels of these chemical elements. Depletion of oxygen (hypoxia) and accumulation of CO_2 (hypercapnia) can occur when the lungs are diseased or circulation is impaired. In the absence of severe pathology of the lungs and/or circulatory system, CO_2 depletion is more common than its accumulation. Low CO_2 levels can develop quickly because of the very high solubility of CO_2 and lack of feedback mechanisms for its retention. The ease with which CO_2 is excreted means that sustained increases in ventilatory drive resulting from stress, disease or disorders of respiratory control can result in significant depletion of CO_2.

Biomechanical

Biomechanical functions of breathing refers to the action of the respiratory pump, the efficiency of which is dependent on the actions of the respiratory muscles, the function of the rib cage and habits and patterns of breathing. The mechanical action of the respiratory pump drives alveolar, intra pleural and intraabdominal pressure changes that influence amongst other thing venous return to the heart, lymphatic circulation and function of abdominal and pelvic organs.

Secondary and Non-Respiratory Functions of Breathing

Breathing plays a role in a number of important non respiratory functions including modulation of physiological arousal and sympato-vagal balance, posture and motor control, speech and vocalization, physiological regulation and fluid dynamics (Table 1). The efficiency of these secondary functions of breathing is reduced when the primary biochemical or biomechanical functions of breathing are abnormal or dysfunctional.

Dysfunctional Breathing - A Definition Related to Multiple Functions and Dimensions of Breathing

Dysfunctional breathing (DB) is breathing that does not efficiently or appropriately performs its primary or secondary functions. It is less adaptive and responsive to the body's changing needs and conditions than healthy breathing. As a result it does not support homeostasis and optimal health and can be the cause of both symptoms and pathology.

Dysfunctional breathing is multi-dimensional. For practical purposes the, three key dimensions are biochemical, biomechanical

***Corresponding author:** Rosalba Courtney, School of Health and Human Sciences, Southern Cross University Avalon, Australia, Tel: 0414918819; E-mail: courtney2107@optusnet.com.au

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Secondary Functions of Breathing				
Psychophysiology and autonomic nervous system	Posture, stability and motor control	Speech and vocalisation	Homeostatic Rhythms and Oscillations	Fluid Dynamics
Regulation of mental and emotional states.	Regulates intra-abdominal pressure needed for physiological stability of the spine.	Supports voice production for speaking, singing and other utterances.	Functions as an oscillating system that promotes homeostatic interactions with other oscillating systems.	Breathing creates and regulates pressure differentials between thoracic and abdominal cavities.
Modulates physiological hyperarousal and sympato-vagal balance.	Provides foundation for functional movement patterns.	Fine motor control of breathing needed for changes in pitch, intonation and phrasing.	Resonance frequencies of breathing at around 4 and 6 breaths per minute (0.06-0.1 Hz) increase physiological regulation.	Affects dynamics of all fluid systems blood, lymph and CSF.
				Drives venous return to the heart.

Table 1: Role of breathing in a number of important non respiratory functions.

and psychophysiological; these dimensions are separate but interact with each other and other body systems [1]. Patients with severe breathing dysfunction are more likely to have disturbances in these entire three dimensions, while patients with mild to moderate breathing dysfunction may be dysfunctional in only one aspect.

Chronic hyperventilation is a classic example of dysfunctional breathing in the biochemical dimension. Hyperventilation disorders are thought to affect about 10% of otherwise healthy individuals, 30% of asthmatic and up to 75% of anxiety sufferers.During hyperventilation a person breathes inappropriately and in excess of their metabolic needs causing depletion of CO_2 or hypocapnia. In chronic hyperventilation, they tend to breathe this way during rest and sleep as well as during physical activity or in response to specific triggers [2]. Their breathing does not adapt or respond appropriately to changing conditions. The breathing is highly inefficient as it uses excess energy and ultimately reduces oxygen uptake. This reduction in oxygen uptake occurs in the lungs as a result of rapid shallow breathing (which increases dead space ventilation while decreasing alveolar ventilation) and at the cell due to the Bohr effect, where low CO_2 levels affect the ability of haemoglobin to release oxygen for cellular metabolism.

Biomechanical dysfunctions in breathing are evident as poor co-ordination, weakness and hypertonicity of respiratory muscles, particularly the diaphragm. These are often accompanied by restrictions of rib cage motion and abnormal breathing patters such thoracic breathing, paradoxical breathing, excessively irregular breathing, frequent sighing, increased lung volume and hyperinflation of the lungs. Respiratory muscle and breathing pattern dysfunctions can be the source of the particular quality of dyspnea known as unsatisfied respiration with symptoms such as the sense that one is unable to take a deep and satisfying breathing [3,4] .

The psychophysiological dimension of DB refers to the various relationships between mental and emotional factors with breathing physiology, breathing behaviors and symptoms. Psychophysiological drivers such as fear, stress and anxiety lead to generalized hyperarousal in the nervous system which is accompanied by increased ventilator drive that can contribute to both hyperventilation as well as breathing pattern disorders. These drivers also increase dyspnea sensitivity while at the same time reducing tolerance to it. Psychophysiological factors also play a role in perpetuation of hyperventilation symptoms such as dizziness, tingling, numbness as conditioned responses linked to previous situations associated with hypocapnia [5].

It is important to recognise that breathing which may appear abnormal or dysfunctional when compared with the breathing of a healthy person at rest can actually be functional if it is transitory or compensatory for disease, or particular environmental or physical conditions. For example, thoracic and upper rib cage dominant breathing is generally thought of as dysfunctional. However it is a natural response by most individuals to upright posture or sudden need to take a deep or rapid breathing [6]. Thoracic breathing can generally be considered to be dysfunctional when it is present inappropriately, such as at rest or during even mild increases of activity, change of posture or increased ventilator need. Hyperventilation can begin as an adaptive response to obstructed airways, increased physiological or psychological arousal or increased ventilation needs. If becomes dysfunctional if it occurs inappropriately, too frequently or if it persists for prolonged periods of time.

Evolution the Multidimensional Model of Dysfunctional Breathing

The use of the term 'dysfunctional breathing' (DB) only appeared in the literature after the 1990's. Prior to this time it was believed that the symptoms and breathing behaviors seen in people with aberrant and disordered breathing were predominately due to hyperventilation. However a series of studies showed that DB could not be tied solely to the biochemical dimension. A key study by Hornsveld et al. clearly showed that patients diagnosed with Hyperventilation Syndrome (HVS), did not consistently have low carbon dioxide levels and that onset of hyperventilation symptoms was not linked directly with CO_2 levels [7].The term dysfunctional breathing in now an umbrella term that includes abnormal breathing patterns, behaviors and symptoms as well hyperventilation disorders [8-11].

The multi-dimensional model of DB presented in this article, with biochemical, biomechanical and psychophysiological dimension is a pragmatic model designed to facilitate evaluation and treatment of dysfunctional breathing. It is based on the more complex and nuanced understanding of DB that has evolved over the last 2 decades as well as by my own research exploring correlations between screening measures used to evaluate DB. In one research study 84 individuals with concerns about their breathing were assessed using various instruments that evaluated biochemical, biomechanical and symptomatic dimensions of DB [1]. Correlations between dimensions were not significant and the resulting conclusion of this research were that for practical purposes DB is probably best characterized as a multidimensional construct with at least three dimensions, biochemical, biomechanical and breathing symptoms. Given that breathing symptoms are often due to a complex interplay between biochemical, biomechanical and cognitive emotional factors, the 3 key dimensions dysfunctional breathing are operationalized as biochemical, biomechanical and psychophysiological.

Practical Application of the Multi-Dimensional Model of DB

Breathing assessment

If one accepts that biochemical, biomechanical and psychophysiological aspects of DB are connected but distinct and that any one of these factors

can be the key impediment to restoring normal breathing homeostasis, then it follows that comprehensive evaluation should include assessment of breathing functionality in each of these dimensions.

The biochemical dimension of dysfunctional breathing is measured most easily through the use of capnometry, which measures the levels of end-tidal carbon dioxide ($ETCO_2$) in exhaled nasal air. End Tidal CO_2 ($ETCO_2$) in most cases gives a close approximation of the alveolar ($PACO_2$) concentration which in turn reflects arterial levels of CO_2 ($PaCO_2$). To determine $ETCO_2$ and presence of chronic or intermittent hyperventilation a nasal cannula continuously samples nasal airflow while the patient breathes through their nose. Measurements can be taken at rest and by applying various challenges.

Breath holding time is a measure of dyspnea threshold and intensity of ventilators drive. Low breathing holding time is a common finding in people chronic hyperventilation. The breaking point of breath holding is also strongly influenced by sensory feedback from the diaphragm and by psychological factors. Breath holding can be measured at the end of a normal exhale, in which case levels below 20 s are mildly suggestive of dysfunctional breathing and below 10 are strongly suggestive of dysfunctional breathing [12].

The biomechanical dimension can be evaluated by observing and measuring breathing pattern through instrumentation such as respiratory induction plethysmography and clinically by simple palpation and observation. There are few validated clinical assessment tools for measuring and quantifying breathing pattern. However, the Manual Assessment of Respiratory Motion (MARM) is one measure which has been shown to have good inter-examiner reliability and utility [13].

Preliminary evaluation of the psychophysiological dimension can be done through questionnaires such as the Hospital Anxiety and Depression Scale (HADS). Also, high symptom scores on dysfunctional breathing questionnaires such as the Nijmegen Questionnaire (NQ) or the Self Evaluation of Breathing Questionnaire (SEBQ), if unexplained by disease, suggests that psychophysiological, emotional and cognitive factors need to be further explored [14,15].

Integrative breathing therapy

The nature of breathing dysfunction and its causes are complex. An integrative approach to breathing therapy addresses multiple dimensions of breathing and corrects the causes of breathing dysfunction when possible.

Breathing therapy is much more likely to be successful if it is comprehensive, targeted and sufficiently intensive to produce measurable improvement.

Integrative breathing therapy addresses biochemical, biomechanical and psychophysiological dimensions of DB with breathing exercises and supportive therapies.

Breathing dysfunction occurs for many reasons and in some cases successful treatment is dependent on identifying and treating underlying issues. A full discussion of the causes and contributing factors in outside the scope of this article. However, some common causes include pathology of the respiratory and cardiovascular system, sleep apnoea, chronic infection, diabetes and metabolic dysfunction, anxiety and any conditions that lead to hyperarousal and excessive allostatic load.

Breathing retraining and supportive therapies should be targeted to the specific breathing dysfunctions present in the patient. Initial and ongoing evaluation of key dimensions of DB can guide the practitioner as to types of breathing techniques to use and appropriate intensity and duration of breathing practices.

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