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

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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 CO₂. 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 CO₂ (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, CO₂ depletion is more common than its accumulation. Low CO₂ levels can develop quickly because of the very high solubility of CO₂ and lack of feedback mechanisms for its retention. The ease with which CO₂ is excreted means that sustained increases in ventilatory drive resulting from stress, disease or disorders of respiratory control can result in significant depletion of CO₂.

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 and psychophysiological.

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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 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 patterns 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 breathing in the biochemical dimension.

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 breathing patterns, behaviors and symptoms as well hyperventilation disorders [8-11]. The term dysfunctional breathing in now an umbrella term that includes abnormal breathing patterns, behaviors and symptoms as well hyperventilation disorders [8-11].
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 (ETCO2) in exhaled nasal air. End Tidal CO2 (ETCO2) in most cases gives a close approximation of the alveolar (PA CO2) concentration in which it reflects arterial levels of CO2 (Pa CO2). To determine ETCO2 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.

**References**


