Breathing for Health:
The Physiology of Breathing

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In most cases, breathing isn't something we think about. However, many people suffer from disorders, such as Cumulative Trauma Disorder, due to stressful breathing. Even little children experience disorders that affect their breathing patterns.[1] Adults develop unhealthy breathing habits, primarily when they are stressed or focused on a task. [2]

Elite athletes, singers, and musicians who play wind or brass instruments know that breathing style and rhythms have a huge impact on performance. The way you breathe can affect you physically and mentally because there are close ties between breathing and the part of the nervous system that controls the involuntary mechanisms of the body.

Breathing affects the oxygen/carbon dioxide balance in the body that affects the health and performance of body tissues. There is evidence that people who learn to control their breathing can relieve harmful stresses in the workplace (and elsewhere). Research has shown that people who practice controlled breathing exercises can reduce discomfort with computer-related disorders including arm, wrist, and hand pain.[3]

There are many sides to the topic of breathing. First there is the medical side that addresses diseases of the lungs including cancer, asthma, snoring, tuberculosis and whooping cough.[4] Another side of the issue addresses breathing relative to health maintenance and improvement. This aspect is, surprisingly, divided into two strong beliefs: one favors deeper breathing and training the body to accept more oxygen.[5] The other favors withholding breath (hypoventilation) and training the body to accept less oxygen.[6] Some look at breathing techniques from the standpoint of achieving certain mental states or level of concentration. These are not mutually exclusive.

We begin this series on breathing with a brief discussion of breathing and how it affects the body. The next article will look at various breathing techniques. We will give some guidance on their usefulness and function with regard to physical and emotional health,

Breathing Basics. With each breath, we bring oxygen into the lungs. When we exhale, we release carbon dioxide (CO2), water, and other gases from the lungs. The balance of CO2 and oxygen in the blood is very important to general health. By altering your breathing, you can change this balance and cause other physical and mental symptoms.

Breathing engages various parts of the body to expand the lungs. The primary muscle of breathing is the diaphragm.[6, 7] As the diaphragm flattens downward when you inhale (also known as inspiration), the chest cavity expands and air is drawn into the lungs.[6]

The intercostal muscles, which are in crisscrossed sets of muscles between each rib, contract during inspiration, expanding the ribcage and increasing chest volume.[6, 8] Muscles of the shoulders may be used to inhale, but this does not increase chest volume very much. If someone primarily uses the shoulder muscles to breathe, breath is often faster and more shallow.[8,9]

During exhalation (also known as expiration), the diaphragm assumes its natural curve. The intercostal muscles relax, decreasing the volume of the chest and causing the air to escape the lungs through the trachea and nose.[6]

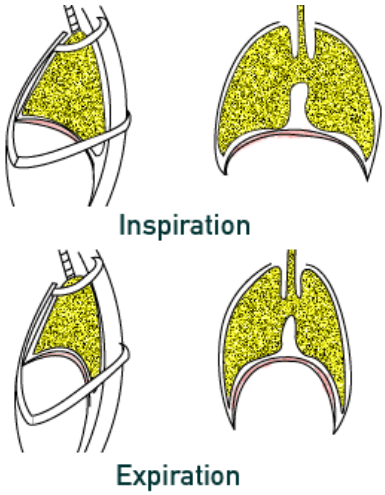

Illustration courtesy of 6

Breathing, as well as functions of the heart, stomach, intestines, and pupils of the eyes, is controlled by the autonomic nervous system (ANS). They are largely involuntary.[9] However, breathing is one ANS function that can be controlled voluntarily.[9] Even heart rate and blood pressure can be controlled through training.[9]

Sympathetic and Parasympathetic Nervous Systems. The ANS is divided into two opposing forces (i.e., the sympathetic and parasympathetic nervous systems) that control many parts of your body. A third part of the ANS, the enteric nervous system, controls the viscera (i.e., gastrointestinal tract, pancreas, and gall bladder). When you are calm, the parasympathetic nervous system is in primary control and breathing is slow and relaxed.[9] When a real or perceived emergency arises, the sympathetic nervous system kicks in to prepare you to respond. Among many other things, your breathing becomes faster to supply your body with the oxygen it will presumably need to escape danger.[9]


Parasympathetic: relaxed

Sympathetic: fight or flight

There are three rhythms in the ANS: [11]

- very low frequencies (0.001 to 0.04 Hz) related to thermoregulatory cycles.
- low frequencies (0.04 to .15 Hz) related to sympathetic rhythm.
- high frequencies (0.15 to 0.4 Hz) related to parasympathetic rhythm.

Various studies have looked at the effect of breathing on the sympathetic (low frequency) and parasympathetic (high frequency) oscillations. The three types of breathing studied were:

- Normal spontaneous breathing
- Controlled breating at 15 breaths/minute
- Hyperventillation with 100% oxygen

Results indicate that the sympathetic (low frequency) oscillations are not affected by any of these breathing modes. However, the parasympathetic (high frequency) oscillations, as well as arterial pressure and heart rate, are influenced by breathing mode.[11] These activities are all mediated by the vagus nerve (see right).

The vagus nerve is the longest nerve in the body. It is the only nerve that starts in the brainstem, wanders through the organs in the neck, thorax, and abdomen, including the stomach, small and large intestines, and the colon.[12, 13] The vagus nerve supplies sensory parasympathetic fibers to all the organs (except the suprarenal glands) from the neck to the second segment of the transverse colon. It also controls a few skeletal muscles. [12, 13] This means that the vagus nerve is responsible for such varied tasks as heart rate, gastrointestinal activities, sweating, and muscle movements in the mouth, including speech and keeping the larynx open for breathing. [12]

Further research has analyzed controlled breathing conditions:

- breath-holding (apnea) after maximum exhalation
- voluntary hyperventilation (with constant CO2)
- hyperventilation induced by raised blood CO2 levels

The study showed varied effects on the parasympathetic and sympathetic oscillations including peripheral muscles and heart muscles.[11] Under extreme conditions, respiration can cause changes in physiological limits in various autonomic drives which may actually induce long-term changes in the autonomic set-up.[11] Close correlations may exist among arterial pressures, heart rate, and muscle sympathetic nerve activity as a result of breathing mode.[11] This affects an individual's risk of nerve damage, as seen in Cumulative Trauma Disorder.

What does all of this mean? By modifying our breathing, we change the stimulation of the sympathetic and the parasympathetic nervous systems. Over time, this may cause long-term changes in the ANS functioning. In addition, the cardiovascular system can be affected by changes to the ANS activity as a result of breathing mode.

How we breathe can actually have very major impacts on how our body functions!

Hypoventilation. Hypoventilation refers to not breathing enough to meet the needs of the body. Breathing is too shallow or too slow. There is inadequate oxygenation of the blood and a rise in CO2 levels with reduced lung function.[14] Hypoventilation occurs when people hold their breath, have sleep apnea, are obese, or take certain drugs.[15] The

dangers of not breathing enough are *much less* dangerous than the dangers of breathing too fast or too deeply.

Hypoventilation can cause acidosis due to loss of bicarbonate[16] which ***actually allows oxygen to be released more easily to the body tissues that need it most***.[6,17] This is called the Bohr effect.[6,17] Hypoventillation has been shown to be of potential therapeutic use in certain instances because it increases blood flow to the brain, lungs, and upper chest area by decreasing vascular resistance.[6,16,18] Intermittent hypoventilation has been used to successfully treat conditions such as asthma, chronic fatigue, sleep apnea, allergy, hypertension, congestive heart failure, and obstructive pulmonary disease.[6, 18,]

Hyperventilation. Some people breathe too much all the time, often using the upper thorax rather than the diaphragm. Panic and asthma can cause people to breathe too much due to a feeling that they are not getting enough air or they have shortness of breath. Hyperventilation causes an imbalance of oxygen to carbon dioxide in the blood, specifically too little CO2. As ***CO2 levels in the blood decrease***, pH becomes more alkaline and ***oxygen is bound more tightly to hemoglobin in the blood, so it is not released to the tissues as readily***.[6]

Panic and hyperventilation become a vicious cycle because panic leads to rapid breathing, while rapid breathing can make you feel panicked.[11, 19] Hyperventilation is a powerful physiological stimulus that can: 1) induce seizures in epileptic patients and heart muscle electrical activity in patients without heart disease, 2) increase blood pressure, and 3) produce spasm in patients with angina.[11] In other words, ***hyperventilation induces tremendous sympathetic stimulation and results in a large number of changes in circulation, gastrointestinal effects, and emotional responses***.[11]

However, hyperventilation is a response in the fight-or-flight episode where a person is agitated, and is necessary for survival.[11]

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