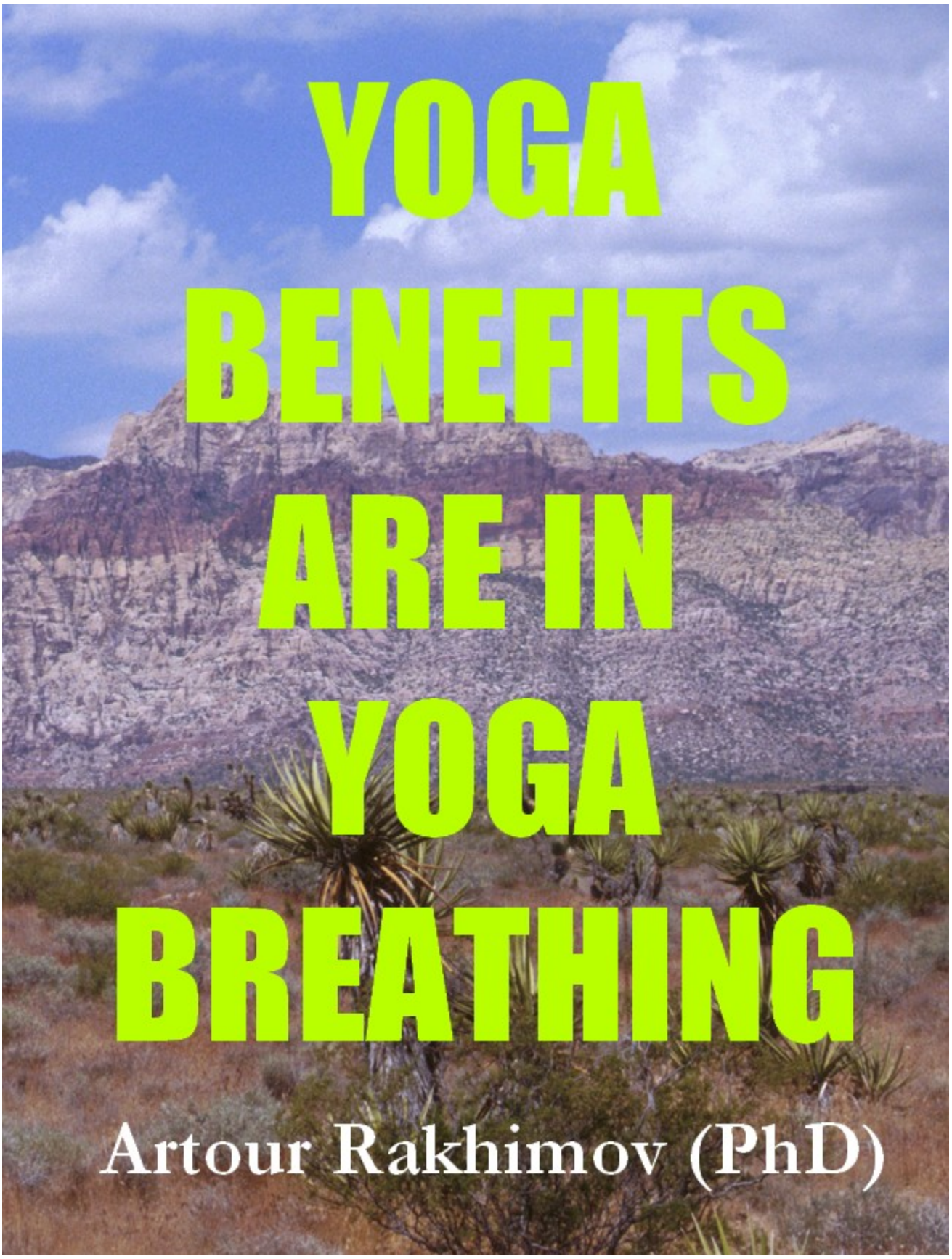
YOGA
BENEFITS
ARE IN
YOGA
BREATHING
Artour Rakhimov (PhD)

Yoga Benefits Are in Yoga Breathing

Artour Rakhimov (PhD)

"All chronic pain, suffering and diseases

are caused from a lack of oxygen at the cell level."

Guyton AC, The Textbook of Medical Physiology*, Fifth Edition.

** World's most widely used medical textbook of any kind*

** World's best-selling physiology book*

Disclaimer

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Content of the book

Introduction

Do you want to get am astonishing boost in your health and main yoga benefits using your usual yoga practice but combined together with one simple tip described in this book? This tip relates to the most important health factor: O2 content in the human body. Furthermore, this book will show you a simple DIY test that is very useful to use in order to monitor your progress in yoga and experience real yoga benefits. If you achieve a certain amount of oxygen in tissues of your vital organs, you will be free from about 200 chronic diseases that include heart disease, diabetes, cancer, asthma, bronchitis and many more. This book provides you with the most important parameters (including exact numbers) in your yoga practice: the direction where to go and the criteria that you need to achieve in order to, first, reduce and eliminate symptoms of common diseases, and, eventually, achieve real yoga health and practically experience yoga benefits.

Yoga has always been about health especially physical health. For centuries, it was one of the most powerful techniques for physical rejuvenation. Probably, it was the most powerful technique for health restoration. Not anymore. You can practice yoga for months and years (the way it is now taught by leading yoga gurus), and your health may not improve or even can get worse. Why does modern yoga provides very limited benefits? Why was it successful in the past?

To put it simply, modern yoga leaders and yoga teachers do not know how to breathe! You can read tens of yoga books, and you will unlikely not find a single book on yoga that provides you exact numbers for ideal breathing even at rest of during sleep for maximum brain and body oxygenation. Furthermore, there is no goal in modern yoga. It is a purposeless eternal activity related to postures and exercise with some variations depending on yoga schools and their specific teachings. As about breathing, they say "breathe more", "breathe deeply", and many yoga gurus and teachers, can even add "expel toxic CO2". These are all inventions and fantasies of modern yoga teachers and mass media.

Traditional yoga never had such ideas. Their teaching was based on breathing slower and less. Furthermore, old yoga had a clear goal in mind, and this goal can found in many yoga books written centuries or many decades ago. There is factor that clearly separates sick and healthy people. Old yoga, without any scientific devices and measurement, grasped the essence of health. And yoga teachers in the past taught their pupils about this essence of yoga. But these days, using medical research, we can prove that old yoga was right.

Hundreds of medical studies have proved that chronic diseases are based on low levels on oxygen in body cells. What about breathing patterns in sick and healthy people? All available research, I am talking about hundreds of studies, has shown that sick people (heart disease, diabetes, cancer, asthma, bronchitis, COPD, and many other conditions) breathe about 2-3 times more air than the medical norm. They breathe deeply and expel "toxic CO2" exactly the way modern yoga gurus teach.

Even modern so called "normal subjects" breathe about 2 times more than the norm and much more than we used to breathe some during the first decades of the 20th century. When we breathe more air than the medical norm (it is called hyperventilation), we get less oxygen into our body cells. This is the law of physiology. Therefore, traditional yoga, and this book provides exact quotes from the most known ancient Sanskrit manuscripts, was absolutely right.

Virtually all traditional yoga practices are about better or slower breathing 24/7. Restoration of correct breathing defeats nearly all chronic diseases and leads to stunning level of health, no pain, no suffering, clarity of mind, joy of exercise, super short and very refreshing sleep (naturally down to a few hours only), and many other effects that comes with high body O2 content.

Note that this book does not provide all details that a yoga student requires to achieve good health. The book discusses the direction and expected results, as it was explained by Dr. Konstantin Buteyko.

Who has special restrictions, limits, and temporary contraindications

Breathing retraining and yoga breathing exercises produce a mild stress for the human body so that it needs to adapt to new conditions and function better in future. Such adaptive effects also take place during, for example, physical exercise. It would be silly for an unfit person to try to run a marathon without weeks or months of preparation.

If the demands due to yoga breathing exercises or other breathing exercises are too high, there is no adaptive response, and, as a result, the exercises can even produce a negative effect. Hence, breathing exercises should also be adjusted to the current adaptive abilities of the human organism. A more gradual approach in relation to hypoxic and hypercapnic demands of breathing exercises (quick changes in air composition) is necessary for many patients with:
- Heart disease (aortic aneurysms; angina pectoris; arrhythmia; atherosclerosis (plaque buildup); cardiomyopathy; ciliary arrhythmia (cardiac fibrillation); chest pain (angina pectoris); high cholesterol; chronic ischemia; congenital heart disease; congestive heart failure; coronary artery disease; endocarditis; extrasystole; heart murmurs; hypertension; hypertrophic cardiomyopathy; tachnycardia; pericarditis; post myocardial infarction; stroke)
- Migraine headaches and panic attacks

Those people, who recently had serious problems with their lungs or suffer from severe and moderate forms of lung damage, should avoid too fast and too large stretching (expansion or dilation) and shrinking (constriction) of their lungs. Hence, their inhalations and exhalations should be limited (not maximum) in their amplitude and velocity. This relates to people with:
- Respiratory disorders involving the lungs (asthma, bronchitis, COPD, emphysema, cystic fibrosis, pneumonia, tuberculosis; pulmonary edema; etc.)

Other specific situations include:
- Presence of transplanted organs
- Pregnancy
- Brain traumas
- Acute bleeding injuries
- Blood clots
- Acute stages (exacerbations) of life-threatening conditions (infarct, stroke, cardiac ischemia, etc.)
- Insulin-dependent diabetes (type 2 diabetes)
- Loss of CO2 sensitivity.

If you suffer from any of these conditions, you should follow special suggestions due to restrictions, limits, and temporary contraindications. These conditions do not prevent you from enjoying excellent health, but they impose some restrictions on your yoga practice.

Warning. ***It is your responsibility, in cases of doubts to consult your family physician or GP about breathing retraining and use of yoga breathing exercises, as well as other breathing exercises, for your specific health problems. In addition, you need to consult your health care provider about your medication and any changes in dosages of medication.***

1. Yoga and breathing

1.1 The role of breathing in modern yoga

There are hundreds of yoga styles or different versions of yoga that exist worldwide. Many of these schools include or even emphasize that breathing is their important part.

Hatha Yoga is the most popular type of yoga and is the origin for many other yoga types and forms including Ashtanga Yoga and Power Yoga considered below. Hatha Yoga includes Pranayama and some other breathing exercises. The instructions and final goals for these exercises are different depending on location and teacher's understanding of yoga. However, the most common views of Hatha Yoga teachers are provided in the following part of this book together with views of other yoga teachers.

Another example of yoga is **Ashtanga Yoga** that suggests relaxed diaphragmatic breathing that is accompanied by sounds from the practitioner's throat. This breathing pattern is aligned with physical movements. This steady cycle of inhales and exhales provides the yoga student with a calming mental focal point.

BTS Iyengar invented his own movement or yoga style that is called **Iyengar Yoga**. It is also based on traditional Hatha Yoga and involves yoga asanas and breathing exercises.

Kriya Yoga is sometimes considered as a direct form of Yoga Therapy. The intention is to purify the body, but there is again no criterion for purification. There are many other forms of yoga that had they origins in Kriya Yoga.

Kundalini Yoga places focus of instruction on student's awareness of the energy centers throughout the body. It is based on a combination of yoga postures, Pranayama, and mantras. The intention is to transform the mind and emotions with some emphasis on yoga breath control. But this technique, as it is taught these days, also does not provide the student with clear goals and criteria of success.

Power Yoga is often known as the Westernized version of the Indian Ashtanga Yoga. It is popular in the Western world. Power Yoga is a physically challenging practice that involves yoga poses and breathing exercises with an intention to cleanse the body of toxins and negative (or destructive) emotions.

Hot Yoga or **Bikram Yoga** includes 26 postures and two breathing exercises that are practiced in a hot room. A specific feature of Bikram Yoga is its surrounding temperature (about 40°C or over 105°F) and humidity (~40%) trying to mimic conditions in India.

Since oxygen to body cells is provided due to breathing, let us consider views of modern yoga leaders related to breathing.

1.2 Contemporary yoga leaders about breathing

First, we can look review written ideas and statements related to breathing that can be found in books written by modern yoga leaders in their books and internet sites devoted to yoga. What do they say about breathing.

There is literally nothing about breathing at all in one of the main Iyengar's book "*Yoga: The Path to Holistic Health*". There is an impression that he either does not how to breathe, or does not know how to explain this part of yoga practice.

The leaders of Hot Yoga movement Bikram Choudhury, in his main book "*Bikram Yoga*", devoted several pages to breathing. On page 99, in this book, there is a chapter called "Standing Deep Breathing" with a subtitle "First Breathing Exercises". The next four pages of the book are devoted to description of this breathing exercise. It is suggested to take the maximum (or "deeper and fuller") inhalation for six counts and then exhale for the same duration of time. This cycle is to be repeated 10 times. As about the progress, at the beginning, as Bikram Choudhury writes, a novice cannot get full inhalations and exhalations because the lungs are "tight and small". But after training, it becomes easier to do the same exercise since the hot yoga student is able to use their lungs more fully and pump more air using the same counting: 6 for inhalations and 6 for exhalations. The main purpose of this exercise, according to Bikram, is to use up to 100% of the lungs so that prevent respiratory problems, such as bronchitis, asthma, and emphysema.

This Section of Bikram's book also suggests that this is Pranayama breathing (see more about pranayama benefits). The exercise may cause unusual symptoms, as he writes. Feeling of dizziness is common, but it should disappear. As Bikram explains, this sensation of dizziness is due to too much oxygen in the system. He also notes that it is important to keep one eye's open to prevent loss of balance and falling over during this breathing exercise.

There is an explanation of another exercise on page 205 that is called "Blowing in Firm Pose (Kapalbhati in Vajrasana)". During this exercise you the student is supposed to expel every ounce of carbon dioxide and replace it with oxygen. This is how one of the modern yoga leaders understands yoga breathing, Pranayama, and expected effects of breathing exercises. Later in this book, we are going to explore the expected effects of low CO2 (when one blows out carbon dioxide due to heavy breathing). We are also going to prove that all these negative symptoms (dizziness and a chance of fainting) are due to reduced levels of oxygen in the brain caused by hyperventilation.

Other yoga teachers that represent other forms and types of yoga generally have the same or similar ideas. During last several years, I spoke with various yoga teachers. Such conversations often could take place before or after my introductory lectures about breathing or in some other situations. Majority of yoga teachers, as soon as they start thinking about breathing, for some strange reasons, focus on breathing exercises and start to claim that breathing should be diaphragmatic and deep. Ask your yoga teachers about breathing. My strong impression, after reading dozens of modern yoga books and speaking with many yoga teachers is that nearly the whole community of yoga teachers lives with some weird obsession that "breathing" means "breathing exercises". Somehow, they assume that oxygen for body cells is required only during some 20, 40 or 60 minutes of yoga breathing exercises.

My views are that we require oxygen 24/7 or day and night. Therefore, we require to have correct breathing every minute of each day. Furthermore, when severely sick and terminally ill people die due to complications of diseases and acute exacerbations, their breathing becomes deeper and faster, while body brain and heart oxygenation becomes critically low. This effect, according to numerous medical

studies, takes place during early morning hours (from about 4 until 7 am), and this is exactly the time that has highest mortality rates due to heart attacks, strokes, seizures, exacerbations of asthma, and many other complications.

Conclusions. There are following serious problems with such teaching of modern yoga leaders and teachers. First of all, yoga teachers assume that "breathing" means "breathing exercises", while, in reality, breathing is a continuous process to deliver oxygen all the time. Second, yoga teachers do not provide any information about ideal automatic (or unconscious) breathing that should be the goal of each and every yoga student.

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1.3 Traditional yoga about breathing

You probably also have heard that they say, "Take deep breath", ""Breathe deeper", and "Breathe more air" and can add, "You will get more oxygen in the cells". Do ancient hatha yoga manuscripts have the same ideas? Some of these books have been written up to 5 and more centuries ago. The main yoga books say that the goal of yoga breathing exercises is to "restrain", "hold", "suspend", and "calm" the breath days and nights. Here are quotes from 3 most important and most know yoga manuscripts: Hatha Yoga Pradipika, the Gheranda Samhita and the Shiva Samhita.

Hatha Yoga Pradipika (15 century)

"3. So long as the (breathing) air stays in the body, it is called life. Death consists in passing out of the (breathing) air. It is, therefore, necessary to restrain the breath."

"17. Hiccough, asthma, cough, pain in the head, the ears, and the eyes; these and other various kinds of diseases are generated by the disturbance of the breath."

The Shiva Samhita (17-18 century)

(5) The Pranayama
"22. Then let the wise practitioner close with his right thumb the pingala (right nostril), inspire air through the ida (the left nostril); and keep the air confined – suspend his breathing – as long as he can; and afterwards let him breathe out slowly, and not forcibly, through the right nostril.
23. Again, let him draw breath through the right nostril, and stop breathing as long as his strength permits; then let him expel the air through the left nostril, not forcibly, but slowly and gently."

"39. When the Yogi can, of his will, regulate the air and stop the breath (whenever and how long) he likes, then certainly he gets success in kumbhaka, and from the success in kumbhaka only, what things cannot the Yogi commend here?"

"43. ... from the perfection of pranayama, follows decrease of sleep, excrements and urine."

Increase of Duration
"53. Then gradually he should make himself able to practice for three gharis (one hour and a half at a

time, he should be able to restrain breath for that period). Through this, the Yogi undoubtedly obtains all the longed for powers."

"57. When he gets the power of holding breath (i.e., to be in a trance) for three hours, then certainly the wonderful state of pratyahar is reached without fail."

The Gheranda Samhita (15-17 century)

"7. Wherenever the yogi may be, he should always, in everything he does, be sure to keep the tongue upwards and constantly hold the breath. This is Nabhomudra, the destroyer of diseases for yogis. "

The Yoga Sutra of Patanjali (4th-2nd century BC)

"Pranayama [the main breathing exercise in yoga] is the cessation of inspiratory and expiratory movements."

As it is easy to notice that classical yoga books say that we need to breathe less and hold our breath for better health. These traditional yoga ideas are exactly opposite to what modern yoga leaders and teachers promote. In classical yoga texts, there are no referrals to breathing more or expelling any toxins from the lungs. Who is right? It cannot be so that we experience the same effects in these 2 conditions:

1) when we breathe more air and expel "toxic" CO2 (as modern yoga teachers advise)

2) we hold the breath and restrain our breathing all the time (as traditional yoga taught).

How can we solve this argument? Obviously, if there is certain usual or normal breathing pattern in a healthy person, then breathing more than in normal conditions or less than in normal conditions should produce some effects on oxygen transport. What are the effects?

When we breathe more air and increase ventilation of the lungs at rest, we should accumulate more CO2 (carbon dioxide) in the airways, blood and other body cells. When we breathe less air, CO2 rises. These physiological effects have been studied in hundreds of studies. What are the effects of changes in CO2 levels on oxygen delivery to cells of the body? If we find the answers to these questions, then we can decide who provides correct ideas (traditional yoga or modern yoga leaders and teachers). In addition, this knowledge can be used in practice in order to improve body oxygenation and overall health.

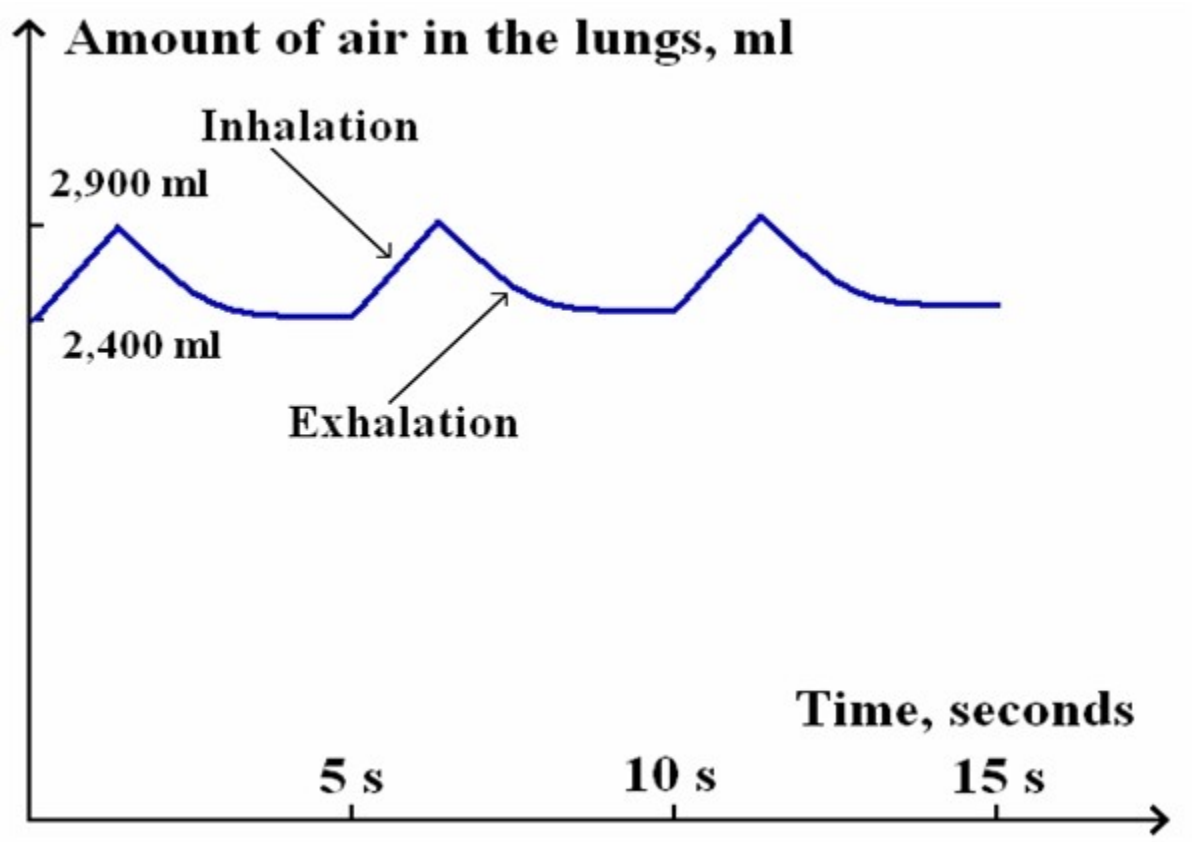
2. Physiology and medicine about normal breathing

Let us start with medical norms for breathing at rest, as well as typical respiratory parameters in healthy, ordinary and sick people.

2.1 Physiological norms for breathing at rest

Normal breathing is strictly nasal (for inhalations and exhalations), predominantly diaphragmatic (i.e., up to 80-90% abdominal), very slow in frequency (about 12 breaths per minute) and imperceptible (no feelings or sensation about one's own breathing at rest since it is very small or unnoticeable). **The physiological norm for minute ventilation at rest is 6 liters of air for one minute for a 70 kg man**, as numerous physiological textbooks indicate (e.g., Guyton, 1984; Ganong, 1995; and Straub, 1998). These medical textbooks also provide the following parameters for normal breathing:
- normal breathing frequency is about 12 breaths per minute
- normal tidal volume (air volume breathed in during a single breath) is 500 ml
- normal inspiration is about 2 seconds
- normal exhalation is about 3 seconds.

To be more accurate, the normal inhalation is little bit shorter or about 1.5 seconds, while the exhalation is longer or nearly 3.5 seconds. The following graph below represents the normal breathing pattern at rest. The graph shows changes in air volume in the lungs as a function of time at rest in an adult.



As it is noted above, if a person with normal breathing is asked about what they feel or their breathing sensations, they will testify that they do not feel their breathing at all (unless their practice yoga breathing or some other breathing exercises). Why could it be so? The normal tidal volume is only 500 ml or about 0.6 g (0.02 ounce) of air, which is inhaled during one inspiration. This is indeed a very small amount.

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2.2 Healthy people breathe very little

We see that, according to these14 recent medical studies, healthy people still breathe very small amount of air at rest.

Table. Minute ventilation at rest in healthy subjects

Condition	**Minute ventilation**	N. of subjects	References
Normal breathing	**6 L/min**	-	Medical textbooks
Healthy subjects	**7.7 ± 0.3 L/min**	19	Douglas et al, 1982
Healthy males	**8.4 ± 1.3 L/min**	10	Burki, 1984
Healthy males	**6.3 L/min**	10	Smits et al, 1987
Healthy males	**6.1±1.4 L/min**	6	Fuller et al, 1987
Healthy subjects	**6.1± 0.9 L/min**	9	Tanaka et al, 1988
Healthy students	**7.0 ± 1.0 L/min**	10	Turley et al, 1993
Healthy subjects	**6.6 ± 0.6 L/min**	10	Bengtsson et al, 1994
Healthy subjects	**7.0±1.2 L/min**	12	Sherman et al, 1996
Healthy subjects	**7.0±1.2 L/min**	10	Bell et al, 1996
Healthy subjects	**6 ± 1 L/min**	7	Parreira et al, 1997
Healthy subjects	**7.0 ± 1.1 L/min**	14	Mancini et al, 1999
Healthy subjects	**6.6 ± 1.1 L/min**	40	Pinna et al, 2006
Healthy subjects	**6.7 ± 0.5 L/min**	17	Pathak et al, 2006
Healthy subjects	**6.7 ± 0.3 L/min**	14	Gujic et al, 2007

Note that "healthy subjects" is not the same as "normal subjects" since ordinary modern people do not have normal breathing parameters and normal body oxygenation.

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2.3 Other parameters of normal breathing

"*If a person breath-holds after a normal exhalation, it takes about 40 seconds before breathing commences*" (McArdle et al, 2000). This 40 seconds indicate normal oxygenation of cells and tissues of the human body. Note that this breath holding test is done after usual exhalation, and it does not imply any stress.

The current medical norm for CO2 content in the alveoli of the lungs is about 40 mm Hg (or about 5.3%). End-tidal gas (at the end of the usual exhalation) and the arterial blood have nearly the same CO2 levels or about 40 mm Hg CO2 partial pressure. This number related to arterial CO2 was established during the first decade of the 20th century by famous British physiologists Charles G. Douglas and John S. Haldane from Oxford University. Their results were published in 1909 article "*The regulation of normal breathing*" by the Journal of Physiology (Douglas & Haldane, 1909). This corresponds to about 5.3% (at sea level). There is no need to remember all these numbers. We need them mainly for comparisons.

Normal breathing is regular (or periodic). It is invisible (no chest or belly movements), mainly diaphragmatic, and inaudible (no panting, no wheezing, no sighing, no yawning, no sneezing, no coughing, no deep inhalations or exhalations).

Does this tiny breathing that people even do not feel provide enough oxygen for the blood? **According to numerous medical textbooks, this very small and slow normal diaphragmatic breathing leads to nearly ideal oxygenation of the arterial blood or about 98-99%.**

Now, we can say, "Aha! Breathing more cannot increase blood and, hence, body oxygenation". This first practical conclusion is important since most yoga teachers believe in a myth that deep breathing or breathing additional air leads to increased blood oxygenation.

In reality, one can breathe 3-5, or even 10 times more than the medical morn, but blood oxygenation and delivery of oxygen to cells will not be improved to any essential degree. In fact, in real life, if we consider virtually all people with heavy breathing, their blood oxygenation becomes less. As it is easy to notice those who have heavy breathing at rest (breathing that is possible to see and hear) are chest breathers. Chest breathing, by definition, does not provide fresh air for the lower parts of the lungs. The textbook, *Respiratory Physiology* (West, 2000), suggests that the lower 10% of the lungs transports more than 40 ml of oxygen per minute, while the upper 10% of the lungs transports less than 6 ml of oxygen per minute. Hence, the lower parts of the lungs are about 6-7 times more effective in oxygen transport than the top of the lungs due to richer blood supply mostly caused by gravity.

Myth: Deep breathing or taking one or more full or maximum inhalations using the abdominal or diaphragmatic muscles increases blood and body oxygenation.

This is just the beginning of the story related to deep breathing at rest and effects of "toxic" CO2. However, before studying the effects of CO2 and details of oxygen transport (and why old yoga could cure chronic diseases), I want to prove the most outrageous fact: you are very unlikely to have normal breathing. Therefore, you will discover later, using a simple DIY body oxygen test that you do not have normal body and brain oxygenation.

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3. You are likely a ... heavy breather

3.1 Breathing in people with heart disease

If you suffer from heart disease, you have heavy breathing 24/7. Here are the results of 8 published independent medical studies about breathing rates (minute ventilation) in 8 different groups of patients with heart disease. You can spot a tiny blue bar in the left bottom corner that represents normal breathing. Red bars correspond to groups of heart patients.

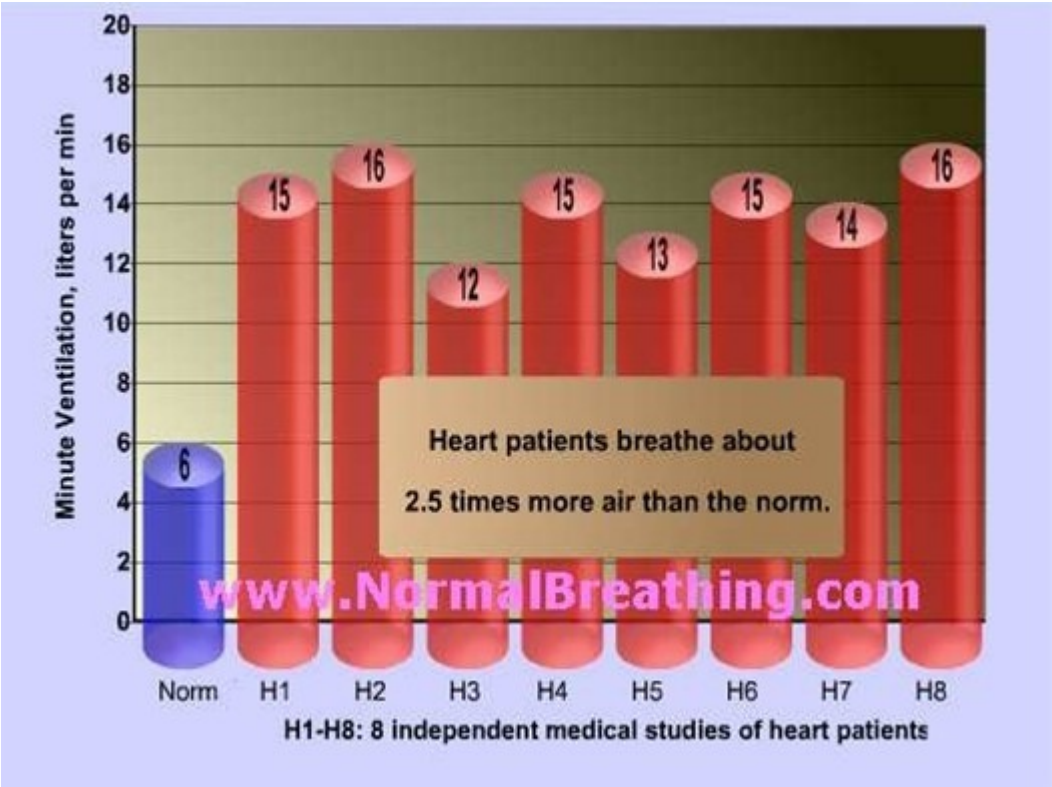

Table. Breathing rates in patients with heart disease.
*One row corresponds to one medical study/publication

Minute ventilation rates in heart patients

Condition	Minute ventilation	Number of patients	References
Normal breathing	6 L/min	-	Medical textbooks
Healthy Subjects	6-7 L/min	>400	Results of 14 studies
Heart disease	15 (±4) L/min	22	Dimopoulou et al, 2001
Heart disease	16 (±2) L/min	11	Johnson et al, 2000
Heart disease	12 (±3) L/min	132	Fanfulla et al, 1998
Heart disease	15 (±4) L/min	55	Clark et al, 1997
Heart disease	13 (±4) L/min	15	Banning et al, 1995
Heart disease	15 (±4) L/min	88	Clark et al, 1995
Heart disease	14 (±2) L/min	30	Buller et al, 1990
Heart disease	16 (±6) L/min	20	Elborn et al, 1990

Based on laws of physiology and medicine, it is possible to prove that virtually all symptoms and health problems in heart patients relate to their heavy breathing. In other words, you can have problems with heart disease only if your breathing is way heavier than the medical norm. You learn how to get back to the norm (using smart steps and correctly done yoga), all your symptoms and problems due to heart disease will disappear.

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3.2 "Asthmatic" means a deep breather

If you do not have heart disease, then you may have asthma. Let us look at MV (minute ventilation) in patients with asthma when they are at rest. Here again, the breathing rates relate to the state of patients when they do not have any acute episodes or symptoms of their disease, since during exacerbations, chronically sick people breathe even more.

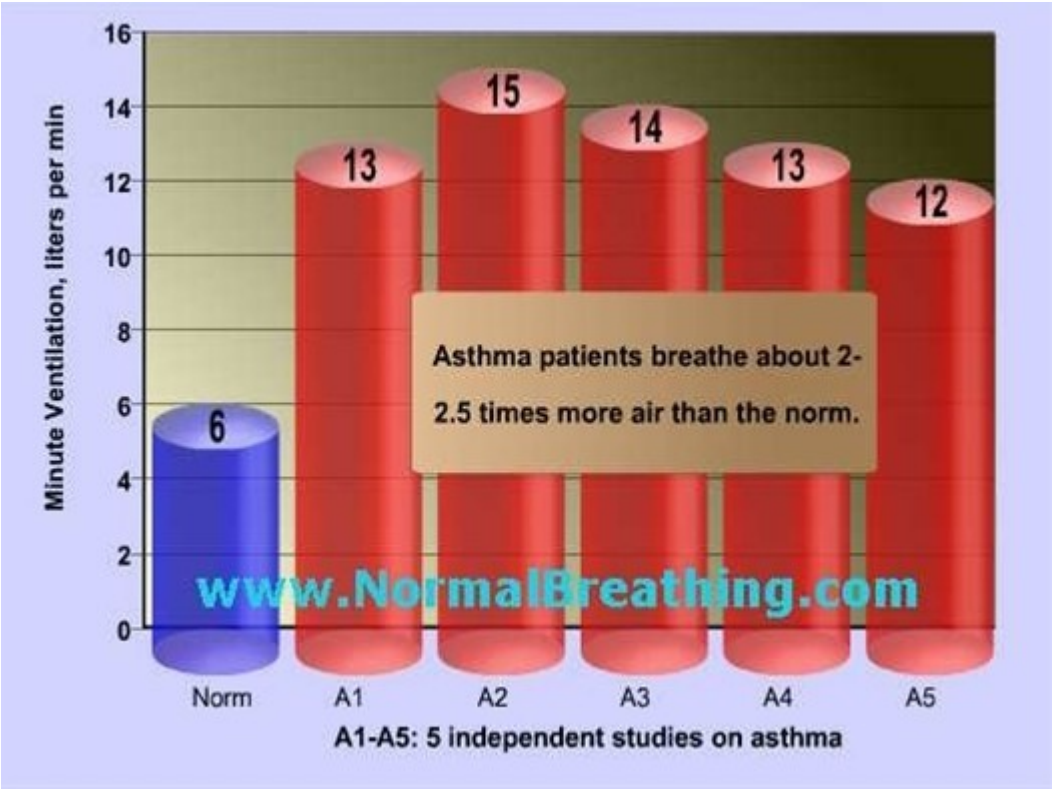

Table. Breathing rates in people with asthma.
*One row corresponds to one medical study/publication

Minute ventilation rates in asthmatics

Condition	Minute ventilation	Number of people	References
Normal breathing	6 L/min	-	Medical textbooks
Healthy Subjects	6-7 L/min	>400	Results of 14 studies
Asthma	13 (±2) L/min	16	Chalupa et al, 2004
Asthma	15 L/min	8	Johnson et al, 1995
Asthma	14 (±6) L/min	39	Bowler et al, 1998
Asthma	13 (±4) L/min	17	Kassabian et al, 1982
Asthma	12 L/min	101	McFadden & Lyons, 1968

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3.3 Deep breathing in people with diabetes

If you do not have asthma or heart disease, then you may suffer from diabetes. Diabetes means deep breathing 24/7, because if a diabetic achieves normal breathing parameters, his or her symptoms of diabetes and abnormal blood sugar levels will disappear.

Table. Breathing rates in diabetics.
*One row corresponds to one medical study/publication

Minute ventilation rates in diabetics			
Condition	**Minute ventilation**	**Number of people**	**References**
Normal breathing	6 L/min	-	Medical textbooks
Healthy Subjects	6-7 L/min	>400	Results of 14 studies
Diabetes	12-17 L/min	26	Bottini et al, 2003
Diabetes	15 (±2) L/min	45	Tantucci et al, 2001
Diabetes	12 (±2) L/min	8	Mancini et al, 1999
Diabetes	10-20 L/min	28	Tantucci et al, 1997
Diabetes	13 (±2) L/min	20	Tantucci et al, 1996

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3.4 People with other chronic diseases are also heavy breathers

Even if you are from those 3 diseases, you can have some others. The following studies also show that heavy or deep breathing is a norm in people with cancer, COPD, liver cirrhosis, epilepsy, cystic fibrosis, panic disorder, bipolar disorder, etc.

Table. Minute ventilation in patients with other chronic conditions.
*One row corresponds to one medical study/publication

Condition	Minute ventilation	Number of people	References
Normal breathing	6 L/min	-	Medical textbooks
Healthy Subjects	6-7 L/min	>400	Results of 14 studies
Pulm hypertension	12 (±2) L/min	11	D'Alonzo et al, 1987
Cancer	12 (±2) L/min	40	Travers et al, 2008
COPD	14 (±2) L/min	12	Palange et al, 2001
COPD	12 (±2) L/min	10	Sinderby et al, 2001
COPD	14 L/min	3	Stulbarg et al, 2001
Sleep apnea	15 (±3) L/min	20	Radwan et al, 2001
Liver cirrhosis	11-18 L/min	24	Epstein et al, 1998
Hyperthyroidism	15 (±1) L/min	42	Kahaly, 1998
Cystic fibrosis	15 L/min	15	Fauroux et al, 2006
Cystic fibrosis	10 L/min	11	Browning et al, 1990
Cystic fibrosis*	10 L/min	10	Ward et al, 1999
CF and diabetes*	10 L/min	7	Ward et al, 1999
Cystic fibrosis	16 L/min	7	Dodd et al, 2006
Cystic fibrosis	18 L/min	9	McKone et al, 2005
Cystic fibrosis*	13 (±2) L/min	10	Bell et al, 1996
Cystic fibrosis	11-14 L/min	6	Tepper et al, 1983
Epilepsy	13 L/min	12	Esquivel et al, 1991
CHV	13 (±2) L/min	134	Han et al, 1997
Panic disorder	12 (±5) L/min	12	Pain et al, 1991
Bipolar disorder	11 (±2) L/min	16	MacKinnon et al, 2007
Dystrophia myotonica	16 (±4) L/min	12	Clague et al, 1994

There are many more published studies that demonstrated the same results: **Sick people have a deep or heavy breathing pattern at rest.** In fact**,** all of the studies which I have found online and libraries demonstrated the same conclusion: sick people breathe too much air in comparison with the medical norm.

Even if you do not suffer from these health problems, I am still going to prove in the next section that you also "follow" the advice of modern yoga teachers to breathe too much air. I will also show that your overbreathing is the cause of your current health problems.

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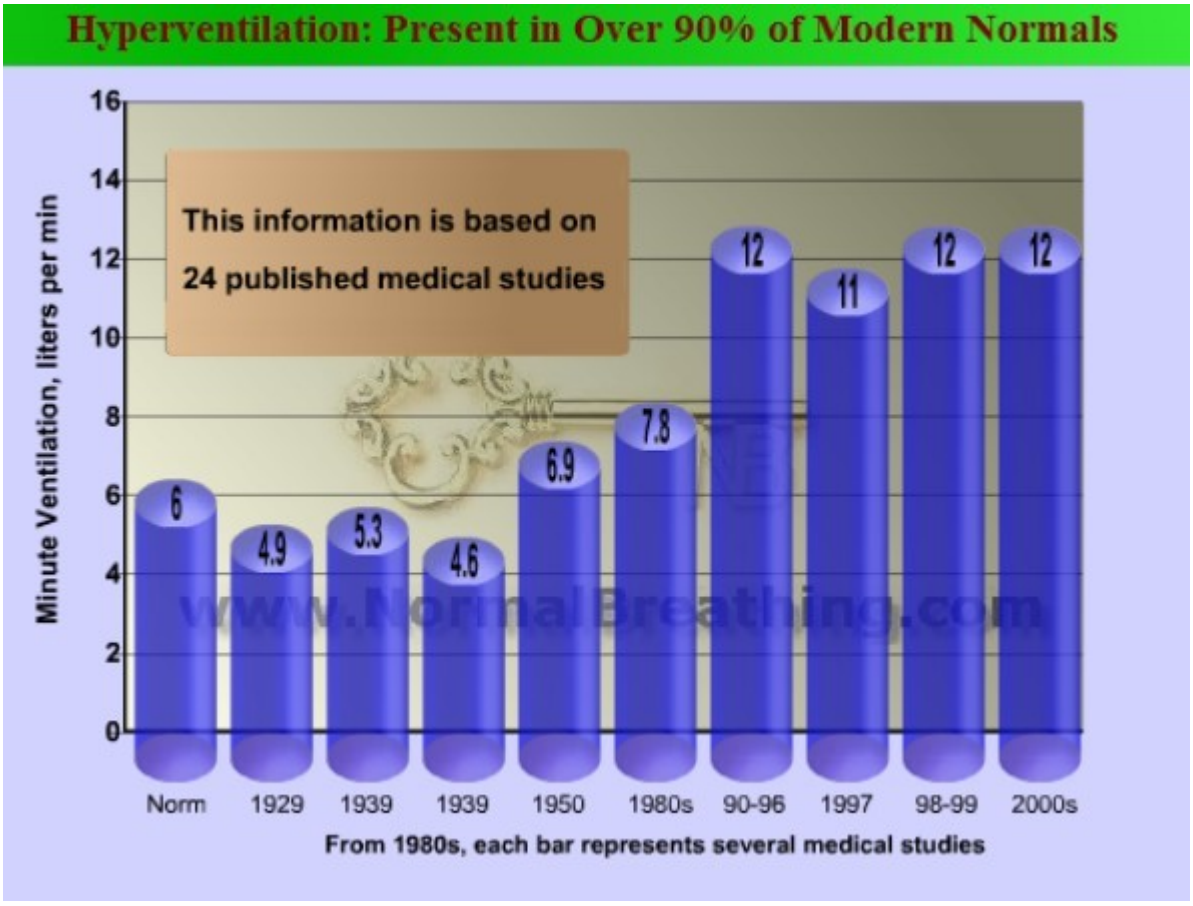
3.5 Over 90% of modern people, you probably included, breathe too much air

Finally, if you avoided all those health problems that are considered above, you are still likely be the person who has heavy breathing days and nights. Here are hard medical facts.



The table below represents results of 24 medical research studies (from 1929 until year 2007). It tells us that before WW2 breathing rates of ordinary people were even less than normal. During last 2 decades ordinary people breathe about 2 times more air than the medical norm or nearly 3 times more than in the 1920's and 30's.

Table. Historical changes in minute ventilation at rest for normal subjects

Condition	**Minute ventilation**	Age	N. of subjects	References
Healthy Subjects	**6-7 L/min**	-	>400	Results of 14 studies
Normal breathing	**6**	-	-	Medical textbooks
Normal subjects	**4.9**	-	5	Griffith et al, 1929
Normal males	**5.3±0.1**	27-43	46	Shock et al, 1939
Normal females	**4.6±0.1**	27-43	40	Shock et al, 1939
Normal subjects	**6.9±0.9**	-	100	Matheson et al, 1950
Normal subjects	**9.1±4.5**	31±7	11	Kassabian et al, 1982
Normal subjects	**8.1±2.1**	42±14	11	D'Alonzo et al, 1987
Normal subjects	**6.3±2.2**	-	12	Pain et al, 1988
Normal males	**13±3**	40 (av.)	12	Clague et al, 1994
Normal subjects	**9.2±2.5**	34±7	13	Radwan et al, 1995
Normal subjects	**15±4**	28-34	12	Dahan et al, 1995
Normal subjects	**12±4**	55±10	43	Clark et al, 1995
Normal subjects	**12±2**	41±2	10	Tantucci et al, 1996
Normal subjects*	**11±3**	53±11	24	Clark et al, 1997

Normal subjects	**8.1±0.4**	34±2	63	Meessen et al, 1997
Normal females	**9.9**	20-28	23	Han et al, 1997
Normal males	**15**	20-28	47	Han et al, 1997
Normal females	**10**	29-60	42	Han et al, 1997
Normal males	**11**	29-62	42	Han et al, 1997
Normal subjects	**13±3**	36±6	10	Tantucci et al, 1997
Normal subjects	**12±1**	65±2	10	Epstein et al, 1996
Normal subjects	**12±1**	12-69	20	Bowler et al, 1998
Normal subjects	**10±6**	39±4	20	DeLorey et al, 1999
Normal seniors	**12±4**	70±3	14	DeLorey et al, 1999
Normal elderly*	**14±3**	88±2	11	DeLorey et al, 1999
Normal subjects	**17±1**	41±2	15	Tantucci et al, 2001
Normal subjects	**10±0.5**	-	10	Bell et al, 2005
Normal subjects	**8.5±1.2**	30±8	69	Narkiewicz, 2006
Normal females	**10±0.4**	-	11	Ahuja et al, 2007
Normal subjects	**12±2**	62±2	20	Travers et al, 2008
Condition	**Minute ventilation**	Age	N. of subjects	Reference

* When the average weight of the subjects was significantly different from 70 kg, minute ventilation was adjusted to the normal weight (70 kg) value.

Note that the results look inconsistent since there is no strict definition for “normal” or “control” subjects in medical research. In addition, there are slightly different methods used to measure minute ventilation. Consider a medical study with a group of people with heart disease. If the organizers of the study want to see the effects of some medication or treatment method for these people with heart disease, the researchers may also select a group of control subjects for comparison (the control group). For some studies they require that these “control” subjects are free from any form of heart disease. However, in other studies, the control subjects should be free from any health problem. Then they can be called "healthy subjects".

Now we are going to prove that breathing more reduces brain and body oxygen content. Later, we are going to discuss the DIY test that accurately reflects body O2 content.

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4. Effects of deep breathing (hyperventilation)

We proved that you have heavy breathing at rest in spite of your possible love for yoga and hundreds or thousands of yoga lessons that you practiced. Now we are going to study the effects of your heavy breathing (hyperventilation) on body oxygenation, states of your brain and other systems and organs.

4.1 Hypocapnia (or CO2 deficiency in the blood and cells)

If a healthy or ordinary person starts to breathe more air (or deeper and/or faster), what are the effects?
- More carbon dioxide is removed from the lungs with every breath and therefore the level of CO2 in the alveoli of the lungs immediately decreases
- In 1-2 minutes of overbreathing, the arterial CO2 level falls below the normal levels in all the arterial blood due to its circulation
- In 3-5 minutes, due to CO2 diffusion from cells and tissues, most cells of the body (including the cells of the heart, kidneys, liver, pancreas, stomach, muscle tissues and many others) experience lowered CO2 concentrations
- In 15-20 minutes, the CO2 level in the cerebrospinal fluid of the brain also drops below the norm due to a slower diffusion rate through the blood-brain barrier.

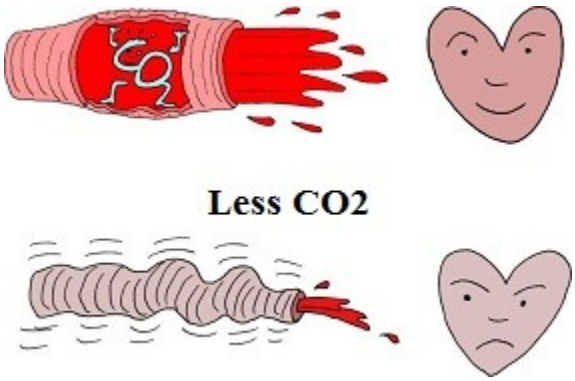
** **Note.** There is a small group of people who suffer from severe problems with their lungs. This relates to people who have emphysema, severe asthma, severe bronchitis, lung cancer, and some other conditions. These people do not get low CO2 in the blood, brain and other body cells. However, their*

problems with lungs will cause the same key final effect: low O2 in body cells. In fact, their hypoxia is usually the most severe one since they are the first candidates for supplemental oxygen (breathing 100% oxygen that is toxic). I can only add that their heavy breathing destroys their lungs and worsens their health. It is beyond the scope of this book to focus on further details related to such cases.

4.2 Vasoconstriction

Does CO2 produce any effects on blood vessels? Yes, as independent physiological studies found, hypocapnia (low CO2 concentration in the arterial blood) decreases perfusion of the following organs:
- brain (Fortune et al, 1995; Karlsson et al, 1994; Liem et al, 1995; Macey et al, 2007; Santiago & Edelman, 1986; Starling & Evans, 1968; Tsuda et al, 1987)
- heart (Coetzee et al, 1984; Foëx et al, 1979; Karlsson et al, 1994; Okazaki et al, 1991; Okazaki et al, 1992; Wexels et al, 1985)
- liver (Dutton et al, 1976; Fujita et al, 1989; Hughes et al, 1979; Okazaki, 1989)
- kidneys (Karlsson et al, 1994; Okazaki, 1989)
- spleen (Karlsson et al, 1994)
- colon (Gilmour et al, 1980).

What is the physiological mechanism of the reduced blood flow to vital organs? CO2 is a dilator of blood vessels (arteries and arterioles) or a vasodilator. Arteries and arterioles have their own tiny smooth muscles that can constrict or dilate depending on CO2 concentrations. When we breathe more, CO2 level in the arterial blood decreases, blood vessels constrict and vital organs (like the brain, heart, kidneys, liver, stomach, spleen, colon, etc.) get less blood supply.



There are literally hundreds of studies that proved or showed presence of this vasoconstriction effect. Some people may argue that this is just a small or insignificant effect, and there are more powerful vasodilators. According to Dr. M. Kashiba, MD and his medical colleagues from the Department of Biochemistry and Integrative Medical Biology (School of Medicine, Keio University, Tokyo, Japan) CO2 is a "*potent vasodilator*" (Kashiba et al, 2002). Dr. H. G. Djurberg and his medical team from the Department of Anesthesia (Armed Forces Hospital, Riyadh, Saudi Arabia) suggested that "*Carbon dioxide, a most potent cerebral vasodilator...*" (Djurberg et al, 1998). Among arterial dilators, CO2 is probably the most powerful chemical. This vasodilation effect is present in healthy people due to normal arterial CO2 concentration.

If a yoga student follows the ideas about breathing more ("to get more oxygen in body cells") and expel toxic CO2, such yoga practice will lead to spasm of all arteries and arterioles and reduced circulation to all vital organs. The effects of overbreathing are individual. There are certain individual short-term effects (like the one described by Bikram Choudhury above) and numerous long-term effects that relate to chronic diseases. Note that if one practices deep breathing exercises with CO2 losses, then this

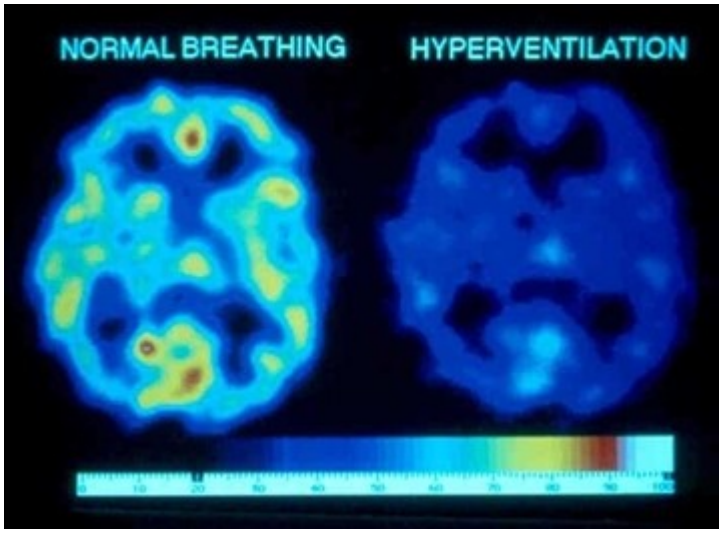
practice leads to deeper and faster breathing for many subsequent hours because breathing is controlled mainly by CO2 and low CO2 means heavy automatic breathing later.

Are there any related systemic effects due to vasoconstriction? The state of these blood vessels (arteries and arterioles) defines the total resistance to the systemic blood flow in the human body since these blood vessels provide the main resistance to blood flow. Hence, hypocapnia or low CO2 constricts the most important blood vessels and increases the strain on the heart. Hence, in a long run, automatic breathing directly participates in regulation of the heart rate. The father of cardiorespiratory physiology, Yale University Professor Yandell Henderson (1873-1944), investigated this effect more than a century ago.

Among his numerous physiological studies, he performed clinical studies with anaesthetized dogs on mechanical ventilation. The results of these studies were described in his article "*Acapnia and shock. - I. Carbon dioxide as a factor in the regulation of the heart rate*". In this article, published in 1908 in the *American Journal of Physiology*, he wrote, "*... we were enabled to regulate the heart to any desired rate from 40 or fewer up to 200 or more beats per minute. The method was very simple. It depended on the manipulation of the hand bellows with which artificial respiration was administered... As the pulmonary ventilation increased or diminished the heart rate was correspondingly accelerated or retarded*" (p.127, Henderson, 1908).

Symptoms due to voluntary hyperventilation

Imagine that a person at rest starts to voluntarily breathe deeply or hyperventilate (deep and fast breathing). What would happen with him or her? The person would feel dizzy and could faint or pass out. Why? This is cannot be due to too much oxygen, since their blood is almost fully saturated with O2 with very small normal breathing at rest. The key effect of vasoconstriction that reduced blood flow to the brain. This graph below is a PET scan that shows brain O2 concentrations in two conditions: normal breathing (the left image) and after 1 minute of hyperventilation (the right image). The red color represents the most O2, dark blue the least, according to the scale given below the images. Overbreathing reduces brain oxygenation by about 40% or almost 2 times (Litchfield, 2003).



This result is also quoted in many medical textbooks (e.g., Starling & Evans, 1968) since the effect is well documented and has been confirmed by dozens of professional experiments. According to the Handbook of Physiology (Santiago & Edelman, 1986), cerebral blood flow decreases 2% for every mm Hg decrease in CO2 pressure. This means that if you reduce your arterial CO2 two times below the

norm (by expelling toxic CO2). you will get twice less oxygen and blood supply provided for the brain at rest.

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4.3 Suppressed Bohr effect

This is not the end of the oxygen and CO2 story since oxygen must be somehow released be red blood cells in tissues. Oxygen is a highly reactive and toxic chemical. Therefore, there is a chemical connection between oxygen molecule and the red blood cell that can carry up to 4 oxygen molecules. This chemical link that prevents oxygen from destroying walls of the blood vessels is also called "chemical affinity".

Why do red blood cells or hemoglobin cells of the arterial blood release oxygen in the tissues, but not in the arteries, or arterioles, or veins, or somewhere else? Why is more oxygen released in those tissues of the human body that produce more energy? For example, those muscles that generate more energy are going to get more oxygen from the blood. Why?

This process of oxygen release depends primarily on local CO2 content (or CO2 levels in tissues) due to the so called **Bohr law** (or **Bohr effect**). The effect was first described in 1904 by the Danish physiologist Christian Bohr (father of famous physicist Niels Bohr). He found that due to higher CO2 concentrations in tissues (and more acidic environment), hemoglobin will bind to oxygen with less affinity. In other words, increased CO2 levels in tissues allow red blood cells to release oxygen. As a result, those tissues that generate more CO2 will get more oxygen from the blood.

There are many modern professional studies devoted to various aspects of this effect (for example, Braumann et al, 1982; Böning et al, 1975; Bucci et al, 1985; Carter et al, 1985; diBella et al, 1986; Dzhagarov et al, 1996; Grant et al, 1982; Grubb et al, 1979; Gersonde et al, 1986; Hlastala & Woodson, 1983; Jensen, 2004; Kister et al, 1988; Kobayashi et al, 1989; Lapennas, 1983; Matthew et al, 1979; Meyer et al, 1978; Tyuma, 1984; Winslow et al, 1985).

Hyperventilation and reduced CO2 tissue tension lead to hampered or reduced oxygen release and low O2 tension in tissues (Aarnoudse et al, 1981; Monday & Tétreault, 1980; Gottstein et al, 1976). In order to improve the release of oxygen by red blood cells, we require more CO2 in the cells and the whole body.

Hence, if yoga student wants to provide more oxygen for the brain, heart and other cells of the body, he or she should learn how to breathe slower and less.

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4.4 Less oxygen for cells

Summarizing the previous physiological laws, we can make the following conclusions:

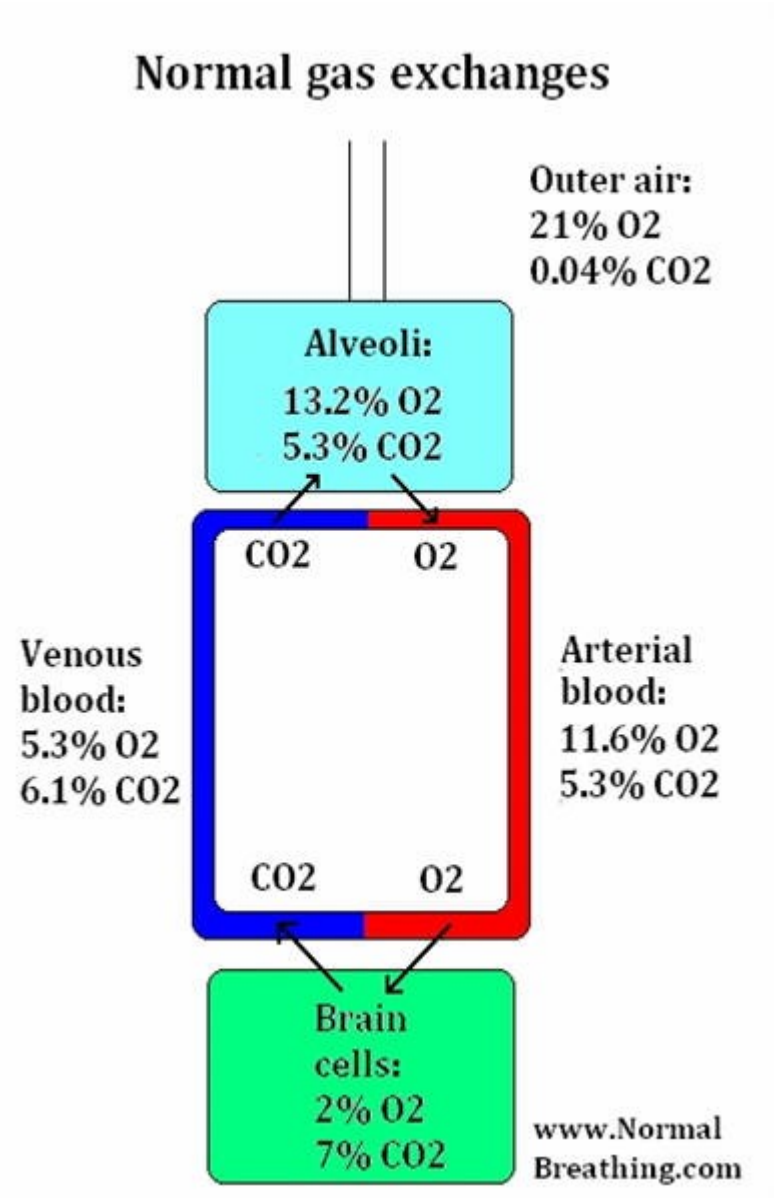
1. **Hyperventilation or deep breathing cannot increase O2 content in the arterial blood to any significant degree (normal hemoglobin saturation is about 98%), but it reduces CO2 concentrations in all cells and the blood**.

2. **Hypocapnia (or CO2 deficiency) leads to constriction of blood vessels and that reduces blood supply to vital organs of the human body**.

3. **Hypocapnia (or CO2 deficiency) also leads to suppressed Bohr effect that causes reduced O2 release in tissues and further reduction in delivery of O2 to cells**.

Hence, the more one breathes, the less oxygen is provided for vital organs of the human body.

The discussed effects of CO2-deficiency on blood flow and oxygen transport are summarized on these two graphs.


Normal gas exchanges
Outer air:
21% O2
0.04% CO2
Alveoli:
13.2% O2
5.3% CO2
CO2
O2
Venous
blood:
5.3% O2
6.1% CO2
Arterial
blood:
11.6% O2
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CO2
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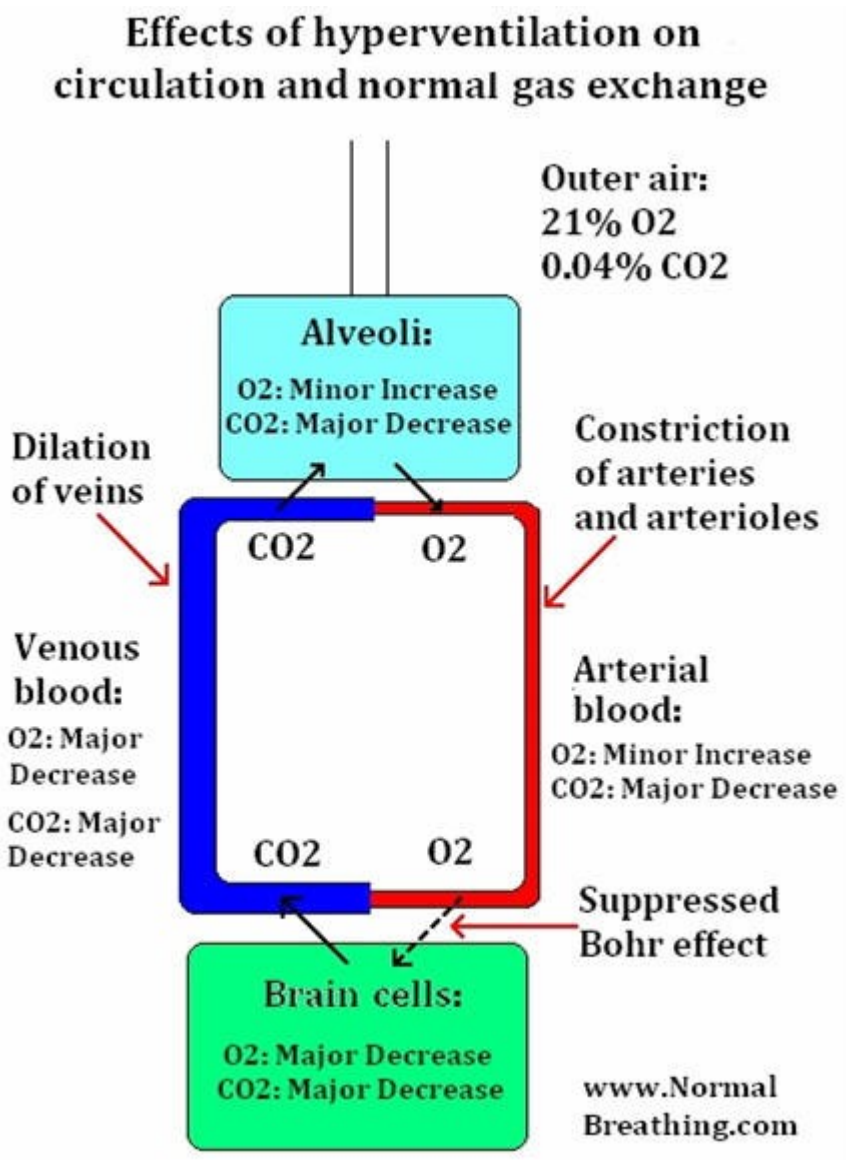
cells:
2% O2
7% CO2
www.Normal
Breathing.com



4.5 CO2 is crucial for mental health

"28. The breathing is calmed when the mind becomes steady and calm; …" **Hatha Yoga Pradipika (15 century)**

Medical research proved an astonishing wisdom that is hidden in this short and simple phrase from yoga Sanskrit book written more than 500 years ago. Let us investigate the role of breathing in mental health and CO2 health effects on transmission of electrical signals between nerve cells.

In order to transmit only right or real nervous signals, the nerve cells have a certain threshold of excitability. The presence and value of this threshold prevent irrelevant or accidental signals from creating chaos in the whole nervous system. Indeed, imagine that there is no any threshold of excitability or it is too low. Then even a small accidental electrical signal will get a strong response from other nerve cells because the signals can be amplified by other nerve cells. As a result, such small accidental signals can be amplified producing a strong effect on the whole brain. This means that any strange idea or fantasy or a signal coming from senses and body organs may become a plan for future

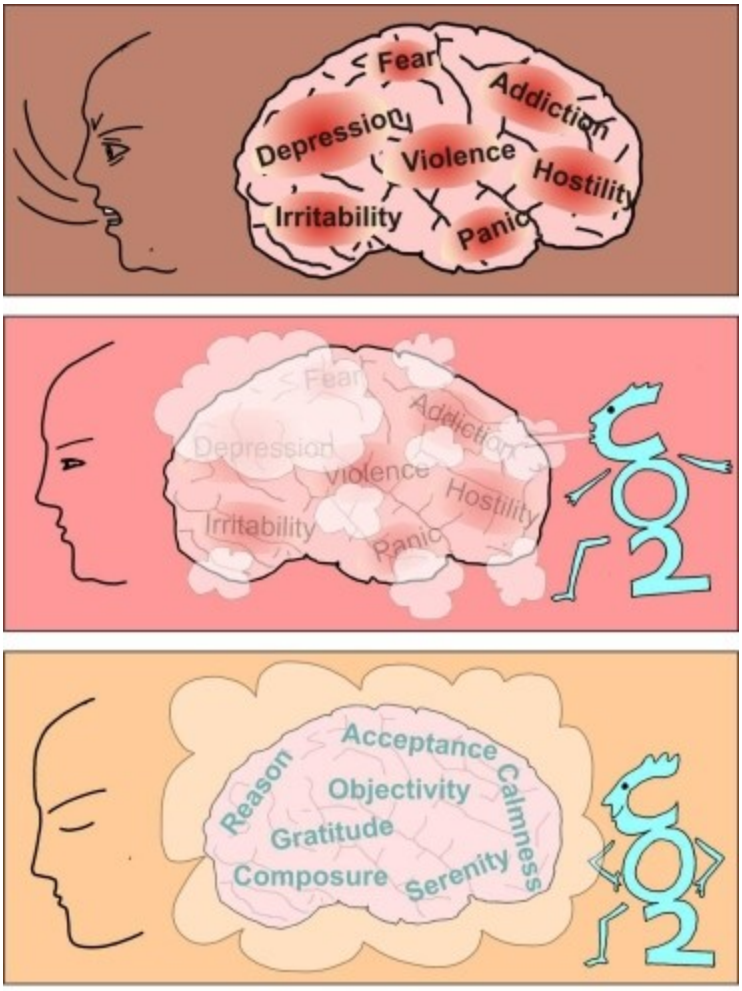
actions. Any delusion can be perceived as an absolutely real. Such destructive effects of low excitability are prevented by having a normal threshold that is, in mammals, is about 40 mV.

However, when brain CO2 becomes abnormally low, nerve cells suffer from abnormal excitability due to the lowered threshold. Therefore, CO2 is also called a tranquillizer or sedative of nervous cells that makes them calm. Normal CO2 concentrations create conditions for the normal work of the nervous system and normal reflection of the real world due to transmission of real signals only. Normal CO2 puts you in control of the whole nervous machinery to make right choices. Overbreathing naturally leads to low CO2 in the brain and all types of mental, psychological and psychiatric abnormalities since the ideas and fantasies appear as out from nowhere.

In the early 1950's, one of the world's leading physiological magazines, *Physiological Reviews*, published an extensive research article with the title "*Physiological effects of hyperventilation*". In this large article, Dr. Brown (Department of Physiology, University of Kansas Medical Center; USA) provided an analysis of nearly 300 professional physiological and medical studies. When considering the effects of carbon dioxide deficiency on the nerve cells, he wrote, "*Studies designed to determine the effects produced by hyperventilation on nerve and muscle have been consistent in their finding on increased irritability*" (Brown, 1953). Muscles and nerve cells become abnormally sensitive or irritated.

In 1965, *Journal of Physiology* (another leading physiological magazine) published the article titled "*Cortical CO2 tension and neuronal excitability*". It was shown that CO2 has a strong calming effect on excessive excitability of brain areas responsible for thinking (Krnjevic et al, 1965). Many other physiological studies confirmed this effect (Davis, Pascual & Rice, 1928; Necheles & Gerard, 1930; Lorente de No, 1947).

In 1988 physiologists from Duke University (Durham, the UK) suggested in their summary, "*The brain, by regulating breathing, controls its own excitability*" (Balestrino & Somjen, 1988).



According to a recent study of Finnish scientists from the Laboratory of Neurology (University of Joensuu, Finland) **hyperventilation "*leads to spontaneous and asynchronous firing of cortical neurons*"** (Huttunen et. al, 1999). The study was published in the *Experimental Brain Research*. If you experience any of the problems related to anxiety, confusion, panic attacks, depression, insomnia or even addictions to coffee, sugar, alcohol, and many other substances, objects or activities (like computer games, gambling, and so forth), then you need to increase your brain CO2 levels. Higher brain CO2 will also raise your brain oxygenation leading to a dramatic improvement in your mental wellbeing.

As a summary, we can conclude that low CO2 prevents normal perception of reality and upsets stability of the nervous system. Instead of objective reflection and analysis of reality, in conditions of low CO2, the brain starts to generate its own "spontaneous and asynchronous" ideas, projects, explanations, and interpretations of real events. Moreover, an excited brain cells can create problems that, in reality, do not exist. Hence, anxiety, fear, panic attacks, and many other negative emotions and states naturally appear in people who have breathing disorders (breathing problems or difficulties), while CO2 is natural sedative and tranquilizer of nerve cells. It is crucial for stability and normal work of nerves and treatment-prevention of anxiety, stress, insomnia, phobias, and many other mental health problems.

There are dozens of other fascinating medical studies that back-up the wisdom of traditional yoga suggest calming the breath (see the yoga quote at the top of this Section). It is beyond the scope of this book to analyze all these medical articles that claimed presence of overbreathing and low CO2 in people with various psychological and mental health problems. However, there are several titles in the second set of references that are provided below. Just titles alone testify the presence of the solid link between abnormal breathing and these health problems.

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4.6 Other hypocapnia- and hypoxia-related effects

There are many other effects of low CO2 and O2 levels. For example, low CO2 leads to the following effects:
- irritable state of muscles (muscular tension) (Brown, 1953; Hudlicka, 1973)
- bronchoconstriction (or reduced diameter of airways causing wheezing and sensations of breathlessness and suffocation) (Buteyko, 1964; Herxheimer, 1946 and 1952; Sterling, 1968; Straub, 1998)
- abnormalities with ions in blood plasma and other bodily fluids (Carryer, 1947)
- innumerable abnormalities in chemical reactions involving synthesis of amino acids, lipids (fats), carbohydrates, hormones, messengers, cells of the immune system, etc.

If you suffer from asthma, or bronchitis, or cystic fibrosis, then CO2 is the key factor that will help you to prevent bronchospasm and increase body oxygenation.

As about too low levels of oxygen in body cells, the effects are also numerous. For example, low body oxygenation is the key factor in development and metastasis of cancer. Low O2 values in the heart tissue is the only factor that create angina pain. Numerous recent cutting-edge medical studies showed that cell hypoxia is the chief factor in development of diabetes and many other conditions.

Low O2 concentrations in cells prevent cells from recovery due to inflammation. In other words, cell hypoxia promotes chronic inflammation that is in the basis of numerous conditions, such as:
- arthritis and related conditions
- Alzheimer's disease
- bronchial asthma
- autoimmune diseases
- acne and related skin disorders
- allergic reactions
- atherosclerosis
- chronic prostatitis
- Crohn's disease
- COPD
- dermatitis
- hepatitis
- hypersensitivities and allergic reactions
- insulin resistance (including diabetes)
- irritable bowel syndrome (IBS) of the intestinal tract
- inflammatory bowel diseases (IBD)
- lupus

- nephritis
- obesity
- cachexia
- gastrointestinal ischemia
- osteoarthritis
- pelvic inflammatory disease
- Parkinson's disease
- sarcoidosis
- sleep apnea
- transplant rejection
- and ulcerative colitis.

Several other chronic diseases (including cancer, atherosclerosis, and ischemic heart disease) have their origins in chronic inflammatory processes.

If a yoga student wants to defeat these health problems, then improving body oxygenation by breathing correctly 24/7 is the smart way to go. Before analyzing these ways, we need to know how to measure body O2 content using a simple test.

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