Breathwork Compendium

Volume 1 — Fundamentals for Everyday Life and Health

Version 1.0 | As of July 2026

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Contents

Part 0 — Key Points at a Glance

If you only have five minutes: This page is enough for everyday use. Everything else deepens, refines, and substantiates what's said here.

Five Key Messages

1. **Nasal breathing as the default mode** 🟢 — filters, humidifies, and warms inhaled air and contributes to local nitric oxide (NO) production (Part 4).

2. **Slow breathing, roughly six breaths per minute** 🟢 — well studied and can influence autonomic regulation; the individually optimal frequency is derived in Part 6.

3. **Exhale longer than inhale** 🟢 — a simple, low-threshold technique that can have a calming effect in many people and is generally well tolerated (Part 6).

4. **Suspected sleep apnea belongs in medical** diagnostics — for nighttime breathing pauses, loud snoring with observed breathing pauses, or pronounced daytime fatigue, seek medical evaluation rather than self-treating with mouth tape (Part 8).

5. **Techniques involving hyperventilation:** never in or near water — the resulting loss of consciousness can lead to drowning (Part 1)

For a direct practical starting point: Part 10 bundles central breathing techniques from this compendium into a concrete ten-minute routine to follow.

The Evidence and Safety Rating System

This compendium rates statements using two independent rating systems, distinguishable by color plus text tag — so the classification also works for color blindness and in black-and-white print. A well-supported effect (🟢 Evidence) can still require caution for certain pre-existing conditions or situations (🟡/⚠️ Safety) — and vice versa.

Evidence Rating (on chapter headings and individual statements)

Rates how well an effect or mechanism is scientifically supported.

- 🟢 **Established** — solid physiology or multiple converging RCTs/reviews.
- 🟡 **Mixed** — plausible mechanism, but limited, inconsistent, or bias-prone evidence.
- 🔴 **Speculative** — popular, but not sufficiently supported or refuted by current evidence.

Safety Rating (in the caution matrix, Part 1, and at safety-relevant passages)

Rates the level of caution warranted for certain techniques or pre-existing conditions.

- 🟢 **No restriction** — no known specific restriction for healthy people.
- 🟡 **Individual** — situation-dependent, requires individual judgment.
- ⚠️ **Caution** — medical consultation recommended for certain pre-existing conditions, pregnancy, or particular risk constellations.

Part 1 — Safety First ⚠️

The Three Absolute Rules 🟢

Before technique, effect, or science: these three rules apply without exception to breathing techniques involving voluntary hyperventilation, intense breath cycles, or extended breath-holding.

1. **Never in or near water**. Not even in the bathtub, not even sitting on the pool edge with your feet in the water.
2. **Never while driving or operating machinery.**
3. **Never fight through dizziness.** Dizziness is the signal to stop immediately and resume normal breathing — not to "push through" the exercise.

Why the Water Rule Applies 🟢

Two independent mechanisms make the combination of hyperventilation and water dangerous:

- First, hyperventilation reduces cerebral blood flow via hypocapnic vasoconstriction. On land, this alone usually isn't enough to cause loss of consciousness, but it becomes critical in combination with additional cardiovascular stressors, such as cold-water immersion or reduced cardiac output (Immink et al., 2014).
- Second — and this is the more specific, more direct reason — artificially lowering CO_2 levels before a breath-hold delays the natural urge to breathe, while blood oxygen keeps dropping unchecked. This can lead to loss of consciousness underwater ("shallow water blackout") before a sufficiently strong subjective warning signal arises (Bart, Murray & Lau, 2026). (Full physiology: Part 2.)

Warning Signs for Medical Evaluation 🟢

Breathing exercises are not a substitute for diagnostics.

- **Seek immediate medical help:** severe shortness of breath, acute chest pain, loss of consciousness.
- **Prompt medical evaluation:** shortness of breath at rest, recurring unexplained breathing difficulties, repeated near-fainting associated with breathing exercises, suspected breathing pauses during sleep (sleep apnea).

Breathing exercises are not a substitute for emergency care. Shortness of breath, chest pain, loss of consciousness, or sudden severe breathing problems are not situations for breathing exercises. In such cases, emergency medical care takes absolute priority.

On the Epilepsy Caution 🟢

Because hyperventilation is deliberately used in EEG diagnostics to provoke epileptiform activity, people with known or suspected epilepsy should not practice intense hyperventilation techniques without prior medical consultation.
Sources: Immink et al. (2014), Journal of Applied Physiology. Bart, Murray & Lau (2026), StatPearls. Callaham (1989), Annals of Emergency Medicine. ANZCOR (2023), First Aid Guideline 9.2.8.

Why Paper Bag Rebreathing Can Be Dangerous 🟢

Rebreathing into a paper bag is a well-known home remedy for hyperventilation: you re-inhale your own exhaled air, which quickly raises CO_2 levels and can relieve symptoms — if the underlying cause really is harmless hyperventilation from anxiety or stress.
The risk: the same symptoms (shortness of breath, tightness, dizziness) can also occur with a heart attack, a pulmonary embolism, or an asthma attack. In one documented case series, mistakenly using paper bag rebreathing on patients having an actual heart attack led to death in three cases (Callaham, 1989). For this reason, current first-aid guidelines explicitly advise against rebreathing techniques for hyperventilation (ANZCOR, 2023). Without a confirmed diagnosis, this home remedy is therefore not a safe form of self-treatment.

Safety and Caution Matrix 🟢

This overview is not a medical contraindication list. It serves as orientation for which techniques require particular caution. If you have known conditions or are pregnant, individual suitability should be discussed with a medical professional.

Technique	Cardiovascular Risks	Pregnancy	Acute Respiratory Illness	Epilepsy (known/ suspected)
Intense Hyperventilation	⚠ Caution	⚠ Caution	⚠ Caution	⚠ Caution
Breath Retention (extended holding)	⚠ Caution	⚠ Caution	⚠ Caution	⚠ Caution
Extended Exhalation	🟢 No restriction	🟢 No restriction	🟡 Individual	🟢 No restriction
Resonance Frequency Breathing	🟢 No restriction	🟢 No restriction	🟡 Individual	🟢 No restriction
Gentle CO_2 Tolerance Training	⚠ Caution	⚠ Caution	🟡 Individual	⚠ Caution

Legend: ⚠ Caution = individually assess with a doctor · 🟡 Individual = situation-dependent · 🟢 No restriction = no known specific restriction

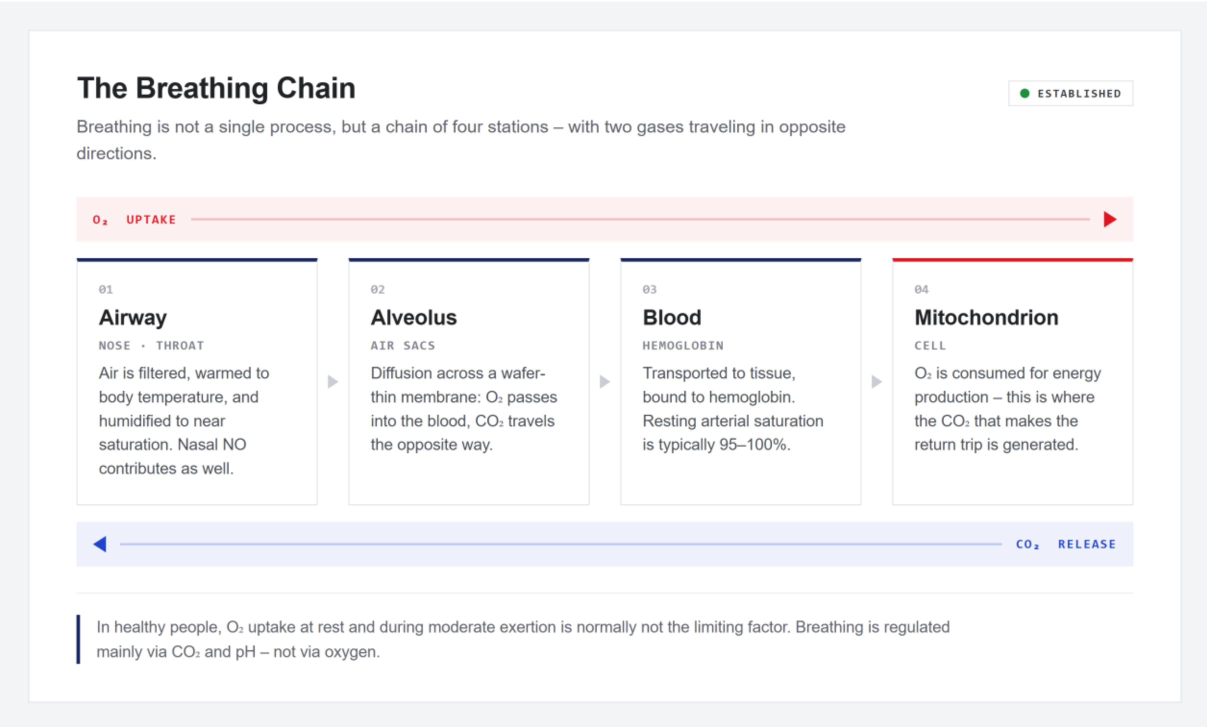
For the distinction between the Evidence Rating and the Safety Rating, see Part 0.

Note: Techniques involving pronounced strain breathing (e.g., the Valsalva maneuver) can raise intraocular pressure and require separate caution for glaucoma. They are not part of this basic compendium and are therefore not included in the matrix.

Part 2 — How Breathing Actually Works

Breathing Chain: Nose → Alveolus → Blood → Mitochondrion

Breathing is not a single process, but a chain of four stations. Air flows in through the nose, where it's filtered, warmed, and humidified. In the alveoli (air sacs), oxygen diffuses across a wafer-thin membrane into the blood, while carbon dioxide (CO_2) travels the opposite way. The blood transports oxygen, bound to hemoglobin, to the tissues. Once there, it's consumed in the mitochondria — the cell's "power plants" — for energy production.
In healthy people, oxygen uptake at rest and during moderate exertion is normally not the problem. Breathing is regulated mainly through the regulation of CO_2 and pH balance.



Why Oxygen Is Almost Never the Problem in Healthy People

Arterial oxygen saturation (SpO_2) in healthy people at rest is practically always in the high normal range — typically between 95 and 100%. A subjective feeling of breathlessness or "not enough air" therefore doesn't automatically mean there's an actual oxygen deficiency in the blood. Conversely, normal SpO_2 alone cannot rule out illness.
Important: normal oxygen saturation doesn't automatically mean every cell is optimally supplied with oxygen at all times. Actual tissue oxygen supply also depends on the amount of available hemoglobin, cardiac output, tissue perfusion, and the cells' ability to use the oxygen delivered. In healthy people, however, these systems normally function reliably enough that oxygen deficiency is not a limiting factor in daily life.

Breathing Is Rarely the Limiting Factor Under Exertion 🟢

In healthy people with normal lung function, the lungs are often not the primary limiting factor during physical exertion. Depending on training status and sport, the cardiovascular system, peripheral muscles, or metabolism may become limiting earlier. An exception is elite endurance athletes, in whom mild exercise-induced oxygen desaturation can actually occur under maximal exertion — but this isn't relevant for the everyday use of this compendium.

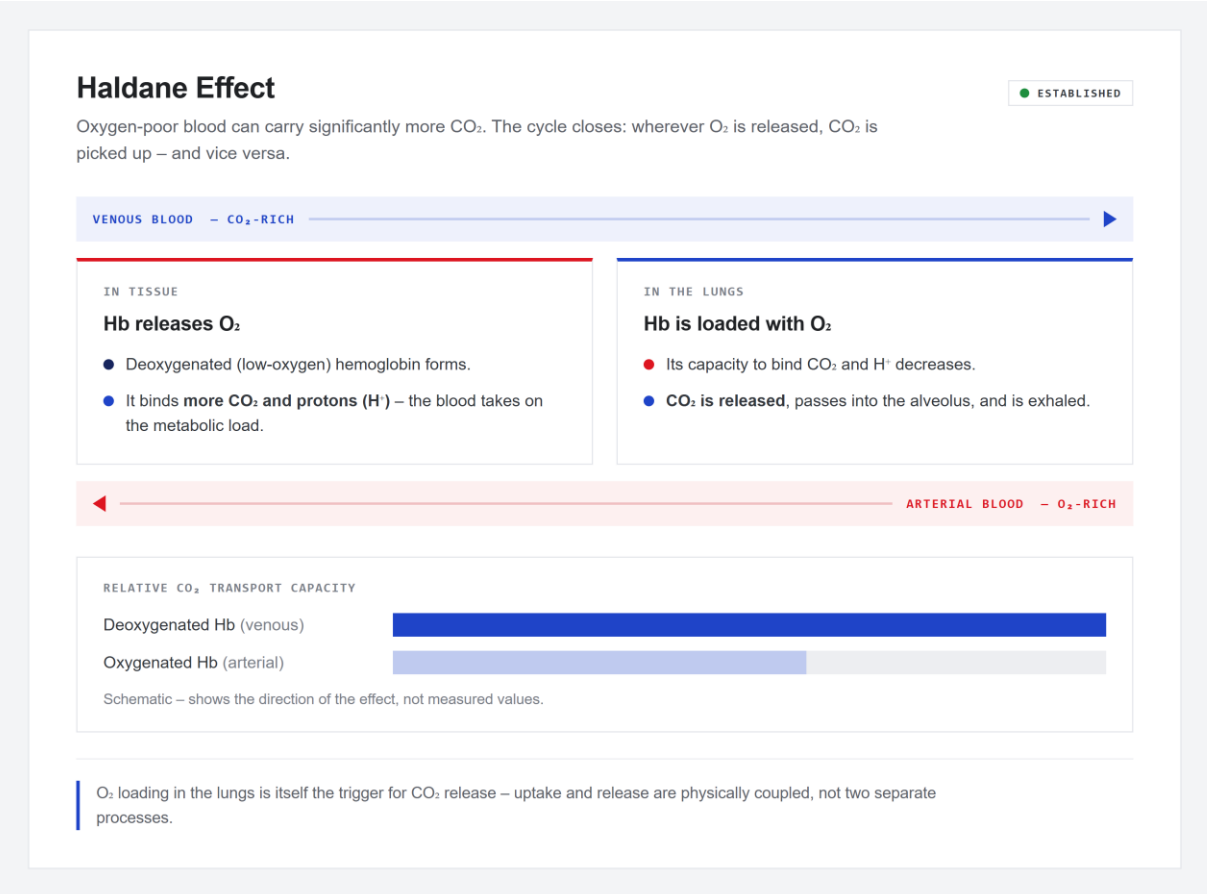
CO_2 as a Regulating Variable, Not a Waste Product 🟢

The most important shift in perspective in this chapter: CO_2 is not merely a waste product of cellular respiration that should be "exhaled" as quickly as possible. CO_2 is the central control variable of breathing itself.

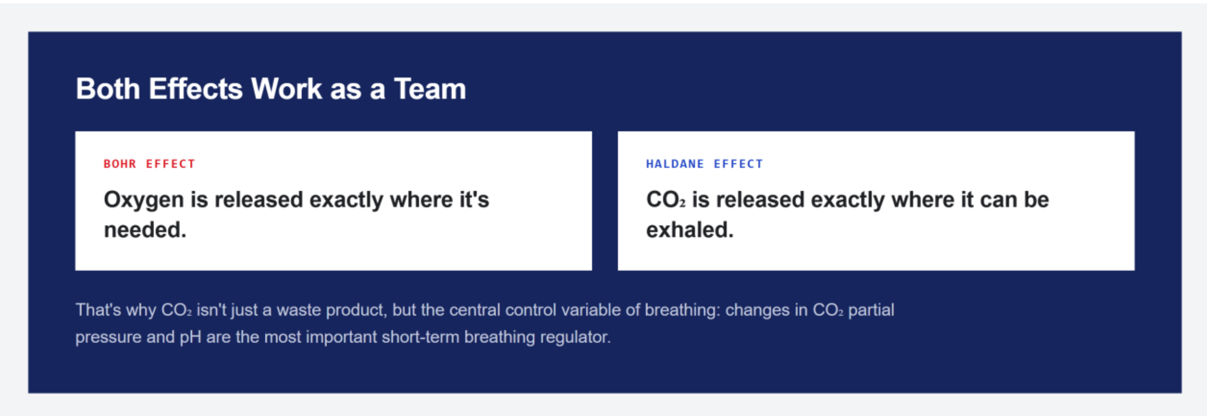
Two classic mechanisms explain why:

- **Bohr effect:** when CO_2 partial pressure rises in active tissue (e.g., working muscle) and pH drops as a result, hemoglobin releases its oxygen more easily exactly where it's currently needed.

- **Haldane effect:** oxygen-poor (venous) blood can carry significantly more CO_2. As soon as hemoglobin is loaded with oxygen in the lungs, its capacity to bind CO_2 and protons decreases. This releases CO_2 from the blood, allowing it to pass into the alveoli and be exhaled.



So both effects work together as a perfect team: the Bohr effect ensures oxygen is released where it's needed — the Haldane effect ensures CO_2 is released where it can be exhaled.



Under normal conditions, CO_2 — more precisely, the change in CO_2 partial pressure and pH — is the most important short-term breathing regulator. However, if arterial oxygen levels drop significantly, peripheral chemoreceptors (particularly in the carotid body) are additionally activated and increase the drive to breathe.

Hyperventilation (breathing too fast, too deep) significantly lowers CO_2 partial pressure, while arterial oxygen saturation in healthy people only rises marginally further, because hemoglobin is already nearly fully saturated with oxygen.

Clarification: Why Hyperventilation Makes You Dizzy 🟢

A common but inaccurate explanation claims that dizziness during hyperventilation arises "via the Bohr effect." That's not correct. The actual mechanism is hypocapnic vasoconstriction: when CO_2 partial pressure in the blood drops (hypocapnia), blood vessels in the brain constrict — cerebral blood flow decreases.

The magnitude is considerable: as a rough approximation in the physiologically relevant range, a change in cerebral blood flow of roughly 3% per mmHg of CO_2 drop is often cited — though the actual response isn't linear across the whole range. At a CO_2 partial pressure ($PaCO_2$) of 20–25 mmHg — as can be reached during strong hyperventilation, compared to a normal value of about 40 mmHg — cerebral blood flow can be markedly reduced compared to the normal range, on the order of several dozen percent. This explains dizziness, tingling, and, in pronounced cases, clouding of consciousness.

Important for context: this reactivity isn't symmetric, but sigmoid (S-shaped). Hypercapnia (elevated CO_2) dilates brain vessels more strongly than hypocapnia (lowered CO_2) constricts them. This means: hyperventilation alone usually doesn't lower cerebral blood flow on land far enough to cause loss of consciousness — it becomes critical only in combination with additional cardiovascular stressors.

The water rule from Part 1, however, has its own, even more direct reason that goes beyond hypocapnic vasoconstriction: when voluntarily hyperventilating before a breath-hold underwater, CO_2 levels are artificially lowered. Because CO_2 — not oxygen deficiency — is the primary drive to breathe, this significantly delays the urge to breathe. Blood oxygen, however, keeps dropping unchecked during this time until it reaches a critical level, causing loss of consciousness without warning ("shallow water blackout"). Those affected feel no shortness of breath that would warn them — that's what makes this mechanism so dangerous. This is the actual, specific reason why hyperventilating before diving or distance swimming underwater is life-threatening.

Sources: Ainslie & Duffin (2009), American Journal of Physiology – Regulatory, Integrative and Comparative Physiology. Bart, Murray & Lau (2026), StatPearls.

pH Regulation: Two Timescales 🟢

The body's acid-base balance is regulated by two systems operating at very different speeds:

- **Breathing — fast regulation:** by exhaling CO_2, blood pH can be influenced within seconds to minutes. Faster breathing lowers CO_2 and raises pH (makes the blood more alkaline); slower breathing retains CO_2 and lowers pH.

- **Kidneys — slow regulation:** by excreting acids and reabsorbing/generating bicarbonate, the kidneys stabilize acid-base balance over hours to days.

These two systems work together, but on different timescales — breathing as fast fine-tuning, the kidneys as slower but more sustained regulation.

Metabolic Load and Compensatory Breathing 🟡

Popular claims like "fast food acidifies the blood, faster breathing counteracts it" oversimplify a real but much more narrowly defined mechanism. Certain metabolic states (e.g., metabolic acidosis in certain conditions) can indeed trigger a compensatory change in breathing — the body then genuinely counter-regulates via breathing rate.
But that's a specific physiological compensation mechanism in clearly defined situations, not an everyday effect of individual meals. The body primarily absorbs diet-related acid loads via its enormous bicarbonate buffering capacity, without any noticeable change in resting breathing. In pronounced metabolic acidosis, the body can significantly deepen and speed up breathing to exhale additional CO_2. This characteristic breathing pattern is called Kussmaul breathing.
The formula "diet acidifies, breathing de-acidifies" is an impermissible oversimplification in an everyday context — it obscures the actual mechanism more than it explains it.
Source: Porter & Graham (2025), StatPearls.

Part 3 — The Diaphragm and Breathing Mechanics

The Key Muscles of Breathing

The lungs themselves have no muscles — they're a passive organ that's expanded or compressed by pressure changes in the chest cavity.

- **The diaphragm:** the most important breathing muscle. It's a dome-shaped sheet of muscle and tendon that separates the chest cavity from the abdominal cavity. When the diaphragm contracts, it flattens and moves downward. This creates negative pressure in the chest, and air flows into the lungs. At the same time, it pushes the abdominal organs down and outward — the typical bulge seen in "belly breathing."
- **The intercostal muscles:** they support the diaphragm by lifting the rib cage up and outward like a bucket handle. This further increases chest cavity volume.
- **Accessory breathing muscles:** recruited additionally during increased breathing effort — on the inhale side, mainly muscles in the neck (e.g., sternocleidomastoid, scalene muscles) during physical exertion or breathlessness. During forced exhalation, accessory exhale muscles are also engaged, particularly the abdominal muscles and internal intercostal muscles.

The "Belly vs. Chest" Myth

Many breathing guides set up a hard dichotomy: belly breathing is "healthy," chest breathing is "unhealthy" or a sign of chronic stress. Physiologically, that's a significant oversimplification.

The diaphragm is active during every inhale at rest — in healthy people, normal resting breathing practically never occurs without diaphragm contraction. The difference lies only in load distribution and direction of expansion. Increased chest breathing during exertion (sport) or acute stress isn't "dysfunction" — it's a sensible physiological adaptation to increased ventilation demand: the body needs to move more air per unit time to meet increased oxygen demand and increased CO_2 production.

The actual lever for acutely influencing the autonomic nervous system (see Part 6) is probably less about the location of the movement (belly vs. chest) and more about breathing rate and exhalation length. That doesn't mean the movement pattern is irrelevant — it does affect breathing effort, comfort, and muscular load — just that it's probably secondary for the relaxation effect. A direct comparison of "slow chest breathing vs. fast belly breathing" wasn't examined in the sources verified here; this statement continues to build on the rate/exhale-length mechanism already established in Part 6. The belly-vs-chest distinction is didactically useful for building awareness of breathing, but falls short as a sole explanation for relaxation.

"Most People Breathe Wrong" — Some Context 🟡

The claim that modern humans have "forgotten how to breathe properly" is a popular narrative that sells well but is scientifically hard to quantify. The autonomic nervous system controls breathing highly efficiently.

When people breathe shallowly, quickly, and predominantly through the chest in daily life, that's not automatically a disorder. It often simply reflects the current physical or psychological situation: a slumped sitting posture can unfavorably affect chest mobility and the mechanical conditions for free diaphragm movement; chronic psychological stress programs the nervous system toward "fight or flight." Both lead to a corresponding breathing pattern without any disorder necessarily being present.

That said, there are also genuinely pathological breathing patterns that should be medically evaluated and, if needed, treated — such as chronic hyperventilation or other forms of dysfunctional breathing. This distinction is explored further in Part 9. Breath training doesn't replace this evaluation; it uses conscious control of the breathing muscles as a feedback loop to signal safety to the brain.

Diaphragm Awareness: 360-Degree Expansion 🟡

Instead of straining to "breathe into the belly," functional breathing exercises aim for three-dimensional expansion of the lower torso. A simple exercise to consciously perceive this three-dimensional breathing movement:

The Flank Grip Exercise:

1. Sit upright or lie on your back. Place both hands on the sides of your lower rib cage (thumbs pointing back toward your spine, fingers pointing forward).
2. **Inhale:** breathe in slowly through the nose. Try to direct the inhale so your lower ribs gently press outward against your hands. The lower back should also expand slightly.
3. **Exhale:** breathe out slowly and relaxed through the nose or mouth, and feel the ribs glide back inward.
4. **Focus:** this isn't about maximum force or extreme belly expansion, but about even, gentle expansion in all directions (360 degrees).

What actually drives the relaxation effect — breathing rate and exhale length rather than where the movement happens — is explored further in Part 6.

Part 4 — Nasal Breathing

Filtering, Warming, Humidifying — Basic Functions of the Nose 🟢

The nose is more than an air inlet. The nasal mucosa filters particles and pathogens, warms incoming air to nearly body temperature, and humidifies inhaled air to near saturation before it reaches the lungs. The nose's higher airflow resistance compared to the mouth also extends the air's contact time with the mucosa — a side effect that supports this conditioning.

Nasal Nitric Oxide (NO) 🟢

The paranasal sinuses continuously produce nitric oxide (NO), a gas with local antimicrobial and vascular-regulating functions. When exhaling through the nose, some of this NO is carried along into the lower airways — with mouth breathing, this nasal NO contribution is largely bypassed, since the sinuses aren't flushed with air.

Humming and Nasal NO: the 15-Fold Increase 🟢

Weitzberg & Lundberg (2002) showed in ten healthy subjects: humming raises nasal NO concentration to 15 times that of quiet exhalation. Explanation: the oscillating airflow created by humming substantially enhances gas exchange between the nasal cavity and the paranasal sinuses.

Important context 🟡: the study was designed as a diagnostic procedure — nasal NO measurement during humming was meant to serve as a non-invasive test for sinus ostium patency. The leap from this finding to the claim "humming is healthy" isn't supported by this study.

Humming Breathing / Bhramari: What a Study Actually Shows 🟡

A more recent study in 24 healthy adults compared four conditions — rest, deep breathing, humming breathing, and "quiet" humming breathing with noise-canceling headphones (to mask the audible tone) — across four randomized sessions. Result: humming and "quiet" humming breathing led to markedly slower, more stable breathing with a frequency near 0.1 Hz — and to higher heart rate variability (RMSSD, SDNN, total power, LF power) than rest, when breathing frequency approached this range.

Crucial for interpretation: there were no significant differences between humming and "quiet" humming breathing — the vibration remained present in both cases, but whether the tone was audible or not changed neither breathing nor HRV values. Subjective ratings (stress, anxiety, confidence, relaxation) didn't differ significantly between any of the four conditions. The authors conclude that the effect is linked to the approach toward the 0.1 Hz resonance frequency created by the extended exhale (see Part 6) — not to the humming sound itself. This can't be generalized to "Bhramari" as a traditional technique as a whole, but applies to

the specific conditions examined here.
Two methodological limitations: breathing parameters weren't measured directly, but estimated from RSA patterns derived from the HRV signal. And the study itself is labeled "preliminary" — an initial finding from a small sample, not a broadly established statement.

Nasal Breathing Under Exertion 🟢

At low to moderate exertion intensity, nasal breathing is readily possible for most people. As intensity increases, however, ventilation demand exceeds the airflow the nose can deliver — the nose's higher airflow resistance, an advantage for the basic functions described above, becomes the limiting factor here. Switching to mouth breathing at high intensity is a physiological necessity, not a bad habit.

Mouth Breathing and Children's Facial Development 🟡

In children, a systematic review with meta-analysis (Zhao et al., 2021) shows a consistent statistical association between chronic mouth breathing and changes in facial skeletal development — including a narrower upper jaw, a high palate, and a more vertical growth pattern ("long face" pattern). However, the direction of causality isn't conclusively established in the literature: whether mouth breathing changes facial shape, or whether an anatomical narrowing (e.g., enlarged tonsils, nasal obstruction) causes both mouth breathing and facial shape together, can't be reliably separated from purely observational studies. In children with noticeable, persistent mouth breathing, an ENT or orthodontic evaluation of the underlying cause is more sensible than pure behavioral correction.

Systemic NO Boosters: a Different Topic 🟢

Dietary nitrate (e.g., from beetroot), citrulline, and N-acetylcysteine (NAC) influence systemic NO levels through other pathways — such as the entero-salivary nitrate-nitrite-NO cycle or effects on endothelial NO synthase. This is conceptually distinct from the local NO produced in the paranasal sinuses discussed in this chapter. The two shouldn't be equated or treated as interchangeable; systemic NO boosters are outside the scope of this compendium.
Sources: Weitzberg & Lundberg (2002), American Journal of Respiratory and Critical Care Medicine. Kim, Lee & Woo (2026), Applied Psychophysiology and Biofeedback. Zhao et al. (2021), BMC Oral Health.

Part 5 — CO_2 Tolerance and the BOLT Score

The BOLT Score: Step-by-Step Measurement

The BOLT score (Body Oxygen Level Test) traces back to the "control pause" of the Buteyko method, a breathing technique developed by Konstantin Buteyko in the 1950s. It was popularized and systematized under the name "BOLT" by Patrick McKeown (Oxygen Advantage).

Procedure: breathe calmly and normally for a few minutes. After a normal (not forced) exhale through the nose, pinch your nose shut. Time how long it takes until the first clear urge to breathe — not until the maximum tolerable limit. At this first urge, release your nose and inhale calmly through the nose, without gasping.

Important for safety : the BOLT test, following the Buteyko/Oxygen Advantage methodology, is explicitly not a maximal breath-hold — stopping at the first urge to breathe is the core of the method, not its limitation. It's done sitting, on land; the water rule from Part 1 doesn't apply to it, but it shouldn't be confused with more intense breath-retention techniques.

What the BOLT Score Does (and Doesn't) Measure

Two separate questions are often conflated in practice: first, whether the BOLT score actually measures what it claims to measure — "CO_2 tolerance" as a physiological construct. Second, whether a higher score says anything about fitness or performance. These aren't the same thing.

An independent, broadly accepted validation of the BOLT score as a measure of CO_2 tolerance, or as a reliable predictor of physical performance, hasn't been established in the academic literature to date. The commonly cited reference values (e.g., "40 seconds ideal," "15 to 25 seconds common") come from the method's own training literature, not from independently published normative data.

No Correlation with Endurance and Performance Parameters

Kowalski et al. (2024) tested this in 49 speed skaters (Polish national squad, development and elite team): BOLT score versus performance parameters from a Wingate test (anaerobic peak performance) and a CPET (cardiopulmonary exercise test, including maximal oxygen uptake).

Result: no significant correlations between BOLT score and any of the tested performance parameters ($r = -0.172$ to 0.013; $p = 0.248$–0.984). This doesn't fundamentally rule out any possible relationship between BOLT score and performance — it shows that in this specific, highly trained population, there was no predictive power for the endurance and strength parameters tested. The authors recommend interpreting BOLT scores in trained individuals "with great caution."

Training CO_2 Tolerance 🟡

The method's training approaches aim to gradually shift the subjective breathlessness threshold — for example, through consciously reduced breathing volume or repeated, moderate control pauses throughout the day. A detailed guide isn't the subject of this foundational compendium; what matters here is only the context that the underlying metric itself (the BOLT score) hasn't been independently validated.

Buteyko for Asthma: What Burgess et al. (2011) Show 🟡

A systematic review (41 included studies) on Buteyko breathing, yoga, respiratory muscle training, and physiotherapist-guided breathing training for asthma arrives at a nuanced picture: most RCTs on the Buteyko technique consistently showed a significantly reduced need for rescue medication (β2-agonists); respiratory muscle training showed reduced bronchodilator need. Where meta-analyses were possible, a benefit for asthma-related quality of life also emerged for yoga, Buteyko, and physiotherapist-guided training. Lung function itself (PEF, FEV1), however, didn't improve significantly in the meta-analysis.
The authors' conclusion: "qualified support" is reasonable for patients who want to use such techniques as an adjunct — but there are too few well-designed, sufficiently powered studies for a definitive assessment. Breath training doesn't replace asthma medication; it should be used as a supplement in consultation with the treating physician.
Sources: Kowalski et al. (2024), Frontiers in Physiology. Burgess et al. (2011), Expert Review of Respiratory Medicine.

Part 6 — Slow Breathing and the Nervous System

One of the most evidence-strong chapters in this compendium — the physiology is exceptionally well documented. The data on long-term clinical effects, by contrast, is considerably thinner; this distinction runs through the whole chapter.

6.1 Respiratory Sinus Arrhythmia (RSA) 🟢

Respiratory sinus arrhythmia (RSA) is a normal, well-measurable phenomenon: heart rate rises slightly during inhalation and drops again during exhalation. This rhythm can be demonstrated in practically every person and is the physiological basis for everything that follows in this chapter.

6.2 RSA Isn't the Same as "Vagal Tone" 🟡

In practice, RSA amplitude is often used as a simple measure of "vagal tone" — the larger the swing, supposedly, the higher the parasympathetic activity. This equivalence is scientifically disputed: according to Grossman (2024), RSA reliably reflects neither cardiac vagal tone nor central vagal efferent outflow. It's an approximation, not a direct instrument for measuring "how active the vagus nerve currently is."

6.3 Resonance Frequency: 3.3–6.6 Breaths per Minute 🟢

This is the actual scientific core of the chapter: at a certain, individually slightly different breathing frequency, two of the body's own oscillations fall into phase — respiratory sinus arrhythmia and baroreflex oscillations (the rhythmic regulation of blood pressure via baroreceptors in the vessel walls). When both rhythms coincide, they reinforce each other instead of averaging out — HRV amplitude rises considerably more than at any other breathing frequency. This is called resonance frequency breathing.

For most people, this frequency lies in the range of roughly 3.3 to 6.6 breaths per minute; a value around six breaths per minute (0.1 Hz) is a practical starting point, not a physiological constant. You have to find your own resonance frequency through trial, not prescribe it.

Important for context on the original study: it's based on only five male participants and is itself labeled "preliminary" in the title — a groundbreaking initial finding, not a broadly established population-level statement.

A larger follow-up study by the same research group with 56 participants (24 healthy, 32 with asthma) confirmed that individual resonance frequency remains stable across multiple training sessions (Vaschillo, Vaschillo & Lehrer, 2006). An independent, large-scale replication of the original baroreflex mechanism, as well as robust evidence of a clinical benefit over simply breathing at six breaths per minute, are still lacking according to current reviews (Shaffer & Meehan, 2020).

6.4 HRV Biofeedback — Making Resonance Visible 🟢

HRV biofeedback uses real-time feedback of heart rate variability (e.g., via a chest strap or a pulse sensor on the ear/finger). The actual benefit doesn't lie in the device itself, but in the feedback loop: the user sees directly at which breathing frequency HRV amplitude becomes largest, and thereby learns to deliberately find and reproduce their own resonance frequency — even without a device being necessary later on.

6.5 Extended Exhalation — the Simple Lever 🟢

Because the heart-rate-lowering part of RSA is coupled to the exhale phase, heart rate is fundamentally slower during exhalation than during inhalation — that's pure RSA physiology and well established.

An important clarification that was conflated in an earlier version of this chapter: whether a deliberately extended exhale-to-inhale ratio (e.g., 4 seconds in, 6 seconds out) has an additional, independent effect beyond the pure effect of overall slower breathing frequency can't be cleanly isolated and demonstrated with the sources verified here. The available evidence mainly shows: slower, steady breathing has a calming effect. Whether specifically the ratio (rather than just the rate) is the decisive lever is a finer question that the underlying studies don't cleanly answer separately.

In practice, this means: extended exhalation is a low-threshold, generally well-tolerated technique — but "no known risks" would be too absolute a statement. As with any conscious breath control, some people may experience an unpleasant sensation or mild dizziness; in that case, the same rule applies as everywhere in this compendium: simply return to normal breathing.

6.6 What HRV During a Breathing Exercise Really Means 🟢

Three limitations are part of an honest assessment:

- Higher HRV isn't automatically equivalent to better health. HRV is a contextual measure, not a universal fitness or health score.
- HRV values measured during slow, conscious breathing aren't directly comparable to resting HRV measurements (normal, unconscious breathing) — both measurement situations are physiologically different.
- Very slow breathing frequencies overlap with the low-frequency (LF) band evaluated in HRV frequency analysis. Part of the measured increase during slow breathing can therefore simply be an artifact of the breathing itself, not necessarily a sign of increased parasympathetic activity.

6.7 Short-Term Effect vs. Long-Term Adaptation 🟡

A distinction that often gets blurred in guides: everything described so far consists of acute effects that show up during the breathing exercise itself — increased HRV amplitude, lowered heart rate, subjective calming. Whether regularly training resonance frequency breathing additionally produces a lasting change in baseline autonomic regulation in daily life is a different, considerably harder question to answer.

The sources verified here provide no direct statement on the long-term effects of regular resonance frequency practice specifically. The best available evidence on breathing techniques in the broader sense (Fincham et al., 2023) finds small to moderate effects on stress (g = −0.35), anxiety (g = −0.32), and depression (g = −0.40) over multi-week interventions, with predominantly moderate risk of bias — with the authors explicitly warning against miscalibration between hype and actual evidence. That's an indication of a real but moderate long-term benefit of breathing techniques overall, not specific confirmation for resonance frequency breathing in particular.

6.8 "Vagus Hacking" — What's True, What's Marketing? 🟡

"Vagus hacking" is a popular figure of speech for techniques that aim to influence the autonomic nervous system via breathing. The underlying effect is real: slow breathing with an emphasized exhale demonstrably lowers heart rate and increases HRV amplitude during the exercise. The specific mechanistic claims that often circulate around this — up to the promise of a targeted, direct "activation" of the vagus nerve with precisely controllable downstream effects — are, by contrast, often overstated and go beyond what the data supports. The vagus nerve isn't a single switch, but a complex network; "hacking" suggests a precision and control that research doesn't confirm.

Sources: Zaccaro et al. (2018), Frontiers in Human Neuroscience. Vaschillo et al. (2002), Applied Psychophysiology and Biofeedback. Grossman (2024), Biological Psychology. Lehrer & Gevirtz (2014), Frontiers in Psychology. Fincham et al. (2023), Scientific Reports. Vaschillo, Vaschillo & Lehrer (2006), Applied Psychophysiology and Biofeedback. Shaffer & Meehan (2020), Frontiers in Neuroscience.

Part 7 — The Toolbox

Not every technique in this chapter is equally well supported. For orientation, they're grouped by strength of evidence instead of listed in arbitrary order.

Category A — Physiologically Well Established

The Physiological Sigh — the Lung's Natural Reset Valve 🟢

Healthy people sigh spontaneously and regularly, typically several times per hour — involuntarily and usually unnoticed. This isn't a sign of exhaustion or frustration, but a distinct physiological reflex: a sigh consists of a second, superimposed inhale directly after a normal inhale, followed by a long exhale. This recruits poorly ventilated or partially collapsed alveoli (air sacs) that accumulate during normal, shallow breathing.

The neuron populations that control this reflex sit in the brainstem, in the retrotrapezoid nucleus/parafacial respiratory group (RTN/pFRG) and the pre-Bötzinger complex — the central pacemaker regions of breathing. The sigh is therefore not a conscious technique, but a hard-wired basic mechanism.

(Resonance frequency breathing and extended exhalation, which also belong in this category, are already covered in detail in Part 6.)

Category B — Technique with Limited or Specific Evidence

The Conscious Sigh as a Technique — Cyclic Sighing 🟡

A voluntary technique can be derived from the natural reflex, often called "cyclic sighing": two inhales in a row (a normal one, immediately followed by a short additional top-off inhale), then a long, slow exhale.

In a controlled study with 108 participants, this technique was compared over 28 days (5 minutes daily) against other structured breathing techniques and a control group. The cyclic sighing group showed a significantly lowered breathing rate compared to the control group, as well as improved mood. None of the four groups, however, showed significant changes in heart rate variability or resting heart rate.

This is a crucial point: what's demonstrated is a subjective mood effect plus a reduced breathing rate — not an objectifiable effect on hard cardiovascular markers. This puts into perspective claims that this technique measurably "retrains" the autonomic nervous system. The study duration also limits how much can be concluded: the observation period was 28 days — the study allows no statement about effects from practice continued over months or years.

Box Breathing and Other Structured Breathing Patterns 🟡

Box breathing (e.g., 4 seconds in, 4 seconds hold, 4 seconds out, 4 seconds hold) was one of the techniques compared in the same study. As a standalone pattern, it's not less well supported than the other techniques compared — but not better supported either — no group was superior to the others on the hard physiological markers.

4-7-8 Breathing 🟡

A structured pattern: 4 seconds in, 7 seconds hold, 8 seconds out. There's no dedicated study for this specific number combination in the sources verified here. The plausible effect is presumably based on the general effect of slow breathing with extended exhalation established in Part 6 — not on the exact numerical ratio. Anyone who has good experiences with it loses nothing; but a commitment to exactly this scheme isn't scientifically justified.

Alternate Nostril Breathing (Nadi Shodhana) 🟡

A technique from the yogic tradition in which breathing alternates through one nostril at a time. The mechanism is plausible, but in the sources verified here, there's no dedicated, robust study demonstrating a specific additional benefit over simple slow nasal breathing without alternation. Traditionally rooted and pleasant for many to practice, but without independent evidence in this compendium.

(Buteyko breathing and humming breathing/Bhramari belong to Part 5 and Part 4 respectively and are covered there, to avoid duplication.)

Category C — Potential Benefit, Relevant Limitations

Cyclic Hyperventilation with Breath Retention (Wim Hof Style) 🟡 ⚠️

This technique — cycles of controlled hyperventilation followed by breath-holding after exhalation — is the most frequently misunderstood in this compendium, because a single, often-cited study is regularly misrepresented.

In the original study, 24 healthy male volunteers (12 per group) underwent a ten-day training program with three components: meditation, this breathing technique, and cold exposure. All participants then received an endotoxin injection (a bacterial metabolic product that triggers a controlled inflammatory response in the body). The trained group showed elevated adrenaline levels, increased release of anti-inflammatory messenger substances, a dampened proinflammatory cytokine response, and fewer flu-like symptoms than the control group.

Three points are crucial for correct interpretation:

- **Suppression, not strengthening:** what was measured was a dampened immune response — not a "strengthened" immune system in the sense of greater defensive power. Whether a suppressed inflammatory response is desirable depends on context.
- **Three components, one result:** the breathing technique was only one of three trained elements. The independent contribution of breathing alone can't be isolated from this study design.
- **Small, one-sided sample:** 24 participants, exclusively men. Generalizability to women or a broader population isn't established by this study.

Risk: the combination of hyperventilation and breath retention carries a syncope risk, especially with unfamiliar use. Shallow water blackout (Part 1) is a documented cause of drowning accidents involving exactly this combination — the water rule applies here without exception.

Notable: in the study by Balban et al. (2023), a fourth group not separately covered here — using cyclic hyperventilation and breath retention (30 deep nasal inhales + passive exhale,

then a full exhale + 15-second breath pause, three rounds) — showed no additional evidence of benefit over the gentler cyclic sighing technique (Category B): it performed no better on either breathing rate reduction or positive affect, while the cyclic sighing technique significantly outperformed the control group (meditation) on both measures. This doesn't prove the more intense technique is ineffective — but it provides no indication that its higher risk is justified by an additional benefit.
Sources: Li et al. (2016), Nature. Severs, Vlemincx & Ramirez (2022), Biological Psychology (I + II). Balban et al. (2023), Cell Reports Medicine. Kox et al. (2014), PNAS.

⚠ Warning Box: Breath Retention

Voluntary breath-holding — whether after inhale or exhale, whether standalone or part of a cyclic technique — warrants its own caution, independent of whatever other technique it's embedded in:

- ● **Particular caution for:** epilepsy, pregnancy, and pre-existing cardiovascular conditions (see the Safety and Caution Matrix, Part 1). For glaucoma, separate caution applies mainly to techniques involving a strain-breathing component, not to simple breath-holding (see the footnote to the matrix, Part 1).
- ● **For healthy people:** brief holds of a few seconds are unproblematic. Risk increases with the duration of the hold and especially in combination with prior hyperventilation (see Part 1: the water rule and the shallow water blackout mechanism).
- ● **Absolute rule:** never in or near water, never while driving (see Part 1).

Practical Takeaway

After all this science, a clear orientation instead of ten equally weighted techniques side by side:

- To get started, one technique is enough: slow, calm breathing with a slightly extended exhale (Part 6).
- For systematic training: find your own resonance frequency and practice it regularly (Part 6).
- For a specific medical question (e.g., asthma): specific techniques like Buteyko only in the appropriate context and in consultation with medical treatment (Part 5).
- Anyone practicing hyperventilation or breath retention: strictly follow the safety rules from Part 1 — without exception.

Part 8 — Breathing and Sleep ⚠

This chapter differs from the others: it's less about what you can achieve with breathing techniques, and more about where their limits lie. Two things are regularly conflated online — the question of how to wind down better in the evening, and the question of what to do about nighttime breathing pauses. One is a comfort question, the other a potentially serious medical problem.

Recognizing Sleep Apnea 🟢

In obstructive sleep apnea (OSA), the muscles of the throat relax during sleep to the point that the upper airway repeatedly partially or fully collapses. Breathing stops for seconds, blood oxygen drops, and the body responds with a brief arousal that reopens the airway. Those affected usually don't remember any of these arousals the next morning — even though, in severe cases, they can occur dozens of times per hour.

Typical signs: loud, irregular snoring with observed breathing pauses — often noticed by a partner, not by the affected person themselves. Waking at night gasping for air or with a choking sensation. Non-restorative sleep despite adequate sleep duration. Pronounced daytime fatigue, microsleep episodes, a tendency to fall asleep during quiet situations. Morning headaches, dry mouth, frequent nighttime urination.

Untreated, sleep apnea is more than a comfort problem. It's associated with elevated blood pressure, cardiac arrhythmias, and increased cardiovascular risk; daytime fatigue also significantly raises the risk of traffic accidents.

Diagnosis isn't made by self-assessment, but by a sleep study — either at home or in a sleep lab. The established standard therapy for relevant severity is nightly positive airway pressure therapy (CPAP); depending on findings, mandibular advancement devices (mainly for mild to moderate severity and suitable dentition), positional therapy, weight reduction, or surgical procedures may be considered.

Key Point: Breathing Exercises Don't Treat Mechanical Obstruction 🟢

This is the most important statement in this chapter, and it can be summarized in one sentence: obstructive sleep apnea is a mechanical problem. The airway collapses because muscle tone drops during sleep and the anatomy can't withstand it. A breathing technique practiced during the day changes nothing about this anatomy — and at the decisive moment, namely deep sleep, voluntary breath control isn't possible anyway.

This doesn't mean the techniques in this compendium are harmful for sleep apnea. It means they don't address the problem. Anyone with suspected sleep apnea who does breathing exercises instead loses time — in a situation where the untreated condition keeps progressing.

Mouth Taping: A Recommendation That Doesn't Hold Up 🔴 ⚠️

Taping the mouth shut overnight has, in recent years, become one of the most widely shared breathing recommendations via social media. The reasoning sounds plausible at first: anyone who breathes through the mouth at night loses the benefits of nasal breathing (Part 4), so nasal breathing is mechanically forced.

A systematic review (Rhee et al., 2025) has, for the first time, compiled the available evidence on this: ten studies with a total of 213 patients. The result is sobering. A benefit appeared, if at all, only in mild obstructive sleep apnea, and the few studies that found any improvement in the apnea-hypopnea index had excluded people with nasal obstruction from the outset. For broad use outside this narrowly defined group, evidence is lacking.

Important context ⚠️: more serious than the lack of benefit is the risk. The authors describe a potentially serious danger for people who adopt this trend indiscriminately — specifically, the risk of suffocation for those whose nasal breathing is already impaired. This is exactly the group most susceptible to the recommendation: people who breathe through the mouth at night usually do so for a reason. Enlarged tonsils, a deviated septum, chronic mucosal swelling, allergies — or undiagnosed sleep apnea. Taping the mouth shut treats none of these causes; it closes off the compensation route.

On top of that: anyone who doesn't know whether they have sleep apnea can't judge whether taping is safe in their case. The order must therefore be reversed — evaluation first, then possibly a measure, not the other way around.

Encouraging Nighttime Nasal Breathing — Without Tape 🟡

Anyone who breathes through the mouth at night and wants to change that is sensibly better off addressing the cause rather than the symptom. The following approaches are low-threshold and low-risk; however, their specific effectiveness for the goal of "more nasal breathing during sleep" isn't backed by robust studies — they follow from plausible reasoning, not controlled trials.

- **Get the cause evaluated:** persistently impaired nasal breathing should be examined by an ENT specialist — the most effective step, and the only one that actually addresses the cause.
- **Reduce allergens:** for allergic rhinitis, treating the allergy can improve nasal patency.
- **Humidify indoor air:** dry heating air dries out the nasal mucosa and encourages the switch to mouth breathing.
- **Adjust sleep position:** back sleeping promotes both snoring and upper airway collapse; side sleeping can reduce both.
- **Avoid alcohol in the evening:** alcohol further lowers throat muscle tone, worsening both snoring and obstructive events.

Breathing Techniques for Falling Asleep 🟡

Distinct from sleep apnea is the question of how to wind down more easily in the evening. Here, the techniques from Part 6 are genuinely applicable: slow breathing with an emphasized exhale has a calming effect during the exercise, and this effect can be used as a bedtime ritual. The popular 4-7-8 breathing (Part 7) falls into this category — plausibly effective via the general slow-breathing effect, not via the specific numerical ratio.

Important context 🟡: for occasional difficulty falling asleep, this is a sensible, low-risk measure. For chronic insomnia — persistent difficulty falling or staying asleep over weeks, with impaired daytime functioning — cognitive behavioral therapy for insomnia (CBT-I) is the established first-line treatment. The American College of Physicians guideline (Qaseem et al., 2016) issues a strong recommendation for CBT-I as first-line treatment for chronic insomnia; relaxation techniques, which include breathing exercises, are recommended only as a conditional single component in sleep medicine guidelines, not as an equivalent alternative to full CBT-I. Breathing techniques can supplement it, but don't replace it. Anyone who has been sleeping poorly for months is better served by structured behavioral therapy than by a breathing exercise.

Warning Signs for Medical Evaluation ⚠️

A compact cross-reference to Part 1, specific to sleep: observed breathing pauses during sleep. Loud, irregular snoring with gasping. Waking at night gasping for air. Pronounced daytime fatigue or microsleep episodes, especially while driving. Persistent sleep disturbances over several weeks. In all these cases: diagnostics first, then measures. Not the other way around.

Sources: Rhee et al. (2025), PLOS One. Slowik, Sankari & Collen (2025), StatPearls. Qaseem et al. (2016), Annals of Internal Medicine.

Part 9 — Recognizing Dysfunctional Breathing

Chronic Hyperventilation: Development and Symptoms 🟡

Unlike acute hyperventilation (see Parts 1 and 2) — deep, fast breathing with immediately noticeable symptoms — a chronic, subtly excessive breathing pattern can develop gradually over weeks or months, often without those affected noticing they're breathing "too much." Depending on individual breathing patterns, this can lead to a repeatedly or chronically lowered CO_2 partial pressure. The result is a broad, nonspecific symptom picture: dizziness, tingling in hands, feet, or around the mouth, chest tightness, breathlessness despite objectively normal lung function, exhaustion, concentration problems.

Important context 🟡: "hyperventilation syndrome" as an independent clinical diagnosis is itself scientifically disputed. It overlaps considerably in the literature with panic disorder and generalized anxiety disorder — the distinction isn't always clear-cut in clinical practice. The classic provocation test (voluntary hyperventilation to deliberately trigger symptoms) is considered diagnostically unreliable. At the same time, chronic hyperventilation as a cause or amplifier of symptoms can be overlooked, since the symptoms are nonspecific and overlap with other conditions. This diagnostic uncertainty isn't a sign of unscientific thinking, but an indication of the topic's complexity. Breathing techniques from this compendium can be helpful as a complement, but don't replace medical evaluation.

The Nijmegen Questionnaire as a Screening Tool 🟡

The Nijmegen Questionnaire (van Dixhoorn & Duivenvoorden, 1985) is a 16-item self-report questionnaire with a five-point scale ("never" to "very often," 0–4 points per item), total score 0–64. In the original and later models, the items can be roughly grouped into three dimensions: breathlessness/shortness of breath, peripheral tetany symptoms (tingling in the extremities), and central tetany symptoms (dizziness, lightheadedness). In the original study, the questionnaire reliably distinguished between 75 clinically diagnosed hyperventilation syndrome patients and 80 healthy controls (93% correct classification).

The original paper cited a score above 19 as indicative of hyperventilation syndrome. Later research has shown that the optimal threshold can vary depending on the population and question studied; a uniform, population-independent cutoff therefore isn't established. The questionnaire is a screening tool, not a diagnostic instrument — a high score doesn't replace medical evaluation, but is a reason to seek it.

The Breathing-Anxiety Spiral 🟡

A mechanism that can independently sustain symptoms: anxiety or stress alters breathing (faster, shallower, more through the mouth) → the resulting physical sensations (dizziness, tingling, tightness) are misinterpreted as threatening → this misinterpretation amplifies the anxiety → the anxiety in turn amplifies the altered breathing. This self-reinforcing cycle is a central component of cognitive models of panic disorder and can explain why physical breathing sensations and anxiety can reinforce each other. Conscious, slow breathing techniques (see Part 6) can be one approach for some people to interrupt this cycle; their effectiveness, however, depends on the specific intervention and clinical context.

Distinction: Breathing Pattern or Illness? (Guidance)

Part 3 already established: a situational breathing pattern — faster under stress, chest-dominant during exertion — isn't, by itself, an illness. Orientation along four criteria:

- **Duration:** temporary and situational versus persistent and recurring without a clear trigger
- **Impairment:** minor, self-resolving versus disrupting daily life
- **Symptoms:** mild and understandable, e.g., before an exam, versus unclear chest pain, breathlessness at rest, or a conspicuous Nijmegen score
- **Improvement:** can be calmed through conscious breathing versus no improvement from slow breathing techniques

The more of these that fall on the second side, the more medical evaluation is warranted. Persistent, recurring, or daily-life-impairing symptoms, a conspicuous Nijmegen score, or symptoms that don't improve with conscious breath regulation are reasons for medical evaluation — not because the compendium reaches a limit of self-help here, but because, before attributing anything to "just" a breathing pattern, more serious organic causes (cardiac, pulmonary, metabolic, neurological) must be ruled out. Breathing techniques from this compendium can be helpful as a complement, but don't replace this evaluation.
Source: van Dixhoorn & Duivenvoorden (1985), Journal of Psychosomatic Research.

Part 10 — Ten Minutes a Day

A practical example routine that combines four already-introduced building blocks. It doesn't replace an individual training plan, but shows how the content of this compendium can be translated into a manageable daily routine.

1. **Arriving (2 minutes)**
   Consciously breathe in and out through the nose, without forcing or deliberately changing your breathing. Goal: shift from autopilot into conscious awareness of your own breathing.
   Basis: Nasal breathing (Part 4).

2. **Extended Exhalation (3 minutes)**
   For example: inhale for 4 seconds, exhale for 6 seconds — through the nose, calm and without strain.
   Basis: Extended exhalation (Part 6.5).

3. **Resonance Frequency Breathing (3 minutes)**
   Roughly 5 seconds in, 5 seconds out. One breath cycle thus takes about 10 seconds, corresponding to roughly six breaths per minute.
   If you like, you can explore your own resonance frequency within the range of roughly 3.3 to 6.6 breaths per minute described in Part 6.3. 5/5 breathing is a practical starting point here, not a fixed prescription. The optimal resonance frequency can vary individually; the stated range should therefore be understood as a search space, not a universally valid target.
   Basis: Resonance frequency breathing (Part 6.3).

4. **Conscious Sighing / Cyclic Sighing (2 minutes)**
   This technique is derived from the natural physiological sigh reflex (Part 7), but is performed consciously here. 3 to 5 cycles: two inhales in a row — a normal inhale, immediately followed by a short additional top-off inhale — then a long, slow exhale.
   The number of 3 to 5 cycles is a practical adaptation for this example routine, not the dosage tested in the underlying study.
   Basis: Cyclic sighing (Part 7).

Important Context

Each individual building block of this routine has a physiological or scientific basis described in its respective chapter. However, the specific combination, order, and duration of this ten-minute routine as a complete protocol hasn't itself been tested in a clinical study. The routine is therefore a practical assembly of individually studied elements — not an independently validated overall protocol. The documented evidence relates to the individual building blocks, not to this specific combination or order. Whether a different order or weighting would be better suited for individual people can't be derived from the available evidence.

Note: this routine is intended as a low-threshold example structure. If dizziness, discomfort, or increased breathlessness occurs, stop the exercise and let your breathing return to normal.

Part 11 — What This Compendium Doesn't Cover

A foundational compendium can't cover everything. The following topics are deliberately left out — not because they're unimportant, but because each represents its own field with its own body of research, its own risks, or a highly specialized audience.

- **Breathing in competitive sports:** VO_2max, inspiratory muscle training, side stitches, and nasal breathing under competitive conditions are their own field within exercise science with their own body of research. The nasal breathing under exertion covered in Part 4 addresses only the basic physiological threshold to mouth breathing — not the specific training questions of competitive sport.
- **Freediving and hypoxia training:** freediving and deliberate hypoxia training (controlled oxygen deprivation) require expert supervision; unsupervised self-study is life-threatening. The water rule from Part 1 applies here in stricter, not merely supplementary, form.
- **Altitude training:** a specialized application in sports medicine with its own equipment and protocols (altitude tents, hypoxic chambers, live-high-train-low protocols) that goes beyond the breathing techniques in this compendium.
- **The Valsalva maneuver and strength training:** strain breathing for trunk stabilization during heavy strength training is its own biomechanical topic with its own risks for blood pressure and intraocular pressure (see the corresponding footnote to the Safety and Caution Matrix in Part 1), and isn't explored or recommended here as a breathing technique.
- **Breathing therapy for asthma, COPD, and long COVID:** structured breathing rehabilitation for chronic lung disease or after viral infections belongs under medical and physiotherapeutic supervision. This connects to the evidence on Buteyko breathing for asthma presented in Part 5, but for more severe cases goes considerably beyond pure self-help in both diagnosis and treatment.
- **Breathing and digestion, longevity claims:** for claims about a direct link between specific breathing techniques and digestion — beyond the general effect of slow breathing on the autonomic nervous system already covered in Part 6 — or increased life expectancy, the current body of evidence is too thin for robust recommendations. Should this change, it belongs in a future update of this compendium, not in vague promises in the current edition.

Appendix

Glossary

- **Bohr effect:** the physiological principle whereby a rising CO_2 partial pressure or falling pH in tissue reduces hemoglobin's oxygen affinity: hemoglobin releases oxygen more easily exactly where it's currently needed (Part 2).
- **BOLT (Body Oxygen Level Test):** a breath-hold test to the first noticeable urge to breathe, not to the maximum tolerable limit. Derived from the Buteyko method; not independently validated scientifically as a measure of CO_2 tolerance or physical performance (Part 5).
- **CO_2 tolerance:** in the breath-training literature, the ability to tolerate a rise in CO_2 levels and the associated urge to breathe and other sensations for longer. Not consistently defined physiologically; the BOLT score isn't independently validated as a measure of it (Part 5).
- **HRV (heart rate variability):** the extent to which the time interval between consecutive heartbeats fluctuates. A contextual measure, not a universal fitness or health indicator (Part 6).
- **Hypocapnia:** a CO_2 partial pressure in the blood below normal, typically caused by hyperventilation. Triggers, among other things, constriction of brain vessels (hypocapnic vasoconstriction, Part 2).
- **NO (nitric oxide):** a gaseous signaling molecule, produced locally in the paranasal sinuses among other places, with antimicrobial and vascular-regulating functions (Part 4). Not to be confused with nitrous oxide (N_2O) or with systemic NO from dietary nitrate, citrulline, or NAC.
- **RSA (respiratory sinus arrhythmia):** the normal, well-measurable fluctuation of heart rate in rhythm with breathing: rises during inhalation, falls during exhalation. The physiological basis of resonance frequency breathing (Part 6).

The Evidence Rating Explained

For the full explanation of the two separate rating systems, see Part 0. A methodological note that applies to practically all the breathing-technique research cited in this compendium: someone doing a breathing exercise usually knows they're doing a breathing exercise — blinding, as in drug trials, is practically impossible for most breathing techniques. This makes it harder to separate expectation and context effects from the specific physiological effects of the breathing technique.

Fincham et al. (2023) — the meta-analysis on breathing techniques in general most frequently cited in this compendium (Part 6.7) — found small to moderate effects on stress, anxiety, and depression over multi-week interventions, with predominantly moderate risk of bias. That's an indication of real but modest effects — not evidence of a particularly strong physiological effect independent of expectation and context.

Bibliography, Organized by Study Type and Source Type

This structure organizes the 26 sources by publication and study type. It doesn't represent an independent assessment of scientific evidence strength — the evidence rating is provided via the rating tags in the main text.

- **Systematic Reviews and Meta-Analyses:** Burgess et al. (2011) — Expert Review of Respiratory Medicine · Zaccaro et al. (2018) — Frontiers in Human Neuroscience · Zhao et al. (2021) — BMC Oral Health · Fincham et al. (2023) — Scientific Reports · Rhee et al. (2025) — PLOS One
- **Randomized or Controlled Experimental Studies:** Vaschillo et al. (2002) — Applied Psychophysiology and Biofeedback · Kox et al. (2014) — PNAS · Balban et al. (2023) — Cell Reports Medicine · Kim, Lee & Woo (2026) — Applied Psychophysiology and Biofeedback · Vaschillo, Vaschillo & Lehrer (2006) — Applied Psychophysiology and Biofeedback
- **Physiological Experimental Studies, Validation Studies, and Case Series:** Callaham (1989) — Annals of Emergency Medicine · van Dixhoorn & Duivenvoorden (1985) — Journal of Psychosomatic Research · Weitzberg & Lundberg (2002) — American Journal of Respiratory and Critical Care Medicine · Immink et al. (2014) — Journal of Applied Physiology · Li et al. (2016) — Nature (animal model) · Kowalski et al. (2024) — Frontiers in Physiology
- **Narrative Reviews, Reference Works, and Guidelines:** Ainslie & Duffin (2009) — American Journal of Physiology · Lehrer & Gevirtz (2014) — Frontiers in Psychology, 5, 756 · Severs, Vlemincx & Ramirez (2022), Part I — Biological Psychology · Vlemincx, Severs & Ramirez (2022), Part II — Biological Psychology · Porter & Graham (2025) — StatPearls · Grossman (2024) — Biological Psychology · Bart, Murray & Lau (2026) — StatPearls · ANZCOR (2023) — First Aid Guideline 9.2.8 · Slowik, Sankari & Collen (2025) — StatPearls (NBK459252) · Qaseem et al. (2016) — Annals of Internal Medicine · Shaffer & Meehan (2020) — Frontiers in Neuroscience

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Source of Information: The core content and structure of this guide are based on a systematic review of the scientific literature on breathing techniques, breathing physiology, and their application in health and performance contexts. The underlying sources are listed in the bibliography.

Methodology & Quality Assurance: For quality assurance, the content was additionally reviewed using modern AI assistance systems (Claude, DeepSeek, ChatGPT, and Gemini) for consistency with current scientific knowledge and the primary sources listed in the bibliography. Final selection, evaluation, and compilation of the content was carried out by the author.

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