THE BREATHING CURE:
DEVELOP NEW HABITS FOR A HEALTHIER, HAPPIER, AND LONGER LIFE

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BONUS CHAPTERS

CHAPTER EIGHTEEN

PHENOTYPES OF OBSTRUCTIVE SLEEP APNEA

Traditionally, obstructive sleep apnea (OSA) was considered an anatomical condition, primarily caused by narrowing of the upper airways. Narrow airways are commonly seen in people who are obese or who have a history of persistent mouth breathing in childhood. Recently, three other non-anatomical traits have also been recognized as contributing to OSA, bringing the total phenotypes of obstructive sleep apnea to four:

1. PCrit – Anatomy of the upper airway,
2. Loop gain – Regularity of breathing,
3. Arousal threshold – How easily the patient wakes from sleep, and
4. Upper airway recruitment threshold – How effectively the dilator muscles of the upper airway maintain an open airway during sleep[1].

Scientists have reported that 69% of OSA patients have one or more of these predisposing physiological characteristics[2]. The key traits of upper airway anatomy and neuromuscular control vary among individuals. This means that anatomically based treatments may not fully resolve OSA. In order to successfully treat the condition, each patient's treatment must be matched with their phenotypes.

Each phenotype can gain significant benefits from restoring functional breathing patterns. However, to date, there has been no clinical trial investigating

the application of functional breathing patterns from the three dimensions of light, slow, and deep breathing for the treatment of obstructive sleep apnea.

In 2018, an editorial titled *The Buteyko Technique: Fake News or No News?* appeared in the *Journal of Dental Sleep Medicine*[3]. The paper was quick to dismiss the benefits of breathing exercises for OSA, but it overlooked a significant body of evidence supporting the restorative role of breathing re-education in the management of sleep-disordered breathing.

The basics of breathing re-education encompass:

- Using breath-hold time to measure chemosensitivity to carbon dioxide,
- Restoring full-time nasal breathing,
- Correcting the resting position of the tongue,
- Reducing the rate of respiration towards normal,
- Learning to properly engage the diaphragm, and
- Achieving normal minute ventilation.

Pharyngeal Critical Closing Pressure (PCrit)

Pharyngeal critical closing pressure is the air pressure at which the upper airway collapses[4]. It is considered the key indicator for quantifying functional anatomy during sleep. It is the measure of the suction pressure required to close the sleeper's upper airway[5]. Ideally, the upper airway should be able to withstand high

levels of pressure. If it collapses easily when pressure is low, the patient is more likely to suffer from sleep problems including sleep apnea.

Sleep apnea often progresses with age, becoming worse as the sufferer gets older. This is generally due to a combination of muscle-tone loss and weight gain around the torso and neck, as well as an increased tendency to mouth breathe[6]. Fat deposits around the throat and in the tongue decrease the size of the upper airway[7]. Elsewhere in the body, fat around the abdomen reduces lung volume, leading to impaired airway functioning of the throat[7]. Mouth breathing makes it is easy for the tongue to fall into the airway[8], causing reduced pharyngeal airway space and leading to upper chest breathing. It has even been claimed that, with our reduced airways and fat tongues, many humans are heading for the same predicament as canine breeds like the bulldog, about which Dr. William Rosenblad, a canine tooth expert, said,

> We've shortened the face of this breed so much... that there's just not enough space for everything to fit. The tongue, the palate, it's all compressed. The teeth often look like they've been thrown in there. They have little tiny nostrils. The end result of all the compression is that many bulldogs can barely breathe[9].

However, obesity is not the end of the line for OSA treatment. In his 2017 paper, airway-centric orthodontist Dr. William Hang cites the case of a woman in

her mid-forties whose sleep apnea was completely resolved by treatment to reopen her maxillary bicuspid extraction spaces, despite gaining more than 10 pounds and having a large tongue[10].

Functional breathing training targets PCrit from two perspectives. First, suction pressure is influenced by flow as well as by airway diameter. An engineer investigating how easy or difficult it is for air to move through a tube would consider not only the diameter of the tube but also the speed of the air. The engineer understands that, as the speed of air travelling through the tube increases, so does the resistance.

When the BOLT score is low, breathing is harder and faster. Hard, fast breathing through a narrow airway increases negative pressure which leads to more risk of airway collapse. The CPAP, the gold standard in the treatment of obstructive sleep apnea, works by pumping air at a high pressure through the airway to help prevent collapse. If positive pressure splints open the airway, it is worth considering whether reducing the negative pressure during inspiration could also help to maintain an open airway.

By practicing the Breathe Light exercises during wakefulness to normalize minute ventilation, the BOLT score increases, and negative pressure decreases. It is my experience in 20 years of working with breathing that improved breathing patterns during wakefulness translate into better breathing during sleep. This is

because nasal breathing with correct tongue resting posture during sleep improves airway diameter, engages the diaphragm[6], and increases lung volume. This causes the tracheal wall to stiffen, enabling the upper airways to stay open[7]. Conversely, mouth breathing is associated with greater upper airway collapse and oxygen desaturation. In a new study published in *Laryngoscope*, the Apnea Hypopnea Index scores (representing the number of apneic events per hour) during mouth breathing were 52.15, compared with 27.4 during nose breathing[11].

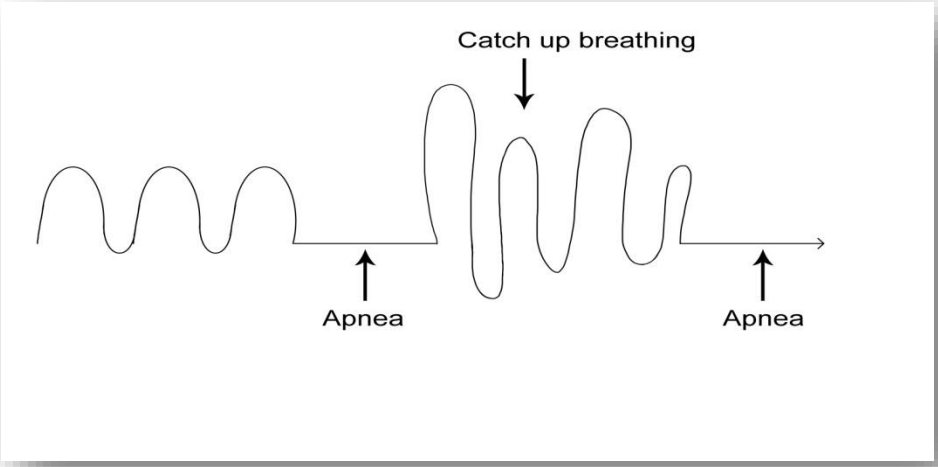
Even the anatomical size of the airway is influenced by whether the mouth is open or closed. During mouth breathing it is not possible for the tongue to rest in the roof of the mouth. This makes it more likely that the tongue will encroach on the airway. Equally, mouth breathing is more often from the upper chest, whereas nose breathing increases the amplitude of diaphragm movement, which is known to increase lung volume[12,13].

Reducing the flow of breathing, as evidenced by a higher BOLT score during wakefulness, not only lessens the negative pressure in the upper airway, it also assists with another trait of sleep apnea called loop gain.

Loop Gain

After anatomical considerations, high loop gain is the greatest contributing factor in OSA[14], affecting one third of patients diagnosed with the condition[2].

Patients with high loop gain have an exaggerated response to even small changes in the level of carbon dioxide.



During an apnea, breathing temporarily stops. Since this makes it impossible for CO_2 to leave the lungs, the gas accumulates in the blood.

When a patient has a high loop gain, ventilation becomes exaggerated when breathing resumes. This faster and harder breathing after an apnea leads to a sudden drop in blood CO_2. As the level of CO_2 in the blood becomes too low, the brain fails to adequately signal to breathe, causing a central apnea[15].

When the brain doesn't send adequate signals to breathe, the muscles in the throat that open the airway become lazy. This leads to airway collapse. In short, with high loop gain, the excessive ventilation following an apnea causes hypocapnia and, therefore, perpetuates the cycle of central and obstructive sleep

apnea[7]. The biochemical effects of mouth breathing during sleep exacerbate OSA. CO_2 levels are lower in mouth breathing than nasal breathing[8], and research has demonstrated the link between low blood CO_2 and apneic spells[16].

In 2018, researchers, headed by Dr. Ludovico Messineo, investigated whether elevated loop gain during sleep could be determined using a breath hold test in wakefulness[17]. The study included 20 people, 10 having OSA. The research assessed two things: first, how long the subjects could hold their breath voluntarily (maximal breath hold), and second, how hard the subjects breathed during their first two breaths after a 20-second breath hold. Messineo's results showed that higher loop gain during sleep was associated with a shorter maximal breath hold and more exaggerated ventilation on the resumption of breathing.

If we look at these findings in terms of the Oxygen Advantage®, they demonstrate that individuals with a shorter breath hold time (lower BOLT score) will have an exaggerated response to the increase of CO_2 in the blood, resulting in higher loop gain. BOLT score can be increased by applying the breathing exercises in this book. This will lower the ventilatory response to hypercapnia and reduce loop gain[18]. The maximal breath hold measurement is one of the basic tenets of breathing re-education[17].

Arousal Threshold

Another potentially important factor in a person's susceptibility to sleep apnea is their propensity to wake up during the night[19]. This is known as their arousal threshold. When a patient has a low arousal threshold, they are likely to awaken before their upper airway muscles have a chance to reopen the airway[15]. In other words, those with a low arousal threshold wake with the slightest stimulus, so their sleep is very disturbed, and they often experience fatigue[5]. Doctors generally treat low arousal threshold with the use of sedatives, but this only improves sleep quality if the upper airway dilator muscles are working effectively[15].

Breathing re-education improves arousal threshold by attacking the underlying causes from two directions. First, individuals with a low BOLT score typically have a faster respiratory rate. According to 2017 research from Stanford Medical School, this faster breathing is likely to cause arousals from sleep. Scientist have recently identified an area of the brain in which neurons are "spying" on breathing and reporting back to another part of the brain called the locus coeruleus. The locus coeruleus is involved with physiological responses to stress and panic[20]. It communicates with almost every other part of the brain and drives arousal, including waking us from sleep[21]. In other words, faster breathing tells the brain to tell us to wake up, that there is a danger.

Second, mouth breathers are more likely to experience light sleep than nasal breathers, and people who sleep more deeply are less likely to wake repeatedly throughout the night. For this reason, nasal breathing can be the key to achieving deeper sleep and a higher arousal threshold. In one study, researchers sought to determine the effect of acute nasal obstruction on sleep and breathing. When the nose was blocked, subjects woke more often, experienced more changes in sleep stage, and spent longer in Stage One, non-REM sleep (light sleep)[22]. Sleep was both subjectively and objectively disturbed by nasal obstruction and mouth breathing.

In another trial, 10 subjects were monitored during and after nasal obstruction. Nasal obstruction was shown to consistently lead to mouth breathing, reducing the time spent in deep sleep stages from 90 to 71 minutes, and significantly increasing the time spent in Stage One sleep. There was an increase in sleep arousals and awakenings of more than 150% due to a greater number of apneas – 34 during normal sleep versus 86 during mouth breathing. The severity of the apneas also increased, with apneas of 20 to 39 seconds in duration becoming two-and-a-half times more frequent during nasal obstruction[23]. Unsurprisingly, all of the subjects in the study complained of poor quality sleep during nasal obstruction.

Low arousal threshold represents the highest risk for OSA patients of all phenotypes. A 2019 paper studied 5,712 women and men with sleep apnea and found that those with the shortest apneic events were at most risk from “all cause mortality”[24]. This relationship was strongest in people with moderate sleep apnea. This means that the people at highest risk in terms of health and longevity aren’t, as you might expect, those with the most severe forms of OSA. They are the people who wake up more frequently during the night.

Slow, nasal breathing activates the relaxation response via the vagus nerve[25], while mouth breathing is associated with activation of the sympathetic stress response[26]. Breathing exercises can be used to reduce the respiratory rate and activate the diaphragm in order to achieve homeostatic balance between the two branches of the ANS, moderating the fight or flight reaction. Acetylcholine (the neurotransmitter released by the vagus nerve), is also instrumental in sleep[27]. People with high anxiety and chronic stress, who may have difficulty falling asleep and staying asleep, can optimize balance in the nervous system by reducing breathing to a rate of 6 breaths per minute.

Upper Airway Recruitment Threshold

The human throat lacks bony support, meaning it is collapsible. However, there are over 20 muscles in the upper airway, each performing a number of

functions, including speech, breathing, chewing, and swallowing[5,28]. Upper airway recruitment threshold refers to the amount of stimulus required to activate the muscles that dilate the upper airway during sleep[7]. If these dilator muscles are doing their job effectively, the airway will remain open during sleep. If, on the other hand, they respond poorly, the risk and severity of sleep apnea increases as breathing stops for longer[7].

Approximately 30% of patients with sleep apnea have poor muscle responsiveness to airway narrowing during sleep[5]. This is often due to, or exacerbated by, mouth breathing, because muscle activity of the upper airways is less during oral breathing than nasal breathing[29]. There are some fundamental differences in the muscles of people with OSA too. They tend to have poorly coordinated upper airway muscle dilation during inhalation[29,30], and their breathing muscles are not as strong as those of age and gender matched individuals without OSA[31]. Nasal breathing harnesses nitric oxide, which is produced in the paranasal sinuses. Nitric oxide plays a role in maintaining muscle tone and regulating neuromuscular pathways in the pharyngeal muscles[8]. Breathing through the nose during sleep helps to reduce all traits of OSA, including muscular control in the airways, and is possibly the single most important way to address all sleep-disordered breathing.

Treatment of Sleep-disordered Breathing

Adequate treatment of sleep disorders requires applying breathing exercises that ensure correct functioning of certain key muscles. This includes the restoration of nasal breathing, correct tongue position and adequate diaphragm movement.

The four phenotypes of obstructive sleep apnea are interconnected. For example, poor upper airway muscle activation interacts with arousal threshold and loop gain to contribute to repetitive apneas. For all of the phenotypes, practicing nasal breathing and diaphragmatic breathing with a tolerable air hunger can reduce the risk of apnea and greatly improve sleep.

To sum up, patients with obstructive sleep apnea commonly breathe through the mouth, resulting in fast, shallow breathing using the upper chest. Dysfunctional breathing during sleep affects all four phenotypes of OSA. Breathing re-education to restore light, slow, nasal breathing from the diaphragm can provide an accessible therapeutic intervention for all patients with sleep apnea, regardless of phenotype.

	Functional Breathing	**Phenotypes of Sleep Apnea**
Nasal breathing (wakefulness and sleep)	Allows correct resting tongue posture. Lower prevalence of lateral pharyngeal wall collapse. Reduces resistance to breathing during sleep. Improves biochemical dimensions of breathing. Harnesses nasal nitric oxide during sleep.	Reduces high Pcrit. Reduces high loop gain. Improves upper airway recruitment. Improves arousal threshold.

	Functional Breathing	**Phenotypes of Sleep Apnea**
Biochemical	Reduces chemosensitivity to carbon dioxide. Normalizes respiratory rate and tidal volume. Reduces negative suction pressure during inspiration. Improves activity of upper airway dilator muscles.	Reduces high loop gain. Improves upper airway recruitment. Reduces AHI (apnea/hypopnea index, the measure of OSA severity).

	Functional Breathing	**Phenotypes of Sleep Apnea**
Biomechanical	Increases lung volume resulting in stiffening and dilation of the pharyngeal airway. Increases stores of carbon dioxide and oxygen.	Reduces high Pcrit. Improves arousal threshold.

	Functional Breathing	**Phenotypes of Sleep Apnea**
Resonance frequency	Improves baroreflex function. Increases heart rate variability. Increases blood gas exchange. Reduces chemosensitivity to carbon dioxide. Improves sympathovagal balance.	Reduces high loop gain. Improves arousal threshold.

CHAPTER NINETEEN

THE BREATH AND THE SINGING VOICE

I was recently approached by a music college and asked to talk to their students about breathing. It's true that the Oxygen Advantage® breathing exercises can be applied in any situation that involves performance anxiety and peak concentration. Indeed, while the exercises in this book are mainly aimed at improving health, whatever your starting point, the same basic ideas can be used by anyone who wants to find their edge. This could be athletic performance, music, or in any other field where it's necessary to present your best work under pressure. The invitation got me thinking more specifically about singing.

Classical singers have to develop virtuosic breath control. While the biochemical, biomechanical, and psychological aspects of breathing have been widely studied in sports, much less work has been done to understand breath control in singers[1]. I was interested to see that the everyday breathing techniques I teach could be helpful to singers in protecting the voice, preparing for performance, and understanding the science behind breathing (especially if singing is something they can "just do").

In the book, *The Oxford Handbook of Singing*, Alan Watson explains that "an awareness of the basic mechanisms of respiration is an essential starting point for the singer"[1]. During quiet breathing, the lungs always contain a certain amount

of air. This is known as *functional residual capacity*. Remember the analogy of trying to inflate a balloon when it is absolutely empty of air? Lung volume is important because the amount of air expelled from the lungs represents the air that is available for singing. At the end of the exhalation, however, the lungs are not completely empty. If they were, the chest would collapse, and the negative suction pressure would make it impossible to inhale again. As it is, functional residual capacity preserves the ability of the lungs to re-inflate.

When you sing, both the in breath and out breath are facilitated by muscle activity. Exhalation in singing is much less passive than in normal breathing, because the singer must alter the volume of each breath to match the phrase being sung. Technical instruction generally focuses on the biomechanical control of the diaphragm and ribs, particularly since singing is managed on a long, slow exhalation and diaphragm control is key.

However, according to Watson, many singers and wind instrumentalists wrongly believe that the diaphragm moves involuntarily. In fact, the diaphragm is made up of striated muscle – the same type of muscle as makes up the skeletal muscles that move our joints. That the diaphragm can be consciously controlled can be demonstrated by placing your hand on your belly and pushing your tummy outwards to make the abdominal wall bulge. According to 1988 research, the only muscle that can possibly make this happen is the diaphragm[1,2]. It is important to

understand that the diaphragm contracts downwards on inhalation and relaxes elastically upwards on exhalation. It does not actually move in or out.

Watson gives a detailed and valuable overview of the principles of breathing. He explains that certain techniques, if misapplied, can lead to excessive effort in the respiratory muscles and that, without a clear physiological understanding of the breath, certain pedagogical ideas are open to misinterpretation. For instance, “elevating the chest” can be easily misunderstood to mean chest breathing.

Watson also discusses breathing mechanisms specific to singers, especially in terms of the *latissimus dorsi* muscle, the broadest muscle in the back, which is normally used in rotation of the arm and shoulder. Some singing materials suggest that this muscle may contribute to breathing during clavicular inhalation (another term for upper chest breathing), which is considered detrimental to voice production. Based on his own research, Watson states that conscious engagement of the latissimus dorsi muscle is associated with increased chest expansion – which contributes to projected singing[3]. He also details different aspects of static and dynamic posture, and the varying positions of the diaphragm and abdomen in the “belly out” and “belly in” singing techniques. His descriptions of various complex anatomical considerations underline the fact that singing requires very managed

breathing movements, and, equally, that many singers do not fully understand the breathing functions behind their choices.

The book *Vocal Technique: A Guide for Conductors, Teachers and Singers*, by Julia Davids and Stephen LaTour, also mentions the problem posed by upper chest breathing[4]. Breathing into the upper chest creates difficulty with the controlled exhalation needed in singing. As we know, upper chest breathing can easily lead to over-breathing – taking in more air than the body needs.

It might seem reasonable to assume that, if you have a long phrase to sing, you must take in as much air as possible before it. However, one 1998 study into vocal pedagogy reports that trained classical singers initiate their singing at a lung volume of 70%, rather than filling the lungs to 90 or 100%[5]. Researchers believed this is so that the elastic recoil of the rib cage and expiratory muscles can be managed. If you take in a really large breath, your initial exhalation will be fast and very difficult to control. By breathing only to 70%, the elastic recoil is reduced, and the breath can be better, more easily controlled. The same paper found that country music singers only inhaled to around 55% of their lung capacity, suggesting they would, therefore, not be able to sustain such long musical phrases as their classical colleagues[5]. The study concluded that, while evidence is lacking as to whether breathing patterns affect vocal health in singers, if teachers make

changes to the breathing habits of their students, they should focus on the factors that enhance vocal health.

While smaller inhalations make sense for controlling elastic recoil, the phrasing, tone, dynamics, and phonation all rely on efficient "metering" of exhaled air. This requires that the singer breathes out only the amount of air required to produce the desired tone. Many singers produce a breathy tone precisely because they expel too much air too quickly. In young singers, breathiness is due to vocal and muscular changes during adolescence, and exercises to strengthen the core can be helpful. Poor core strength in older singers can be responsible for poor support and "a wavering vibrato"[4]. (We have already discussed the close connection between the diaphragm, the core, and the breath across various topics.)

Davids and LaTour also caution against overfilling the lungs, a point that I have made repeatedly throughout this book in relation to the health implications of over-breathing. While singers normally breathe through the mouth, they suggest practicing nasal inhalations to slow the in-breath, then moving to inhalations using both the nose and mouth, and finally moving to mouth inhalations. In this way, you can monitor the size of the breath much more easily until you are accustomed to smaller breathing volumes. Interestingly, it is possible to use nasal inhalations when singing. One classical singer I discussed this with said that the onset of a

note is less breathy when she uses nose breathing, and she mentioned others in the profession who breathe only through the nose with excellent results.

One common practice used to learn control of the exhalation involves an “s” sound or hissing through the teeth. This exercise concentrates and reduces the flow of the breath. Another common technique involves blowing gently onto a candle flame. The flame is held eight inches from the face, and exhalation is so soft as to only slightly bend the flame, not to extinguish it. The exhalation is practiced for as long as possible and timed to assess progress. Gently blowing towards a flame allows for a relaxed, controlled exhalation. Some people use the analogy of blowing through a straw, but the perceived resistance in the example can cause muscle tension and strain that does not properly allow for a full exhalation.

Virtuosic singing certainly requires specific physical adaptations to breathing. According to 2016 research, singing involves “distinct respiratory kinematics (i.e., movements of rib cage and abdomen) to quiet breathing because of different demands on the respiratory system”[6]. The active control of the abdomen often practiced by classical singers is thought to prevent shortening of the diaphragm, elevate the rib cage, and produce sufficient pressure in the lungs (called subglottal pressure) to enable phonation. In this study, seven professional classical singers and four untrained people were assessed during quiet breathing and singing. There were no differences between singers and non-singers during

quiet breathing, but both groups adapted to the rhythmical constraints imposed by singing with decreased inhalation time and bigger breaths. The classical singers were able to substantially alter the coordination between rib cage and abdomen during singing, compared with breathing during rest. In particular, inward movements of the abdomen, which were seen in the classical singers, elevated intra-abdominal pressure in a way that may "increase the length and pressure-generating capacity of the rib cage expiratory muscles for potential improvements in voice quality"[6].

Research from 2009 describes breathing as the "intermediary between phonation, emotion, and music" and suggests that these functions cannot be sustained if the breath is viewed from a segmented or larynx-driven perspective[7]. In line with a more holistic idea of the breath and voice, diaphragm breathing exercises have been found to help people with speech disorders such as stuttering[8,9], and it is known that speech problems can be addressed by changing breathing habits[10]. Equally, music therapists have recorded instances of patients who are non-verbal or have problems speaking but are able to sing every word of familiar songs[11]. The 2009 research presents a broader concept of breathing as "consistent with the nature of singing at all levels: the technical, the interpretative, and the human."[7]

I can confidently suggest that daily breathing patterns do affect vocal health in singers and agree with the interpretation that the way you breathe will feed or starve your singing voice. Although it is universally accepted that good singing starts with “good breathing,” you don’t take your breath out of the case to practice singing in the same way a violinist takes out their violin to play. Breathing carries on, day and night, on and off the platform. How you breathe every day will affect your singing, health, and confidence on stage. This basic underlying knowledge is largely absent from the otherwise comprehensive breathing instruction given to singers.

In terms of performance, links have been found between hyperventilation and stage fright. For instance, a 2020 paper published in *Frontiers in Psychology* found a link between performance nerves and frequent sighing in music students[12]. Researchers demonstrated that, in the 10 minutes before and after performing, the students exhibited greater variance in breathing, including tidal volume, inspiration time, expiration time, and more frequent sighing. They also experienced more anxiety, tension, and breathing symptoms. Students who suffered from higher levels of anxiety demonstrated a greater difference in sighing, anxiety, tension, and breathing symptoms between practice and performance than those who felt more confident.

This correlates with research from 2011 which found that hyperventilation-linked breathing disturbances may play a role in performance anxiety prior to performance[13]. This study was followed by a paper in 2012, from the same team, which examined physiological variables, including end tidal CO_2, in 67 music students who experienced high levels of performance anxiety. It again supported the hypothesis that stage fright is linked to hyperventilation[13].

Everyday Breathing for Singers

From a simple perspective, the breathing fundamentals throughout this book will support healthy breathing and vocal health in singers. Dysfunctional breathing will affect the ability to sing:

- If you have a low BOLT score, you will have poorer breath control, your tone will be breathy, and you will be less able to sustain a phrase.
- If your breathing is fast and into the upper chest, you will not be able to control your exhalation to produce the sound you want.
- If you mouth breathe during sleep or exercise, your airways will become irritated and inflamed. Inflamed airways produce excess mucus to compensate for the dryness and throat clearing that come from mouth breathing. Mouth breathers are also more susceptible to chest infections, head colds, allergic rhinitis, and viruses. One of the best things you can

do to protect your voice is to tape your mouth at night to ensure nasal breathing.

Ideally, your BOLT score should be 25 seconds or more. This will support your singing practice by producing the following results:

- The ability to sustain a note longer
- A clearer, stronger sounding voice (One of my courses is peer-reviewed by the American Speech-Language-Hearing Association.)
- Less need to clear the throat due to more efficient breathing
- Improved functional breathing and lung volume and better use of the diaphragm
- Less breathlessness
- Less nasalization as the nasal airway is more open
- A calmer state of mind
- A more “normal” breathing volume, resulting in less fatigue of the brain and better focus (Excessive breathing during prolonged singing or talking is exhausting, because breathing “too hard” causes the body to lose CO_2. When levels of blood CO_2 fall, oxygen delivery to the brain is reduced, causing brain fog and tiredness.)

- Reduced trauma of the upper airways (Breathing too much air through the mouth draws moisture from the upper airways. This can lead to dryness and inflammation.)

Nose breathing, especially during sleep, also supports singing in the following ways:

- Nose breathing during sleep moistens, warms, and sterilizes the air. This helps protect the upper airways and the vocal cords. It is important that the upper airways recover during sleep. Nose breathing is vital for this.
- Nose breathing with a slow rate of respiration is essential for good quality deep sleep.

Healthy everyday breathing involves keeping the lips together during wakefulness and sleep, nasal breathing during rest and exercise, and maintaining relaxed jaws with the tongue resting in the roof of the mouth to maximize airway space during sleep. Conversely, mouth breathing promotes stress, anxiety, panic feelings, and poor oxygenation of the body and brain.

Your regular breathing pattern is important. Pay particular attention if your breath is audible during rest, or if you yawn or sigh regularly. One sigh every few minutes is enough to sustain a poor breathing pattern and cause low levels of blood CO_2.

As we've said throughout this book, CO_2 is instrumental in the oxygenation of the cells and tissues. It encourages good circulation and therefore promotes better concentration and alertness. It helps to maintain an open nose. Chronic mouth breathers often have nasal-sounding speaking voices due to the loss of CO_2 from the body, which causes constriction of the airways. CO_2 also relaxes the smooth muscle, and, for singers, this includes the vocal cords, which consist of two bands of smooth muscle.

You will find the exercise #3 in Chapter Two helpful in slowing down your breath. "Breathe Slow" is a great practice to use before bed or to incorporate into a meditation.

Performance Preparation Routine:

- Working to maintain a high BOLT score before performances (and in general) is always important. Ideally, it should be more than 25 seconds.
- Sleep well the night before a concert, in a dark, silent room with a good exchange of fresh air, if possible. Reduce and slow down your breathing for 20 minutes before sleep. If you have to look at a screen in the hours before bed, use glasses that filter out blue light. Tape your mouth to ensure nasal breathing while you sleep.

- Arrive one hour before the performance, if possible, and make an effort to devote some space to yourself. Steve Jobs was known to meditate prior to a speech. This is important. Conversing with many people just before a performance can result in decision fatigue and increased anxiety. Use the time before you sing to conserve your energy and to focus inwards.
- ***Find a quiet space and slow down your breathing for 20 minutes.***
- Use the "Breathe Slow" exercise #3, to slow down your breath.
- After slowing down your breathing before a performance, you will be focused but may be a little too relaxed. If so, ***practice six repetitions of strong breath holds*** (see instructions below). This will increase blood flow to the brain and make you more alert, bringing a wave of energy through your body.

Oxygen Advantage® Breath Holding

This exercise is designed to challenge the body, open the airways, and improve respiratory muscle strength. (only suitable for persons in good health)

- Breathe in and out through the nose.
- Pinch your nose with your fingers to hold the breath.
- Walk while holding the breath.
- As air hunger gets stronger, walk faster or jog lightly.

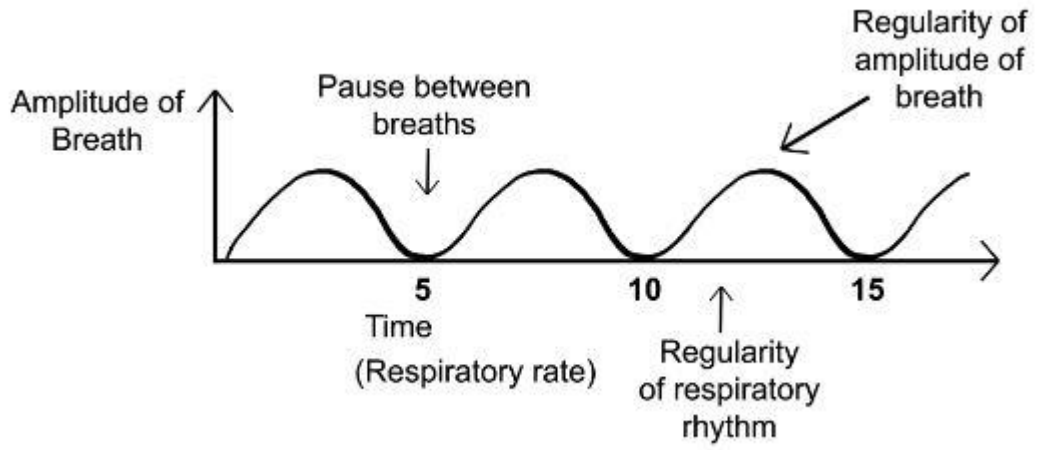
- Continue walking/light jogging and holding the breath until a medium-to-strong air hunger is experienced.
- Resume breathing with six minimal breaths in and out through the nose. When doing this, try to avoid taking big breaths.
- Breathe normally for 12 to 18 breaths.
- Repeat five to six times. Practice once daily.

CHAPTER TWENTY

ABC ADULT BREATHING CLASSIFICATION

OBSERVATION OF BREATHING	**Normal Ventilation**	**Grade 1**	**Grade 2**	**Grade 3**	**Grade 4**
Respiratory Rate per minute	10 to 12 breaths	12 to 14 breaths	14 to 16 breaths	16 to 20 Breaths	20 to 25 breaths
Regularity of breathing pattern	Regular	Regular	Relatively regular	Irregular	Rapid *Air trapping
Amplitude of breath	Normal	Normal	Higher than normal	Higher or lower than normal	Higher or lower than normal
Natural pause following expiration	2-3 seconds	1-2 seconds	1 second	No pause	No pause
Breathing Pattern	Primarily driven by the diaphragm	Primarily driven by the diaphragm	Breathing is diaphragmatic or thoracic	Breathing is thoracic	Breathing is thoracic or clavicle
Mode of breathing*	Nasal	Nasal	Oral	Oral	Oral
			Nasal	Nasal	Nasal
			Oral/Nasal	Oral/Nasal	Oral/Nasal
BOLT score*	30 seconds plus	20-30 seconds	15-20 seconds	10-15 seconds	5-10 seconds
		PREDICTED OUTCOME			
Dyspnea at rest	No dyspnea	No dyspnea	No dyspnea	Moderate	Moderate to severe
Dyspnea during light exercise (such as walking)	Very mild sensation of breathlessness	Very mild sensation of breathlessness	Mild sensation of breathlessness	Moderate sensation of breathlessness	Moderate to severe sensation of breathlessness
Expected FEV and FVC	Normal	Normal	Normal/Lower than normal	Lower than normal	Lower than normal

Interpretation of Breathing Pattern Classifications for Adults



NOTES:

A high score (Grade 3 or 4) is associated with increased breathing effort and dyspnea (breathlessness). Respiratory rate is more rapid, and the breathing pattern is irregular. Breathing may be nasal, oral, or oronasal (nose and mouth combined). The BOLT score is less than 20 seconds. The higher the grade, the more likely you are to experience periodic sighing and feelings of lack of air.

A low score (Normal Ventilation, Grade 1) indicates normal ventilation with effortless inspiratory expansion and expiratory contraction. Breathing is predominantly through the nose during rest and driven by the diaphragm. The

respiratory rate and amplitude are relatively regular. Comfortable breath hold time during rest as measured following a passive expiration is greater than 20 seconds.

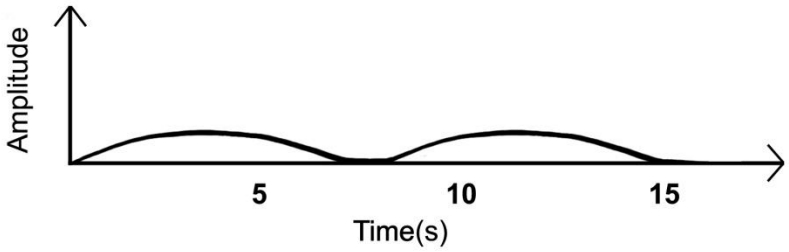
A Grade 2 score straddles functional and dysfunctional breathing.

The BOLT Score: The BOLT score refers to the number of seconds from the time of holding the breath on a passive expiration until involuntary movements of the breathing muscles are experienced.

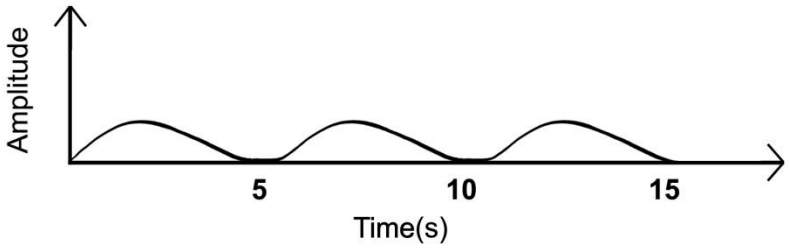
***Air trapping or hyperinflation of the lungs**: This is when expiration doesn't fully take place before inspiration begins. Air becomes trapped in the lungs with each successive breath causing the lungs to overinflate.

Expected Breathing Pattern Based on Grade

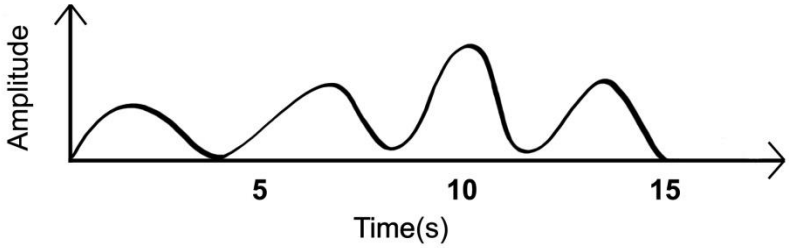
Normal Ventilation



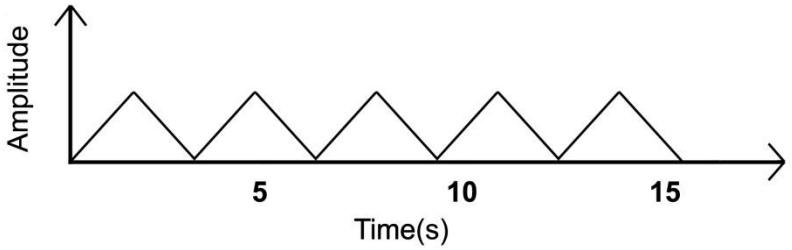
Grade 1



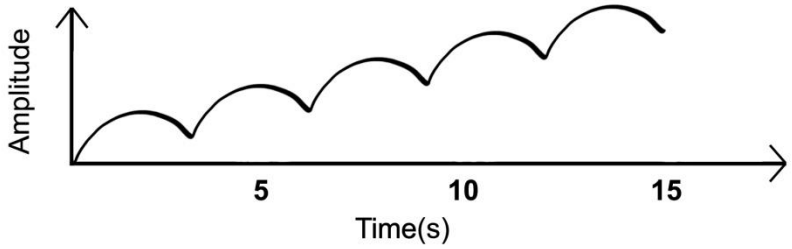
Grade 2



Grade 3



Grade 4



CHAPTER TWENTY-ONE

THE SUBTLE ART OF YOGA BREATHING

A Conversation Between Patrick McKeown and Robin Rothenberg

Robin Rothenberg is a Washington-based yoga therapist, Pranayama breathing expert and author of several books including, *Restoring Prana: A Therapeutic Guide to Pranayama and Healing Through the Breath*. She studied functional breathing with me in Ireland and integrates her understanding of respiratory science into deep research of the Vedic texts. We had this conversation in November 2019, just before the release of Robin's book.

Robin: Patrick and I met years ago when I was exploring this amazing breathing technique that completely transformed my life and changed how I thought about the breath and Pranayama. I recognized I needed to understand more about the physiology of the breath, and ended up in Galway, studying with Patrick. It was one of the most exciting weeks of education I've ever experienced. I came home ready to share what I had learned with others.

Patrick has since visited my studio twice and trained many yoga teachers and health practitioners who are interested in learning functional breathing to be better able to serve their clients.

Patrick: *I think it's a great marriage, functional breathing and yoga. Yoga often looks at the biomechanics of breathing but can neglect the biochemistry. Bringing the two together is a perfect fit.*

Robin: What I've learned in my research is that the ancient yogis understood the biochemistry. If you go back to the original texts, learning about their methodology, they clearly knew they were manipulating their chemistry, whether or not they knew it in terms of oxygen versus carbon dioxide. They knew that by increasing their Kumbhakas - their breath-hold times - they could achieve altered states of consciousness and deep stillness and quiet within.

A lot of the biomechanics around the bandhas were all about controlling the baroreceptors and chemoreceptors in order to sustain breath holds for longer and longer periods of time. Of course, I didn't understand any of that until I studied breathing physiology and then started going back and reading the original texts on Pranayama. It's clear to me that they understood biochemistry, but that was not transmitted or passed down through most of the yoga lineages, so we lost that component.

Patrick: *So, an experienced student of Pranayama would tend, inevitably, to have a long breath hold time? You would expect that you could identify an experienced student because they've been practicing slow breathing, so their sensitivity to carbon dioxide will reduce and their breath-hold time will increase. And this would originally have been the premise in yoga?*

Robin: What the premise was originally in yoga and what's happening in contemporary modern yoga are very different things. I would say this: As a long-time practitioner of Pranayama, my colleagues used to tease me because I was the only person in our group who actually practiced Pranayama. I took it very seriously because I had so many respiratory issues, and I believed that there was a nugget there for me that would help. I sought out teachers who were particularly attuned to Pranayama and knew a lot about the breath, and I studied with a teacher who is considered to be most senior in Pranayama.

What I learned was that the most important thing was to increase the length of the inhale and exhale. I developed very slow breathing where I could sustain an inhalation and exhalation for 24 to 30 seconds. I

was breathing slowly, but now I realize I was breathing a very large volume of air. That does nothing to transform the biochemistry. You're maintaining minute volume, it's just a different ratio. In the process of slowing the breath, we're increasing the volume, so we are not getting the effect that was originally intended, because we're not making the breath more subtle, we're making it more 'gross'. In all the original texts the direction is about making the breath more and more subtle so that it's imperceptible. That is the teaching. And now we have people competing for who can ujjayi the loudest and the longest, so we have people hyperventilating in their yoga classes.

Patrick: *So, what it boils down to is that the yogis understood the critical importance of carbon dioxide in combination with oxygen. When we're talking about the chemosensitivity of the body and the biochemistry, traditionally that relates to the pressure of CO_2 in the blood, which in turn is determined by CO_2 in the lungs, which is determined by the breathing. Alveolar ventilation or alveolar CO_2 will determine arterial CO_2. If the body is overly sensitive to the build-up of CO_2, our breathing tends to be heavier. We can measure chemosensitivity using breath hold time (BHT). Someone with a low BHT*

will have a high chemosensitivity to carbon dioxide, and as a result they have harder breathing, and they won't be able to sustain a breath hold for the same length of time. So, when you're talking about subtle breathing, how do you think the yogis would have described this? Do you think they would have had "air hunger" during the duration of the exercise?

Robin: I did this deep dive into the Vedic teachings, and looked at how they described the process of Pranayama, and how they determined the length of the various parts of the breath. It's actually quite comical. Things like, how long it takes to circle the knee with your finger and then listen to the cowbells chime five times and then blink – it hardly makes sense to us now, but now we have stopwatches on our cellphones so we can measure in seconds. A lot of it was very subjective, but in terms of measurement it was very clear. All the texts say the same thing, which is that the farther out you can feel your breath (with your hand/the distance of your hand from your face), the less Pranayama. Pranayama is when you can barely feel the breath with the hand close to your face, so that means the breath has to be very light and very subtle. If you breathe hard, it's going to be felt farther away.

Patrick: *Then we're talking about conservation of the breath?*

Robin: Conservation of Prana. It all comes back to Prana. I titled my book *Restoring Prana*, which was not originally what I was thinking, but as I studied deeper, and with my background in yoga philosophy and Ayurveda, and understanding something about the teachings around Pranayama, I realized the reason it's called Pranayama is because it's about restraining, containing Prana. It's about filling our vessel, making it more vital and alive. That's the intention of Pranayama, which even though I'd practiced for almost 30 years before I met you, I never really experienced. Then I got sick, and I was so depleted, and I became involved in the breathing training and I started getting the experiences that are described in the texts in relation to Pranayama. The results of Pranayama practice are an increase in energy, clarity of mind, needing less sleep, needing less food, vibrancy, and a sense of health and wellbeing. I had experienced some calming and energizing effects from my Pranayama, but they were temporary, lasting maybe half an hour after practice, and then I was back into "normal" mode. What struck me so profoundly from the first 24 hours of practicing functional breathing

was that I had this sustained quality of attentiveness, awareness and focus. I've always been a highly focused person, but this is a different kind of focus, and the internal quiet that I felt just settled me. That sustained sense of deep stillness was unlike anything I had ever experienced, and it has sustained now for going-on four years, so I think it's working.

Patrick: *Do you think that the yogis originally would have taken into consideration everyday breathing - in other words, how we should breathe during sleep, physical exercise and stress? I believe it's not just about how we should be breathing during a practice. We should be taking that information into our everyday breathing. I can imagine that many people who go to a yoga studio arrive with stress related conditions, wanting to improve their health, and they're getting the benefits inside the yoga studio, but they're not carrying those benefits into their everyday life. Do you think we're missing something?*

Robin: I'll address that on two levels. For me, personally, my teachers always stressed nose breathing when practicing. So, I was a dedicated and committed nose breather whenever I was practicing yoga,

whether I was in class or at home. But I was a consummate mouth breather every other minute of the day and night, not even realizing that my mouth was open. My teacher had never said, “Nose breathe when you’re not on your mat.” So that’s one of my big calls when I’m teaching yoga teachers. This isn’t just when you’re practicing yoga. Functional, healthy breathing is through the nose 24/7. That information definitely hasn’t been passed down.

In terms of the teachings around how to breathe for different activities, remember I was talking about the different distances of the hand from the face? One of the texts actually lists different activities including meditation, exercise and eating, and exercise and sleeping are actually the farthest out. So, they do recognize that people breathe more heavily during sleep. There was a recognition that breathing does change. However, there’s another piece that I think has also been missed in the transmission down the lineages of yoga, which is that what worked in that environment for the yogis then, because of the kind of life they were living, doesn’t work for us now. They were living in an environment where they ate only organic, local food, the water, air and soil were healthy, they had to be physically active to keep themselves

warm, fed and watered, and they weren't communicating much. They weren't sitting around talking. Their life was much quieter and simpler.

They wrote about stress, so they understood stress. The word *Duḥkha* refers to a sense of stuck-ness that can manifest on a number of levels. Whether it's mental, emotional or physical, there's a sense of not knowing the way out, of some kind of deep-seated pattern that you're stuck in. This is the seed of all suffering. If they didn't understand that, they couldn't have written so profoundly about it. At the same time, they weren't dealing with the same kinds of things that we're dealing with in our lives. What I appreciate about the insights that respiratory science brings is that it is more contemporary, dealing with people with chronic health issues in society today. The yogis were engaged in these practices all day. The achievement of the state of Samadhi (one-ness) was the goal, whereas scientists are looking at people with critical health issues and asking how they can help. We can use the breath as a tool for healing. This is a different goal and a different use of that tool, and so I think it's more relevant in some ways because it's more in keeping with what the people I work with as a yoga therapist need.

Patrick: *Dr. Buteyko saw that sick people breathe hard. He asked, was it the sickness that was causing the hard breathing, or the hard breathing that was causing the sickness. This ties into a saying I heard from yoga many years ago, that man's life is not measured by the number of his years, but by the number of his breaths. We have a limited number of breaths.*

If we look at the animal world, the animals that breathe fast have short lives, and those that breathe slowly have long lives. If we have a high breath hold time, we tend to have a slow respiratory rate. This is very important. That description you gave of the breath being measured by the distance of the hand from the face… if the objective is to breathe so light that we feel hardly any air on the hand, the person practicing is going to feel air hunger. We know that working with air hunger is a good way to reduce chemosensitivity and address the biochemistry.

It's almost like it's coming full circle. Maybe air hunger wasn't described in the texts, but the very practice of light breathing would have produced air hunger. If my aim is to slow down my breathing until I can't feel the air on my hand, I'm going to reduce my minute ventilation, which in turn is going to increase carbon dioxide in the blood, which will reduce chemosensitivity to carbon dioxide, resulting in slower breathing.

And nose breathing connects with the diaphragm, and diaphragm and slow breathing are interlinked.

Robin: Absolutely. The Pranayama ratios emphasize retention and suspension (breath holds after inhaling or exhaling) and reading the texts, retention and suspension have different chemical components.

There are four phases of the breath. Each phase has a different quality. Depending on the balance between inhale and hold-after-inhale, exhale and hold-after-exhale, you can manipulate energy. For example, inhale and breath hold on the inhale have a more energizing quality.

Patrick: *If you inhale slowly and hold your breath, it's also going to give more time for oxygen to diffuse from the lungs to the blood.*

Robin: Right. And then the exhalation is more parasympathetic, so an emphasis on the exhale is the most common orientation towards Pranayama in the world of yoga. Hold after exhale is considered to be the most stilling, calming and quieting. If people are stressed out, slow exhalations are going to bring immediate calm and bring them off the limb of the tree they're hanging from. Short term, that's useful. But

what's missing is the integration of how they were breathing before. If someone is a chronic hyperventilator, and long exhalations are their primary mode of Pranayama, that's going to exacerbate their hyperventilation, which is what happened to me.

Patrick: *Sometimes I think there's such a myth out there about breathing - that we must bring in as much oxygen as we can and get rid of as much CO_2 as possible. Breath holding after exhalation is going to increase CO_2 in the blood and allow oxygen to be released more readily from the red blood cells to the cells. Even the slow inhalation is allowing a pooling of nitric oxide inside the nasal cavity. If you're really breathing slowly, nitric oxide is coming from the nose into the lungs, helping to redistribute the blood throughout the lungs, which in turn increases the pressure of oxygen in the blood.*

Some of this stuff is relatively new to science, even though the yogis knew about it. The fact that nitric oxide is produced in the sinuses around the nose was only discovered in the 90s. In 1988, the researcher, Swift, found that when people were forced to breathe nasally after jaw surgery, when their jaws were wired shut, the pressure of oxygen in the blood increased by nearly 10%[1]*. Very few people realize that. I was a*

mouth breather for 20 years, and none of my health professionals ever said to me, "Patrick, breathe through your nose." Most people think that breathing is just one of those things that is simple - but it's not so simple. The science is still just catching up. Even though the functions of nitric oxide in sleep are understood, it's still not fully known what it does.

Breathing, the emotions and sleep all go together. If you have a poor night's sleep, your mind is more likely to be agitated during the day. If your mind is agitated, your breathing is agitated, and unstable breathing affects your sleep. Each one feeds into the other, like three sides of a triangle.

Robin: That's been my orientation towards teaching people - educating my colleagues and peers about this - to look at the primary breath myths. For instance, some people think that CO_2 takes up space that would otherwise be occupied by oxygen, so we have to get rid of it all. I'm dispelling those myths. But every single one of the myths I address in my book is something that I actually taught and passed on before I knew better.

There's this word in yoga, *Avidyā*, that means not knowing, and it's considered to be the seed of all of the Duḥkha, the suffering that we

experience. Underneath our suffering is the fact that we really don't "get" what's going on. Avidyā manifests in a variety of different ways, such as our ego, attachments, aversions and fears. All of these distort our ability to see what is. In some ways my book is a confessional of my deep Avidyā around the breath and my arrogance in believing that I knew, because I had studied with these incredible teachers – for whom I have great respect - but I didn't realize this Avidyā was being passed down.

Patrick: *I wouldn't call it arrogance, and I admire that you realized there was more information than you'd been taught. How many occupations, professions, and instructors are so closed to hearing new information? It's likely that your own health condition was a blessing in disguise, because it forced you to look into different means.*

I remember, when I was reading your book, that you quote the work of the Italian cardiologist, Luciano Bernardi. He looks very much at the cadence of breathing. So, when you're talking about breathing in the book, you're not just talking about the biomechanics. It's not enough to emphasize diaphragmatic movement. We also need to look at the biochemistry, which we've spoken about with the roles of carbon

dioxide, and the cadence too. It's a question of bringing the three things together.

Robin: It's also the psycho-emotional aspect. In yoga, the breath is directly connected to the mind and the emotions. In fact, all of the unilateral nostril patterns in yoga specifically target different psycho-spiritual and emotional factors, and are directly related to the chakras, and all the teaching around the chakras. Breath and mind are not separate.

In yoga teaching, there are five dimensions to our manifest being: the physical body, the energetic body, the mental body, the deeper emotional, or character "knowing" body, and the spiritual body. In the teaching, they are not five separate things, they are all inter-related. The word that is used to describe them is "*panchamaya*." *Pancha* means five and *maya* means interpenetrating or pervading dimensions. Just as you can't identify the emotional part of a cell or separate the mental from the physical, it's all one. There's a constant informational relay going on between these dimensions, and so, if I get stressed about something my body tenses and my breath accelerates. The practice of yoga is brilliant, because it gives all these different doorways into transformation. If you

come to class and move your body differently, you're going to feel different. If you breathe your body differently, you're going to feel different. If you *think* your body differently, you're going to feel different. Any one of these doorways in will transform the whole.

Patrick: *When you look at the dimensions that you spoke about, we can influence blood circulation by slowing down the breath with a slight air hunger and we feel warmer. We can also increase oxygen delivery to the cells. We can decongest the nose using breath holding. We can open up the lower airways, increase blood flow to the brain, switch the body from a parasympathetic to a sympathetic state and back again, stimulate the baroreceptors, help restore normal autonomic functioning, and increase RSA, HRV and vagus nerve traffic. It's really amazing the power, when you bring all of these dimensions of breathing together. But Robin, nobody is doing this. Why? Why have people just emphasized one dimension of breathing and forgotten about the other dimensions?*

Robin: I don't know. My lineage goes back to Krishnamacharya who is considered one of the greatest yoga masters in contemporary

time. He trained Pattabhi Jois, BKS Iyengar, Indra Devi and his own son, TKV Desikachar. All of these people went on to really promote yoga in the west. Many of the major schools of yoga have come from people who studied with him. I posed this question to someone who studied with Desikachar, Krishnamacharya's son, and she said that what became apparent was that it was so hard for westerners to breathe at all. Krishnamacharya adapted, and said, "Let's just get these people breathing." He aimed to get his students breathing in a steady cadence, putting a little more emphasis on exhalation. They weren't even in a place where they could do breath holding.

Patrick: *So really, just getting them out of their mind and onto the breath, using the breath as a meditation, as mindfulness, and connecting with the body as well?*

Robin: Exactly. I think there are a couple of things. One is that this was an idea, but it didn't get developed to circle back and take people further into those deeper states. People are busy, they don't have a lot of time, there's all that.

The other thing is, you and I both know that, for anyone who's actually done the practice of reduced breathing and breath holding, initially, especially if you're a big over-breather and have a high ventilatory rate, it's not comfortable. It doesn't feel good. It's like portion control, like going on a crash "air diet." There's a lot of discomfort. If people have had trauma, or any kind of experience with drowning or suffocation, it triggers all that emotional stuff, anxiety, panic attacks… And I don't want to scare anybody away, but it's a process.

There are ways and means of calming the mind. In yoga there are lots of great tools like *mantra* and *mudra*, which can help people through that initial stage - through that transition - where they become acclimatized and they're able to relax into the lesser breath. I think that also becomes a barrier. If people aren't fully trained in how to adapt and fine-tune the practice, it becomes very cumbersome. For instance, how do you teach a group of forty students in a yoga class?

Besides, making all that noise and those big breaths, it's really dramatic, right, and it feels like you're doing something. You inflate the lungs and puff up your chest and it's a dynamic experience. We're not trained to appreciate the subtle, but yoga across the board is all about

becoming more and more subtle. It's about needing less from "out there", being pulled less into externals, and being more and more at home and comfortable with the inner silence of our own essence. That is the state of meditation.

It's very clear that the way the yogis listed the eight limbs of yoga - going from how we interact with people, to how we live in our bodies, breathe and relate to our senses, to these deeper states of focus and meditation, and ultimately *Samadhi* enlightenment - that we have to get quiet and still, and be less engaged "out there" in order to achieve those deeper states of consciousness. Unfortunately, I do feel like, somewhere along the line, we started turning the wheel the other way and making yoga about, "Look at what I'm wearing and look at the poses I can put myself into." None of that is what yoga is about. It's very understated. It's very undramatic.

Patrick: *It was interesting what you said - that when we practice reduced breathing, we generate air hunger, and that can be a bit challenging for some people. We can always change that - and we can always tailor it - and that's one of the beauties of this method. We can measure the response of each individual with the BOLT score. We can*

also assess them, and if the air hunger is getting too much, we can ease off. I think it's about giving people a teaspoon of air hunger. From a psychological perspective, the great thing about giving a teaspoon of air hunger is that for people with panic attacks, or who've had drowning experiences during childhood, this can really help condition them away from that fear of suffocation. Some people have an overly strong fear of suffocation, and we can change that.

I'm really interested in how you are tying this in with yoga. If a yoga instructor is guiding their students through a particular set of postures, and they are encouraging their students to take big breaths, is it possible to change that to integrate functional breathing patterns? Can you bring breathing from a biomechanical, biochemical and cadence perspective into an existing yoga structure?

Robin: I've spent the last several years developing ways of doing that. The first thing is to give people some ideas about how to get their breath quieter and more internal. The biomechanical, abdominal/ diaphragmatic aspect is bigger, I think, than most people realize.

One of the many surprising things that happened to me when I was researching my book is that I fell in love with the diaphragm. I was

blown away when I started studying what the diaphragm conducts with its movement, with the heart literally right on top. The heart and diaphragm are connected through the fascia. There's no separation between the diaphragm and the pericardium around the heart - it's one piece of fabric. As the diaphragm moves, it's literally massaging the heart. Then you've got all the visceral organs underneath, you have the vagus nerve coming through, the vena cava, the aorta, the lymph system. Everything there depends on this movement of the diaphragm. In order for the diaphragm to move well, we have to be breathing biomechanically in a functional way, which means abdominal/diaphragmatic breathing, because the abdominals work synergistically with the diaphragm. When the abdominals contract, the diaphragm relaxes, and when the diaphragm contracts, the abdominals relax, and so they work in tandem together to get that nice visceral pump for every system in the body.

Patrick: *It's relevant to intra-abdominal pressure and lower back pain too.*

Robin: Exactly, because the diaphragm is a primary stabilizer. It's part of the inner core, working with the transversus abdominus, the pelvic floor muscles and the multifidi. They all work together, if they work well together.

I looked at a lot of the biomechanical studies examining functional movement and functional breathing, and there's a lot of correlation. People who chest breathe, which means they are not abdominal/diaphragmatic breathing, are also much more vulnerable to back pain, neck pain, fascia issues and dysfunction in their pelvis. There's a correlation. Of course, there's also the vagal response, so that's keeping the nervous system in a nice equilibrium.

Patrick: *If you look at Bordoni's research, the diaphragm also seems to be connected with the emotions.*

Another thing is, many disciplines - physiotherapists, physical therapists, speech and language pathologists - talk about diaphragmatic breathing, but I think they sometimes fail to consider the importance of nose breathing. Do you think you can adequately achieve diaphragmatic breathing if you continue to breathe through an open mouth?

Robin: No. There's a direct correlation between nose breathing and diaphragm breathing. You can breathe diaphragmatically through your mouth but it's not as impactful or effective. If somebody is a chronic chest breather, diaphragm activation has to be consciously created until it is integrated. You have to recruit and condition the abdominal muscles to synchronize with the diaphragm, and with the breath. There are studies demonstrating that the best pelvic floor muscle exercise is abdominal/diaphragm breathing in synchronicity. If the diaphragm and abdominals are working well, the pelvic floor will automatically sync with the diaphragm and work in an efficient and effective way. If you're not breathing well, not only does it cause tension in the neck and shoulders, it also creates dysfunction in the pelvic floor. So, they go together, and that goes with mouth breathing as well.

Patrick: *I suppose breathing is going to trump everything. If breathing is dysfunctional, other systems will be made secondary to assist with breathing, because ultimately breathing is paramount in the sustenance of life.*

I think sleep is also getting a lot of attention at the moment, and breathing is going to play a huge role in sleep medicine in terms of

snoring, obstructive sleep apnea and upper airway resistance syndrome. These disorders are relatively common in the United States and in Western countries. Sleep disorders affect 9% of women and 26% of men aged between 30 and 49. When women hit 50, it triples to 27%, and in men it increases to 43%. Poor sleep quality plays a huge role in the generation of diseases, for example, diabetes and dementia are linked with sleep problems. Have you noticed that when you get your students breathing through their noses, they see a difference in their sleep?

Robin: Absolutely. I experienced it myself, and it's often the first thing my students and clients come back with - that they're sleeping better. That has been consistently true, even when I taught the old way of Pranayama, with more focus on slowing the breath down and increasing exhalation. That already helped people get to sleep and relax. All of those Pranayama techniques that involve calming the nervous system and creating more of a parasympathetic vagal tone are going to help people let go of what's going on in their mind, and that helps with sleep. I think it is the *quality* of sleep that is the biggest change with nose breathing. Less getting up and having to pee, less midnight waking and more of a

sense of feeling refreshed and rested. Not just going to sleep more easily, but also staying asleep, deeper sleep and more effective sleep.

Patrick: *Because people with breathing pattern disorders who breathe fast and hard generally breathe through an open mouth... You can imagine the cohort of people going to yoga studios - people over 40 years of age are six times more likely to spend at least 50% of sleep time breathing through an open mouth. I often use the example that if you wake up with a dry mouth in the morning, you're not getting full, restorative sleep.*

It's interesting what you said about the emotions, that you've been using Pranayama and activating the parasympathetic response in order to ensure that people do go to sleep. Any of us who have had a stressful day find it hard to switch off, and if the mind is agitated we are more likely to be twisting and turning. I have a relatively calm temperament, but my sleep can be affected. Now, how about people who are prone to anxiety? They will have a hard time switching off. That's impacting their sleep. If you look at the people who are prone to breathing pattern disorders, it's 9.5% of the normal population, 30% of the asthma population (according to the literature, but we would say it's a lot more),

and 80% of people with anxiety. Cognitive behavioral therapy really works for people with anxiety. But in terms of addressing the big picture, the elephant in the room in my opinion is the breathing of people with anxiety, and their sleep. Where this will be very interesting in terms of yoga is incorporating slow breathing with air hunger - changing the biochemistry and cadence and restoring nasal breathing - for the individuals who are seeking out yoga for stress, anxiety and depression.

Robin: A lot of the people I see as a yoga therapist have anxiety and depression. They're in chronic pain, so it's hard to know which came first. Some lead with their structural or physical health issues. Others come because of their anxiety and depression. Regardless, I always teach them functional breathing, which means a softer, reduced, gentler cadence, taking them in the direction of reduced breathing, and introducing short breath holds to get them having that experience.

I think that the other thing that yoga brings to the conversation is that if people are stressed all day, their body is in a state of contraction, and this is going to affect the breath and the mind. One of the assignments I give my yoga therapy students when they are in the program is that they have to develop a "pocket" insomnia practice. The

idea with yoga therapy is that we're customizing for an individual. I want them to think through a physical sequence, a breathing practice, a mental practice, how to incorporate lifestyle, sleep hygiene, and really look at the whole picture to get them back into a good sleep rhythm, because nobody can heal without sleep. That's the bottom line.

Patrick: *I would agree. There was a really interesting paper published in 2018, looking at people with obstructive sleep apnea, and which group of people had the highest risk of mortality. The individuals with low arousal threshold (see Appendix One) - light sleepers - came out with the greatest risk of mortality. I was shocked. I was expecting it to be the man whose breathing was stopping for a minute and a half, but it wasn't him. It was the people with mild to moderate sleep apnea. And really, it comes back to your point – can people really get better, health-wise if their sleep is sacrificed?*

Often, you'll see people going to their doctor with depression and anxiety, and they're also exhausted. All too regularly, I think the healthcare professional assumes it is the depression and anxiety which is causing the exhaustion. But maybe we should be asking the question, is it

poor sleep quality that is causing the exhaustion? Is the exhaustion increasing anxiety? And is prolonged anxiety leading to depression?

Today's modern society is a little bit crazy. It's go, go, go, and we're expected to function to the height of our abilities. We cannot function if we don't have good breathing, and we can't function if we don't have good sleep. If we can't function, of course mental health is going to be affected.

Robin: Along with that, people are spending most of their lives sitting. They sit at their computers, they sit in the car for long commutes, they come home and sit and watch TV. They're not moving. We used to move to live.

I always go back to, what were these bodies designed for? They were designed to walk, lift, haul, dig, maneuver and harvest. We were not designed to sit all day, and there's an impact that affects our psychophysiology.

When it comes to breathing, if people are not moving, what happens to their CO_2 levels? The more we move, the more CO_2 we have, so if people are in pain, sick or tired all the time, they're going to be more lethargic and feel less like moving. The less they move, the harder

they breathe - the harder they breathe, the less they'll sleep - and it just goes on and on from there. Then we eat carbs to get a boost of energy, and that accelerates the breathing and affects our weight and mental capacity. It's got to be looked at as a whole.

Patrick: *Many people who really need to exercise won't do it because they feel too breathless and it's too exhausting. So, what you could be doing is teaching them reduced breathing to increase their blood circulation, increase oxygen delivery and reduce chemosensitivity of the body to carbon dioxide, which in turn increases breath hold time (BHT). BHT is a measure of breathlessness. With a higher BHT you can exercise more easily, and it is more enjoyable. I would say that people will do something if they enjoy it more.*

Pain perception is another aspect that is interesting in terms of its connection with the diaphragm. Pain reduces when we breathe in and hold the breath, so an inspiratory apnea reduces pain. I remember reading a paper by James Bartley who's an ENT doctor, about temporomandibular joint disorder. He was talking about increased muscle fatigue and lactic acid because of reduced oxygen getting to the cells. The hydrogen ion coming from the cells doesn't get oxidized to

form water, so it forms lactic acid. So really, it's a vicious circle. Everything is connected.

Robin: Going back to the brilliance of the yogis, the more I learn, the more in awe I am of their capacity to put all of these pieces together. They were scientists. We as yoga teachers and therapists need to take that on as part of our lineage. We have to be scientists, and be willing to investigate, and not just take things as given. We should never just think, "My teacher said," but really constantly evolve and educate ourselves.

Asana and Pranayama were put together. You do this conscious movement with breathing, intentionally. This goes back to the question about how yoga teachers take this into their classes. When I work with my students to bring this in, we begin by just getting more aware of abdominal/diaphragmatic breathing, breathing less and targeting the biochemistry. Then, we start with simple, small movements that aren't particularly taxing, and keep the breath settled. If the breath starts to get excited, we must be willing to pause, wait for the breath to settle and then begin moving again. We gradually progress into bigger movements - movements that tend to accelerate the breath more - working to keep the breath light and silent.

Patrick: *So, you're maintaining subtle breathing?*

Robin: Be willing to settle the breath. And I have to say, my therapeutic students - and these are people who can't take a regular yoga class because they have some kind of limitation - they are all awesome breathers, they are feeling better and they like coming to the class because they feel the energetics of the experience as well as the physical benefit. They feel the energy of how breathing has made a huge difference in their experience of the yoga practice.

Patrick: *For transformation of health, can you imagine if yoga instructors throughout the world (and this is not a criticism of yoga, I'm not a yoga person, so I'm looking from the outside in) were to bring in a breathing technique that encompasses all three dimensions, which can be incorporated seamlessly into postures, not just for the people who are sick, but for the people who are healthy? It could be transformative in terms of the power of influencing blood circulation, increasing oxygen delivery, and for people with asthma and sleep problems. There's something that could be massive here. We've been working with*

thousands of people, and there are only a few of us. Imagine if this were embraced by the yoga community. Especially considering that a lot of it originated from yoga.

For instance, my teacher, Dr. Buteyko. If you look at the older textbooks from the Buteyko method, a lot of his work came from Eastern medicine and from the Eastern yogis. He was a medical doctor, so he was able to apply the science and his medical training to what the yogis had understood. It's literally transformative.

I am often a bit discouraged that someone might go to a yoga studio, and the students are being told to take deep, full, big breaths in the belief that it's going to increase oxygen delivery to the tissues. If we look at the science, it doesn't happen that way. If we take full, big, deep breaths and increase the minute ventilation, if we increase the volume of air beyond what it should be, or beyond what we normally breathe, we get rid of too much carbon dioxide. This causes red blood cells to actually hold on to oxygen instead of releasing it.

By having subtle, soft, slow, light breathing, while also maintaining the biomechanics, you're increasing oxygen delivery to the cells. This is where it's going to transform health. If this were embraced by the yoga community worldwide, it would create a revolution, because

there are only a few breathing instructors, but there are thousands of yoga teachers.

Robin: There are millions of us. I think in the United States there are something like 20 million people practicing yoga.

Patrick: *It would absolutely transform it. I would say to anybody who's teaching breathing, learn just a little bit about the basic physiology. Look at the Bohr Effect.*

Actually, we should talk about Bohr for a moment. Christian Bohr was a biochemist from Denmark. In 1904 he wrote that the partial pressure of carbon dioxide plays an important role in human physiology. When there's an increase of carbon dioxide in the blood, blood pH drops and the affinity of hemoglobin for oxygen reduces. Hemoglobin is the main carrier of oxygen in the blood. In fact, 98% of oxygen in the blood is carried by hemoglobin. But the catalyst for the release of oxygen from the hemoglobin to the cells is carbon dioxide.

Ultimately, you could nearly call carbon dioxide "Prana." By conserving the breath, you're conserving carbon dioxide. CO_2 *is accumulating in the blood, and the body is very sensitive to it, because*

the primary stimulus to breathe is CO_2, not oxygen. We have to bear in mind that hard breathing is getting rid of CO_2. If we were to believe that this hard breathing is increasing body oxygenation, the truth of the matter is that it's actually doing the opposite.

I'll give you an example from before I learned about the breath. I was doing an exam at the University in Dublin, and I was highly anxious before this exam, because, as a mouth breather and poor sleeper, I had dreadful concentration. So, because I thought breathing "big" was good, five minutes before the exam I went for a walk, and I literally took these big, really hard breaths, thinking I was flooding my brain with oxygen. I went into the exam hall dizzy. Little did I realize that the big breaths were getting rid of so much CO_2 from the blood, that the blood vessels to my brain were constricting. I went into the exam hall lightheaded, when my aim was to have good concentration. I can imagine that a lot of people in the Western world with the belief that it's good to take big breaths, are ironically breathing hard to bring in more oxygen to the cells. The opposite is happening.

Robin: Exactly. I know that you do a lot of work also with professional athletes, training them, using the same techniques to increase their aerobic capacity and performance time.

I have a funny story like yours. I took my daughter to this spa down in California, and there were all these exercise classes. We both love to work out and she knows my deal, so when she's in class with me her lips are sealed. We had this instructor who was like your nightmare bad P.E. teacher. She kept yelling at us to open our mouths to increase oxygenation. So, we're back there, lips sealed, doing the class - which is a high-intensity aerobic work-out - and the teacher was really eyeballing me: "Open your mouth."

After class, we went out into the cafeteria and there was a cluster of people around this woman who was seeing stars. I had her do some short breath holds. She was hyperventilating. It's so important to keep your mouth closed when you exercise.

Patrick: *Yes totally. The science is only starting to catch up with what we've been saying for years. There was one paper by an American academic, George Dallam. He's a triathlete as well, and he's been nasal breathing during sport for a number of years and seeing the benefit of it.*

He trained ten recreational athletes to only breathe through the nose during physical exercise, and then he tested them nose breathing versus mouth breathing. After six months, when the body had made adaptations, CO_2 in the blood was higher, but the athletes didn't feel the air hunger. These athletes were able to attain 100% of their work-rate intensity with 22% less ventilation by breathing through the nose. This is why, when I was writing an article for the UK fitness magazine, Men's Health, I was talking about the stupidity of mouth breathing during exercise. If you were told that mouth breathing was going to reduce oxygen uptake in the blood and oxygen delivery to the cells, you wouldn't do it. That's really what happens. With nasal breathing, you're able to increase oxygen uptake and delivery to the working muscles. The benefits far outweigh the challenges.

I can understand why people switch to mouth breathing, because the air hunger while breathing through the nose can be a little bit taxing. But this is where we need to stick with nose breathing, and let the nose dictate the intensity of physical exercise until it becomes a habit.

Robin: For me, it was a huge shift. I live on a steep hill. When I leave the house, I either go down the hill and come back up, or I go up

the hill and come back down, but there's no "flat." I've been walking this hill for over 25 years and not thinking about it. Then I learned functional breathing, and I was being told to take it into exercise and movement. So, I take off, and I go up my hill, thinking I'm good and my BOLT score is up. With my mouth closed, I got barely 300 yards up the hill and I was bent double and gasping. It took me two weeks of walking really slowly (sometimes I felt like I was walking backwards!) stopping if I felt I was going to gasp, keeping my mouth closed… And then within ten days or two weeks, I was able to head out the door and up the hill, and I walked faster with a feeling of lightness in my body that I've never experienced. My mouth is closed the entire time. I get up to the top of the hill, come back down and I'm like, "Who the heck are you?" Peter, my husband, calls me a gym rat now, because I want to exercise all the time, and I never wanted to exercise before. I didn't even realize my lack of breath capacity was holding me back. Now I love it. I stay longer, and I do all my exercise with my mouth closed. I'm healthier, I have more endurance and I'm stronger. I'll never be an athlete or run a race…

Patrick: *It's not about that. It's about energy. It's about quality of life, really.*

Robin: Exactly. It's increased my quality of life because I can now exercise. I put this in my book, even though it's a little bit provocative, but I think many people like myself who were not ever conditioned or felt like we could do sport or exercise, were drawn to yoga because it was a way of moving that didn't tax us like cardio-aerobic exercise does. And yet, you get benefits. However, if we do yoga in the tradition of Pranayama, the way it was supposed to be done, and weave that into our Asana practice, we can move very vigorously, strongly, "bigly" and keep our breath low, and actually get similar benefits on an anaerobic level. Unfortunately, what we're doing now is what you describe. We're having people do this big breathing in Asana class, so they're diminishing their oxygen, and not getting the full benefit of yoga that was intended.

Patrick: *I think it's a nice way to bring it full circle and draw our conversation to a close. The power of this is enormous. Your book is putting information out there which I would encourage anyone who is working in any way with the breath to read. I think the information is absolutely invaluable. It may open your eyes. Some of the information*

might be a little bit different to what you've believed, but I think if anybody really wants to improve their knowledge and the application of simple breathing techniques and incorporate it into their way of work, I highly recommend reading Restoring Prana. It's going to be transformative for a population that is ever-more reliant on pharmaceutical intervention, and not living the quality of life they should be. It's going to transform the experience for people practicing yoga, in terms of the changes to breathing, body oxygenation, blood flow, stimulation of the baroreceptors and restoration of the autonomic nervous system. The potential here is enormous and I don't think we've fully realized it.

Robin: I really encourage yoga teachers to step up and become informed about respiratory physiology. It's the foundation for Pranayama, and if we're teaching Pranayama without that, we're really the blind leading the blind, and it puts people at health risk, including ourselves. I speak that from the inside. I did it for years, and I don't recommend it.

This is also relevant for physical therapists, physiotherapists, myofunctional therapists, dental hygienists, and speech and language

pathologists. The hazards of mouth breathing are starting to become more known in the worlds of dentistry and sleep, and so this feels like a tipping point in a variety of areas.

Patrick: *I would agree. Breathing has really changed. In 2002, not so many people knew about breathing and the methods we're using. I've noticed that, since 2015, the awareness has increased. Two topics are hot at the moment - breathing and sleep - and we can impact both of them.*