The Science behind High Performance Breathing Technology and
“The Oxygen Advantage”

This educational module has been prepared for you to review the science behind High Performance Breathing Technology (HPBT) in a quick and easy manner. For those of you that want a more in-depth view into the science, I have provided you with the appropriate information so you can find the studies on the internet or Pub Med. HPBT is scientifically researched with multiple overlapping studies published in prestigious medical, sports and physiologic journals to verify, confirm and essentially prove our protocols. Your athletes are assured that hype, sales pitches or anecdotal results will have nothing to do with HPBT performance outcomes.

Some of the cornerstones of elite level athletics are muscle balance, proper breathing, quality sleep, endurance, mental acuity, speed and endurance. HPBT is able to impact all of these essential topics by touching on each and every one of them in a significant manner. HPBT doctors examine all clients first to evaluate for any pathologic breathing patterns. If dysfunctional breathing is determined, HPBT has developed a referral source for quality medical care to correct any issues. This step essentially sets the table for the athlete to be able to take full advantage of the second phase of HPBT, “The Oxygen Advantage”, or simulated high altitude training at sea level. By altering breathing, blood oxygen saturation is lowered to between 80% and 90%. At the same time, a hypercapnic response is generated to further increase hydrogen ions. Both effects greatly disturb blood acid base balance causing the body to make adaptations to delay the onset of fatigue. These exercises are simple, safe and highly effective.

When reviewing this literature consider the impact of what you might think is an insignificant issue, such as the improper placement of one’s tongue at rest, and how through a
cascade of events a competitor’s muscle balance, sleep, endurance, stamina and mental acuity are negatively impacted.

For any questions you might have feel free to email Dr. Denbar at dr.denbar@highpbt.com or Patrick McKeown at Patrick@OxygenAdvantage.com

Thank You,

Martin Denbar, DDS
Patrick McKeown M.A (TCD) FRSB
Gregory Carter, MD PhD
David Craig LAT ATC
Mark Andrew Zwartynski
Click on the links below to read the science

Addresses dysfunctional breathing patterns at rest:

- Improve oxygen delivery to working muscles
- Reduce oxidative stress and risk of injury
- Measure and reduce breathlessness during physical exercise
- Address mouth breathing and forward head posture and their effects on respiratory biomechanics and exercise capacity

Simulate high altitude training:

- Improve anaerobic capacity
- Increase EPO and improve aerobic capacity
- Improve respiratory muscle strength
- Improve running economy
- Improve swimming performance
- Improve sleep for better focus and concentration
- Help prevent exercise induced asthma
Improve oxygen delivery to working muscles

The Importance of optimal breathing to improve oxygen delivery to working muscles (1) The entire premise of addressing dysfunctional breathing is based on the Bohr Effect. Christian Bohr, a Danish biochemist, won the Nobel Prize in 1903 for his discovery that “the lower the partial pressure of carbon dioxide (CO2) in arterial blood (paCO2), the greater the affinity of hemoglobin for the oxygen it carries” (read more here)

In other words, the lower the partial pressure of CO2 in arterial blood, the lower the amount of oxygen released by hemoglobin to cells for production of energy.

This discovery was named ‘The Bohr Effect’.

Restated – it is CO2 that determines how freely oxygen (O2) is released into the cells for energy production. So, rather than O2, it is CO2 that is the limiting factor in respiration potential.

The role of CO2 in the Bohr Effect occurs via its role in altering blood pH. The optimal pH for uptake of oxygen from inspired air by hemoglobin in the lungs is 7.45, while the optimal pH for release of O2 by hemoglobin into cells in arterial blood is 7.35. Therefore a drop in pH, or increase in acidity, is required between O2 being taken up into the blood in the lungs and being released into tissue or cells.

The presence of CO2 in our lungs, and subsequently our arterial blood, allows for this change in blood pH by being converted into carbonic acid in the blood. The
minimal partial pressure of CO2 required in arterial blood to allow optimal release of O2 by hemoglobin into cells (at pH 7.35) is 40mmHg. In order to achieve this minimal partial pressure of 40mmHg we need to have a residual store of 5% CO2 in our lungs after exhalation. This residual storage of CO2 in the lungs then permeates back into the arterial blood to affect the drop in acidity to 7.35 for optimal release of O2 into our cells.

**So how do we ensure we maintain this storage reservoir of 5% CO2 in our lungs to enable optimal release of oxygen to the cells?**

**By breathing a physiologically correct volume of air, of which nose breathing during wakefulness is vital.**

The following studies show that nose breathing activates the diaphragm and increases arterial oxygen uptake. The benefits of nasal and diaphragmatic breathing include activation of the parasympathetic nervous system and reduced oxidative stress.

Habitual mouth breathing during rest can be a red flag that signals the need to investigate and correctly diagnose the source of symptoms. The observational skill of dental clinicians can be key in identifying potential signs of mouth breathing, and can help initiate a vital first step toward correct diagnosis and effective treatment.

[http://usprofessional.gumbrand.com/media/assets/EBriefJune2014.html](http://usprofessional.gumbrand.com/media/assets/EBriefJune2014.html)
Diaphragmatic amplitude and accessory inspiratory muscle activity in nasal and mouth-breathing adults: A cross-sectional study

Mouth breathing is considered an abnormal and inefficient adaptation of breathing mode and it may induce functional, postural, biomechanical and occlusal imbalances. Mouth breathing reflected on lower recruitment of the accessory inspiratory muscles during fast inspiration and lower diaphragmatic amplitude, compared to nasal breathing.


Nose breathing imposes approximately 50 percent more resistance to the air stream in normal individuals than does mouth breathing, resulting in 10-20 percent more oxygen uptake.
Cottle, 1972: Rohrer, 1915

Nitric oxide in the nose and paranasal sinuses--respiratory tract physiology in a new perspective.
The discovery of surprisingly high concentrations of NO in the nasal airway and paranasal sinuses has important implications for the understanding of airway physiology.
Tidsskr Nor Laegeforen, 1999 Nov 10; 119(27)

Comparison of maximal oxygen consumption with oral and nasal breathing. During exercise, nasal breathing causes a reduction in FEO2 (fraction of expired air that is oxygen (O2%)), indicating that on expiration the percentage of oxygen extracted from the air by the lungs is increased and an increase in FECO2, indicating an increase in the percentage of expired air that is carbon dioxide. Morton, King, Papalia 1995 Australian Journal of Science and Medicine in Sport 27, 51-55

Mouth breathing: Adverse effects on facial growth, health, academics, and behavior
Nitric oxide inhaled via nasal respiration has been shown to increase oxygen exchange efficiency and increases blood oxygen uptake by 18%, while improving the lungs’ ability to absorb oxygen. Growth & Development 2005
Reduce Oxidative Stress and risk of injury

**Diaphragmatic breathing is relaxing and therapeutic, reduces stress.** Results demonstrate that relaxation induced by diaphragmatic breathing increases the antioxidant defense status in athletes after exhaustive exercise. These effects correlate with the concomitant decrease in cortisol and the increase in melatonin. The consequence is a lower level of oxidative stress, which suggests that an appropriate diaphragmatic breathing could protect athletes from long-term adverse effects of free radicals.


**Diaphragmatic breathing reduces postprandial oxidative stress.**

**Diaphragmatic breathing reduces heart rates** (p<0.01), **increases insulin** (p<0.05), **reduces glycemia** (p<0.01), and **reduces free-radical production** as indicated by the higher antioxidants levels (p<0.05).

Diaphragmatic breathing, likely through the activation of the parasympathetic nervous system, increases insulin, reduces glycemia, and reduces reactive oxygen species production

Measure and reduce breathlessness during physical exercise

As far back as 1975, researchers noted that the length of time of a comfortable breath hold served as a simple test to determine relative breathing volume during rest and breathlessness during physical exercise.

The ideal comfortable breath hold score (BOLT) for a healthy individual is 40 seconds. In the book entitled *Exercise Physiology: Nutrition, Energy, and Human Performance* by William McArdle and colleagues, the authors observe: “If a person breath holds after a normal exhalation, it takes approximately 40 seconds before the urge to breathe increases enough to initiate inspiration.”

The goal of HPBT is to increase BOLT over four to six weeks, and thereby reduce breathlessness during physical activity. Reduced breathlessness is very beneficial to the athlete as there is a substantial cost associated with high rates of ventilation, so much that as much as 10% of the oxygen consumption at VO2 max may be used to support the respiratory muscles.

Evaluation of breath holding in hypercapnia as a simple clinical test of respiratory chemosensitivity.

It is concluded that the breath hold test/Pco2 relationship provides a useful index of respiratory chemosensitivity which is not influenced by airways obstruction.

Thorax (1975), 30,337
Mouth breathing and forward head posture: effects on respiratory biomechanics and exercise capacity

Three-dimensional assessment of pharyngeal airway in nasal- and mouth-breathing children


Airway volume = 5045.1 mm$^3$

Airway volume = 9395.2 mm$^3$

Mouthbreathers have significantly smaller airway space.

(measurements PAS-OccL, PAS-UP, airway volume, area and minimum axial area)

Figure 1
Breathing pattern and head posture: changes in craniocervical angles.
Our study confirms that the oral breathing modifies head position. The significant increase of the craniocervical angles NSL/OPT and NSL/CVT in patients with this altered breathing pattern suggests an elevation of the head and a greater extension of the head compared with the cervical spine.
Minerva Stomatol. 2015 Apr; 64(2):59-74

Mouth breathing and forward head posture: effects on respiratory biomechanics and exercise capacity in children.
Respiratory biomechanics and exercise capacity were negatively affected by Mouth Breathing. The presence of moderate forward head position acted as a compensatory mechanism in order to improve respiratory muscle function.

Impact of the mouth breathing occurred during childhood in the adult age: biophotogrammetric postural analysis.
The results indicate that adults with mouth-breathing childhood have postural alterations, mainly in the head and lumbar column, which keeps for the whole life.

Exercise capacity, respiratory mechanics and posture in mouth breathers.
Mouth breathing children had cervical spine postural changes and decreased respiratory muscle strength compared with NB.
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**Improve anaerobic capacity**

By using high resolution pulse oximetry we are able to determine the height we are training an athlete at. 1 meter = 3.28 ft.

It is our experience that every athlete is able to lower their blood oxygen saturation to between 80% and 90% within one week of practice using The Oxygen Advantage program.

Breath holding after an exhalation causes a decrease to the concentration of oxygen to trigger increased lactic acid. At the same time, carbon dioxide also increases...
leading to an increased concentration of hydrogen ions to further acidify the blood. Repeated exposure to increased acidosis forces the body to adapt to it. To neutralise H+, buffering capacity improves to delay the onset of lactic acid and fatigue. These exercises are simple, safe and highly effective.

Factors participating in the weaker blood acidosis may have an origin within the muscular cell. Hydrogen ions may accumulate more slowly and allow the athletes to continue to exercise longer or at a higher intensity for a given distance. Respiratory Physiology & Neurobiology 160 (2008) 123–130

In addition, it can be traumatizing to repeatedly perform physical exercise at high intensities to stimulate an anaerobic state. Training at a moderate intensity with breath holding induces an anaerobic state but without risk of injury.

**Moderate exercise in hypoxia induces a greater arterial desaturation in trained than untrained men**

These results demonstrate that a moderate exercise carried out in hypoxia, contrary to normoxic conditions, can lead to a greater arterial desaturation in TM compared with UTM. This phenomenon could be partly attributed to a relative hypoventilation in trained subjects. Scand J Med Sci Sports 2007: 17: 431–436
Prolonged expiration down to residual volume leads to severe arterial hypoxemia in athletes during submaximal exercise

We demonstrated that repeated prolonged expirations carried out down to residual volume during a submaximal exercise to a drop of SaO2 down to 87% and was also accompanied by a marked hypercapnia.

Respiratory Physiology & Neurobiology 158 (2007) 75–82

Breath Holding, an Adjunctive Training Method

It is the conviction of the researcher that breath holding could be a respiratory endurance training method. It could also be used to augment training for "handicapped" athletes who cannot train using the more traditional methods due to injury, seasonal changes, off season and the sort.

Department of Physical and Health Education, University of Dorta, Nigeria.

Nonhematological mechanisms of improved sea-level performance after hypoxic exposure.

Specific beneficial nonhematological factors include improved muscle efficiency probably at a mitochondrial level, greater muscle buffering, and the ability to tolerant lactic acid production."

Increase EPO and improve aerobic capacity

Increased erythropoietin concentration after repeated apneas in humans. Results showed that EPO concentration increased by 24% which peaked at three hours after the final breath hold and returned to baseline two hours later. Eur J Appl Physiol 2008; 102:609–13.

The Effects of Hypercapnic-Hypoxic Training Program on Hemoglobin Concentration and Maximum Oxygen Uptake of Elite Swimmers
The above shows a significant increase to hemoglobin in the group that practiced breath holding after an exhalation. Furthermore, there was a 10.79% increase to VO2 max.
Faculty of Kinesiology, University of Zagreb, Croatia
Improve respiratory muscle strength

There is strong evidence that the diaphragm and other respiratory muscles may become exhausted during both short term, high intensity exercise (Bye et al) and more prolonged exercise such as marathon running (Loke et al). Special breath hold exercises until a medium-to-strong need for air mobilizes the diaphragm, providing it with a workout and helping to strengthen it.
**Improve running economy**

All the runners who trained with breath holding on the exhalation twice a week improved their performance over distances ranging from 1200 meters to 3000 meters. The velocity improvement was 1.33% on average.

Hypoventilation Training by Xavier Woorons

Controlled-frequency breathing improves running economy.
Researchers found that running economy improved by 6% in the group that performed reduced breathing during swimming.
Scandinavian Journal of Medicine & Science in Sports 2013 Oct 24
Improve swimming performance

Apnea training effects on Swimming Coordination
The researchers concluded that their studies indicated that "breath hold training improves effectiveness at both peak exercise and submaximal exercise and can also improve swimming technique by promoting greater propulsive continuity."


Swimmers can train in hypoxia at sea level through voluntary hypoventilation.
This study demonstrated that swimmers can train under hypoxic conditions at sea level and can accentuate the glycolytic stimulus of their training if they perform voluntary hypoventilation at low but not high pulmonary volume.


Physiological responses to repeated apneas in underwater hockey players and controls
The underwater hockey players were noted to have reduced breathlessness and higher concentration of CO₂ in exhaled breath after the test (ETCO2).

**Improve sleep for better focus and concentration**

Effect of nasal or oral breathing route on upper airway resistance during sleep

*Upper airway resistance* during sleep and the propensity to obstructive sleep apnea are *significantly lower while breathing nasally rather than orally.*

*Eur Respir J.* 2003 Nov; 22(5):827-32

Influences of the breathing route on upper airway dynamics properties in normal awake subjects with constant mouth opening

When compared with nasal breathing, *mouth breathing decreases the stability of the lower airway independent of mouth opening.*

This effect of mouth opening and moving from nasal breathing to *mouth breathing* may add to the effects of sleep on upper airway muscle tonic activity *worsening upper airway stability and favor the occurrence of upper airway obstruction during sleep.*


The impacts of open-mouth breathing on upper airway space in obstructive sleep apnea: 3-D MDCT analysis.

Results suggest that the more elongated and narrow upper airway during *open-mouth breathing may aggravate the collapsibility of the upper airway* and, thus, negatively affect OSA severity.

*Eur Arch Otorhinolaryngol.* 2011 Apr; 268(4):533-9
Effect of Nasal or Oral Breathing Route on Upper Resistance during Sleep

Upper airway resistance during sleep and the propensity to obstructive sleep apnea are significantly lower while breathing nasally rather than orally. This mechanical advantage may explain the preponderance of nasal breathing during sleep in normal subjects. Eur J Pediatric. 2013 Apr172 (4)

Airway collapsibility in normal sleeping subjects

We conclude that mouth opening increases UA collapsibility during sleep and that mouth opening may contribute to the occurrence of sleep related breathing abnormalities.


Effects of oropharyngeal exercises on patients with moderate obstructive sleep apnea. Oropharyngeal exercises significantly reduce OSAS severity and symptoms and represent a promising treatment for moderate OSAS. Am J Respir Crit Care Med. (2009).

The Nose and Sleep-Disordered Breathing

Although increased nasal resistance does not always correlate with symptoms of congestion, nasal congestion typically results in a switch to oronasal breathing that compromises the airway. Moreover, oral breathing in children may lead to the development of facial structural abnormalities associated with SDB. We postulate that the switch to oronasal breathing that occurs with chronic nasal conditions is a final common pathway for SDB.

Myofunctional Therapy to Treat Obstructive Sleep Apnea, A Systemic Review

Current literature demonstrates that Myofunctional therapy decreases apnea-hypopnea index by approximately 50% in adults and 62% in children. Lowest oxygen saturations, snoring, and sleepiness outcomes improve in adults. Myofunctional therapy could serve as an adjunct to other obstructive sleep apnea treatments.

Sleep, Volume 38 Issue 5
Help prevent exercise induced asthma

Effect of nasal and oral breathing on exercise-induced asthma.

The study found that ‘the post-exercise bronchoconstrictive response was markedly reduced as compared with the response obtained by oral (mouth) breathing during exercise, indicating a beneficial effect of nasal breathing’. Clin Allergy.1981 ;( Sep; 11(5)):433-9

Based on the fact that a number of clinical trials have shown that asthma symptoms and the need for asthma medication significantly reduces following the employment of reduced breathing exercises, there is no doubt that overbreathing is a significant contributor to asthma.

c) Cowie RL, Conley DP, Underwood MF, Reader PG.. A randomised controlled trial of the Buteyko technique as an adjunct to conventional management of asthma. Respiratory Medicine.2008 May;102(5);726-32