OXYGEN ADVANTAGE
ATHLETE DAY
One Simple Technique. Multiple Results.

- Measure and reduce breathlessness during physical exercise
- Nose breathing to improve arterial oxygen uptake
- Improve tolerance to reduced oxygen and increased carbon dioxide
- Improve aerobic capacity
- Increase production of EPO (Erythropoietin) safely and legally
- Improve running economy and running time
One Technique. Multiple Results.

• Delay the onset of fatigue and lactic acid
• Improve respiratory muscle strength
• Pre match preparation
• Improve sleep
• Help prevent exercise induced asthma
• Enter the Zone
• ‘One of the first lessons in the Yogi Science of Breath is to learn how to breathe through the nostrils, and to overcome the common practice of mouth-breathing.’

• Ramacharaka Yogi. Nostril versus mouth breathing. In: (eds.)THE HINDU-YOGI SCIENCE OF BREATH By YOGI RAMACHARAKA Author of "Yogi Philosophy and Oriental Occultism", "Advanced Course in Yogi Philosophy", "Hatha Yogi", "Psychic Healing", etc. Copyright 1903 (Expired)
THE NOSE

• ‘many of the diseases to which civilized man is subject are undoubtedly caused by this common habit of mouth breathing.’

• Ramacharaka Yogi. Nostril versus mouth breathing. In: (eds.) THE HINDU-YOGI SCIENCE OF BREATH By YOGI RAMACHARAKA Author of "Yogi Philosophy and Oriental Occultism", "Advanced Course in Yogi Philosophy", "Hatha Yogi", "Psychic Healing", etc. Copyright 1903 (Expired)
BENEFITS OF NOSE BREATHING
BENEFITS OF NOSE BREATHING

• Dr. Maurice Cottle, who founded the American Rhinologic Society in 1954: your nose performs at least 30 functions, all of which are important supplements to the roles played by the lungs, heart, and other organs.

• Timmons B.H., Ley R. Behavioral and Psychological Approaches to Breathing Disorders. 1st ed. Springer; 1994
**BENEFITS OF NOSE BREATHING**

- Nose breathing imposes approximately 50 percent more resistance to the air stream than mouth breathing during wakefulness, resulting in 10-20 percent more O2 uptake;
- Warms and humidifies incoming air;
- Removes a significant amount of germs and bacteria;
BENEFITS OF NOSE BREATHING

• Increased risk of developing forward head posture, and reduced respiratory strength

• A dry mouth also increases acidification of the mouth and results in more dental cavities and gum disease;
BENEFITS OF NOSE BREATHING

• Mouth breathing causes bad breath due to altered bacterial flora.

• Proven to significantly increase the number of occurrences of snoring and obstructive sleep apnoea.
NITRIC OXIDE
Nitric oxide (NO) is released in the nasal airways in humans. During inspiration through the nose this NO will follow the airstream to the lower airways and the lungs. Nasally derived NO has been shown to increase arterial oxygen tension and reduce pulmonary vascular resistance, thereby acting as an airborne messenger.

*Lundberg JO. Nitric oxide and the paranasal sinuses. Anat Rec (Hoboken).2008 Nov;(291(11)):1479-84*
Since NO is continuously released into the nasal airways, the concentration will be dependent on the flow rate by which the sample is aspirated. Thus, nasal NO concentrations are higher at lower flow rates.

NITRIC OXIDE

• Among the various biological properties of NO are its effects on the growth of various pathogens including bacteria, fungi, and viruses.

THE DIAPHRAGM
THE DIAPHRAGM

- Mouth breathing is considered an abnormal and inefficient adaptation of breathing mode and it may induce functional, postural, biomechanical and occlusal imbalances.

*Diaphragmatic amplitude and accessory inspiratory muscle activity in nasal and mouth breathing adults: a cross-sectional study. 2015; Journal of electromyography and kinesiology 25. 463-468
THE DIAPHRAGM

- To evaluate diaphragmatic amplitude (DA) in nasal and mouth-breathing adults. The study evaluated 38 mouth-breathing (MB group) and 38 nasal-breathing (NB group) adults, from 18 to 30 years old and both sexes.

*Diaphragmatic amplitude and accessory inspiratory muscle activity in nasal and mouth breathing adults: a cross-sectional study. 2015; Journal of electromyography and kinesiology 25. 463-468*
• Mouth breathing reflected on lower recruitment of the accessory inspiratory muscles during fast inspiration and lower diaphragmatic amplitude, compared to nasal breathing.

• Diaphragmatic amplitude and accessory inspiratory muscle activity in nasal and mouth breathing adults: a cross-sectional study. 2015; Journal of electromyography and kinesiology 25. 463-468,
16 athletes during an exhaustive training session. After the exercise, athletes were divided in two equivalent groups of eight subjects. Subjects of the studied group spent 1 h relaxing performing diaphragmatic breathing and concentrating on their breath in a quiet place.

*Martarelli D1, Cocchioni M, Scuri S, Pompei P. Diaphragmatic breathing reduces exercise-induced oxidative 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.

Martarelli D1, Cocchioni M, Scuri S, Pompei P. Diaphragmatic breathing reduces exercise-induced oxidative stress.
**THE DIAPHRAGM**

- Diaphragmatic breathing reduces heart rates, increases insulin, reduces glycemia, and reduces free-radical production as indicated by the higher antioxidants levels.

- Martarelli D1, Cocchioni M, Scuri S, Pompei P. Diaphragmatic breathing reduces exercise-induced oxidative stress.
THE DIAPHRAGM

• 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.

• Martarelli D1, Cocchioni M, Scuri S, Pompei P. Diaphragmatic breathing reduces exercise-induced oxidative stress.
RESPIRATORY WATER LOSS
RESPIRATORY WATER LOSS

• To compare the difference in respiratory water loss during expiration through the nose and through the mouth, in healthy subjects.

• The study included 19 healthy volunteers.

RESPIRATORY WATER LOSS

• The mean loss of expired water was 42% less by nasal expiration before decongestion than by oral expiration.

RESPIRATORY WATER LOSS

• Increased water and energy loss by oral breathing could be a contributing factor to the symptoms seen in patients suffering from nasal obstruction.

HEAT & WATER LOSS
HOW SHOULD WE BREATHE?

• To determine if mucosal surface heat and water loss influence the nasal functional response to cold air, we measured nasal resistance by posterior rhinomanometry.

HOW SHOULD WE BREATHE?

• During the challenge period, the subjects breathed either in and out of the nose or in through the nose and out through the mouth.

HOW SHOULD WE BREATHE?

• No changes in nasal resistance developed when subjects breathed exclusively through the nose;

HOW SHOULD WE BREATHE?

• However, when subjects breathed in through the nose and out through the mouth, nasal resistance was increased 200% at 1 min after the challenge and returned to baseline values by 10 min after cessation of the challenge.

HOW SHOULD WE BREATHE?

• If the heat given up from the nasal mucosa to the incoming air is not recovered during expiration (as is the case with inspiration through the nose and expiration through the mouth), nasal obstruction will occur.

HYPERVENTILATION SYNDROME

• 14 patients presented complaining of nasal congestion after previous nasal surgery and who appeared to have an adequate nasal airway with no evidence of nasal valve collapse, were evaluated for HVS.

HYPERVENTILATION SYNDROME

- All patients had an elevated respiratory rate (>18 breaths/minute) with an upper thoracic breathing pattern. An average number of 2.5 procedures had been performed on each patient.

HYPERVERVENTILATION SYNDROME

• Conclusion: HVS should be included in the differential diagnosis of patients presenting with nasal congestion, particularly after failed nasal surgery.

DENTAL HEALTH

• 35 triathletes who trained almost 10 hours a week

• Significant correlation was found between caries prevalence and the cumulative weekly training time

• Athletes produced less saliva and it was acidic. Degree of acidity increased with the length of time exercising. Saliva is considered important to good tooth health.

• (Sports drinks, dry mouth)

FORWARD HEAD POSTURE
FORWARD HEAD POSTURE
Our study confirms that the oral breathing modifies head position. The significant increase of the craniocervical angles 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.

*Breathing pattern and head posture: changes in craniocervical angles. Minerva Stomatol. 2015 Apr; 64(2):59-74.*
FORWARD HEAD POSTURE

• 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.

FORWARD HEAD POSTURE

• Mouth breathing children had cervical spine postural changes and decreased respiratory muscle strength compared with Nose Breathing.

FORWARD HEAD POSTURE

• 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.

FORWARD HEAD POSTURE

- Neck accessory respiratory muscles and mouth breathing suggest a direct relationship among asthma, Temporomandibular (TMD) and Cervical Spine (CSD) Disorders.

FORWARD HEAD POSTURE

• Thirty asthmatic children.

• 30 non-asthmatic predominantly mouth breathing children.

• 30 non-asthmatic predominantly nasal breathing children.

• Both AG and MBG groups demonstrated palpatory tenderness of posterior TMJ, medial and lateral pterygoid, and trapezius muscles when compared to NBG. Results showed a positive correlation between the severity of TMD and cervical spine disorders signs in asthmatic children.

Good Definition of Cheekbones
Alert Eyes
Straight Teeth
Straight Nose
Wider Face
Good Airway Size
Well Developed Jaw
WORKLOAD
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.

Morton, King, Papalia 1995 Australian Journal of Science and Medicine in Sport. 27, 51-55
WORKLOAD

• While breathing through the nose-only, all subjects could attain a work intensity great enough to produce an aerobic training effect (based on heart rate and percentage of VO2 max).

• Morton, King, Papalia 1995 Australian Journal of Science and Medicine in Sport. 27, 51-55
WORKLOAD

- Maximal exercise intensity that could be achieved by healthy subjects while nasal breathing
- On average subjects could reach 90% of their max workload while nasally breathing (at least for the short period during the test).

12 healthy physiotherapy students aged between 21 and 27 (8 male and 4 female) completed both runs. Nasal breathing was continued to 85% of V02 peak achieved suggestive of potentially high training loads, indicating that people are capable of nose breathing at much higher intensities than they would normally chose to do.

NOSE VERSUS MOUTH
NOSE VERSUS MOUTH

• Competitive athletes

• Alternate nasal breathing with mouth breathing.

• High-intensity training helps to prevent muscle de-conditioning and will require an athlete to periodically breathe through their mouth.
NOSE VERSUS MOUTH

• For less-than maximum intensity training, and at all other times, nasal breathing should be employed.

• For example, competitive athletes may spend 50 percent of their training with the mouth closed.
• Also devote training to working at an all-out pace in order to maintain muscle condition, for which brief periods of mouth breathing will be required.
NOSE VERSUS MOUTH

- During competition there is no need to intentionally take bigger breaths.
- Instead, bring a feeling of relaxation to your body and breathe as you feel necessary.
- However, breath-holding exercises during your warm-up can be very advantageous, as can practicing breathing recovery during your warm-down.
NOSE VERSUS MOUTH

• Competition isn’t the ideal time to focus about how well or poorly you are breathing, as your full concentration should be devoted to the game. The best way to improve breathing for competition is to improve your everyday breathing, and the key to this is obtaining a higher BOLT score.
NOSE VERSUS MOUTH

- Recreational athletes
- Nasal breathing at all times
- If you find that your need for air is so great that you need to open your mouth, simply slow down and allow your breathing to calm once more.
BREATHING EFFICIENCY
BREATHING EFFICIENCY

- During hyperpnea (increased depth of breathing), the relative cost of breathing increases exponentially when moving from moderate exercise to heavy and maximal exercise levels.

**BREATHING EFFICIENCY**

- While at moderate exercise, the cost of the respiratory system accounts for 3-6% total VO2max, heavy exercise accounts for a ~10% demand and maximal exercise accounts for anywhere between 13-15%.

Breathing efficiency and physical fitness are both independent and complementary; while physical fitness does not always translate into breathing efficiency, there is no doubt that breathing efficiency is the gateway to attaining physical fitness.
BREATHING EFFICIENCY

• Breathing is light, quiet, effortless, soft, through the nose, diaphragmatic, rhythmic and gently paused on the exhale.

• This is how human beings breathed until the comforts of modern life changed everything, including our breathing.
HOW SHOULD WE BREATHE?

• “Generally speaking, there are three levels of breathing. The first one is to breathe SOFTLY, so that a person standing next to you does not hear you breathing. The second level is to breathe softly so that YOU do not hear yourself breathing. And the third level is to breathe softly so that you do not FEEL yourself breathing.”

• Chris Pei: Beginners guide to Qi Gong
HOW SHOULD WE BREATHE- YOGA?

- Professional Hatha yogi breathing just one gentle breath per minute for the duration of one hour.

HOW SHOULD WE BREATHE?

- 4 -6 liters of air per minute during rest

HOW TO MEASURE BREATHLESSNESS
BOLT (COMFORTABLE BREATH HOLD TIME) MEASUREMENT

• Take a small silent breath in through your nose.

• Allow a small silent breath out through your nose.

• Hold your nose with your fingers to prevent air from entering your lungs.

• Count the number of seconds until you feel the first distinct desire to breathe in.
BOLT (COMFORTABLE BREATH HOLD TIME) MEASUREMENT

Measuring How Big You Breathe

- Control Pause (CP)
- Breath In
- Breath Out
- Calm Breath In

- Comfortable Breath - HOLD
- First signs of air hunger
- Tummy may jump

[Diagram showing the process of measuring comfortable breath hold time]
HOW TO MEASURE BREATHLESSNESS

• Stanley et al. concluded that, ‘the breath hold time/partial pressure of carbon dioxide relationship provides a useful index of respiratory chemosensitivity’.


• Voluntary breath holding duration is thought to provide an indirect index of sensitivity to CO2 buildup.
HOW TO MEASURE BREATHLESSNESS

• Breath holding as one of the most powerful methods to induce the sensation of breathlessness, and that the breath hold test ‘gives us much information on the onset and endurance of dyspnea.

How to Measure Breathlessness
HOW TO MEASURE BREATHLESSNESS

• “If a person breath holds after a normal exhalation, it takes approximately 40 seconds before the urge to breathe increases enough to initiate inspiration.”

HOW TO MEASURE UPPER LIMIT OF BREATHELESSNESS

Simulate Altitude Walking

• Exhale normally through nose
• Walk while holding the breath
• Measure how many paces you can hold your breath for

• Goal 80 to 100 paces
• Less than 60 paces- significant room for improvement
HOW TO MEASURE UPPER LIMIT OF BREATHELESSNESS (& NOSE UNBLOCKING)

• Psychological willpower and endurance influence the duration of the breath holding.

• The breakpoint of breath holding is preceded by the onset of respiratory movements.

• These irregular contractions of the inspiratory muscles reduce the unpleasant sensation in the lower thorax and abdomen that occurs progressively through a breath-holding period.
HOW SHOULD WE BREATHE?

• When your breathing receptors have a strong response to carbon dioxide and reduced pressure of oxygen in the blood, your breathing will be intense and heavy.
HOW SHOULD WE BREATHE?

- During strenuous physical exercise, the consumption of oxygen increases, leading to a slightly reduced concentration of O2 in the blood. At the same time, increased muscle activity and metabolic rate produces more carbon dioxide, causing an increased concentration of CO2 in the blood.
The sensitivity of your receptors to carbon dioxide and oxygen will have implications for the way your body copes with physical exercise.
• One difference between endurance athletes and non-athletes is decreased ventilatory responsiveness to hypoxia (low oxygen) and hypercapnia (higher carbon dioxide).

HOW SHOULD WE BREATHE?

• The lighter breathing of the athlete group may explain the link between “low ventilatory chemosensitivity and outstanding endurance athletic performance.”

HOW SHOULD WE BREATHE?

• The lower ventilation in Trained Men than in Untrained Men, both at sea level and in hypoxia, was probably due to reduced chemoresponsiveness. A weaker hypercapnic ventilatory responsiveness may reduce ventilation in trained men.

EFFECT ON VO2 MAX
EFFECT ON VO2 MAX

• The maximum capacity of your body to transport and utilise oxygen in one minute during maximal exercise.
EFFECT ON VO2 MAX

• The athletes’ response to increased carbon dioxide was 47% of that recorded by the non-athlete controls. Athletic ability to perform during lower oxygen pressure and higher carbon dioxide pressure, corresponded to maximal oxygen uptake or VO2 max.

• CO2 responsiveness was found to correlate negatively with maximum oxygen uptake in four out of the five trained subjects.

BREATHE LIGHT TO BREATHE RIGHT

• Slowing down breathing volume to create a hunger for air

• The hunger for air signifies an accumulation of carbon dioxide in the blood

• Breathe Light anchors the mind to the breath- trains the brain to improve focus and concentration

• Experience the physiological effects
INTERMITTENT HYPOXIA TRAINING (IHT)
For hundreds of thousands of years, breath holding was extensively practised by our ancestors for the purposes of foraging for food, might have been responsible for a number of unique human features.
INTERMITTENT HYPOXIA TRAINING (IHT)

• Intermittent hypoxic interval training (IHIT) is defined as a method where during a single training session, there is alternation of hypoxia and normoxia.

INTERMITTENT HYPOXIA TRAINING (IHT)

- It is possible to get a significant arterial desaturation during exercise without being placed in an hypoxic environment.

INTERMITTENT HYPOXIA TRAINING (IHT)

- Repeatedly using breath holding following exhalation during training would represent an intermittent hypoxic exposure and could therefore be likened to IHT, although hypoventilation also induces hypercapnia.

INTERMITTENT HYPOXIA TRAINING (IHT)

- During a breath hold, the cells continue to extract oxygen from the blood while oxygen levels are not renewed.
INTERMITTENT HYPOXIA TRAINING (IHT)

• Breath-hold training causes lower blood acidity, higher tolerance to anoxia, decelerated metabolism and an increase in Hct value, Hb and EPO concentration as well as the mass and volume of the lungs.

INTERMITTENT HYPOXIA TRAINING (IHT)

- Not all researchers have reported improvements to aerobic capacity. More research is required.

- No change in Hb after training

Xavier Woorons, Pascal Mollard, Aurélien Pichon, Alain Duvallet, Jean-Paul Richelet, Christine Lamberto. Effects of a 4-week training with voluntary hypoventilation carried out at low pulmonary volumes. Respiratory Physiology & Neurobiology 160 (2008) 123–130
INTERMITTENT HYPOXIA TRAINING (IHT)

• For most people, after a week or so of practice, a drop of oxygen saturation below 90% can be observed – a level that is comparative to the effects of living at an altitude of 3,000-4,000 metres.
INTERMITTENT HYPOXIA TRAINING (IHT)

• During a prolonged breath hold, the Oxyhaemoglobin dissociation curve shifts to the right due to increased CO2 and drop to pH.

• The combination of an arterial P02 close to 60mmHg and the rightward shift of the oxyhaemoglobin dissociation curve elicits a fall in SaO2 and therefore a significant hypoxic effect.

• Woorons et al.
Left shift
- Decreased temp
- Decreased 2-3 DPG
- Decreased [H+]
- CO

Right shift
(reduced affinity)
- Increased temp
- Increased 2-3 DPG
- Increased [H+]
Oxygen Saturations at Altitude

Graph showing the relationship between altitude and arterial oxygen pressure (PaO2 in mmHg) and saturation (SaO2 in %) as altitude increases from 0 to 10,000 meters.
THE SPLEEN
THE SPLEEN

• The Spleen acts as a blood bank by absorbing excess volume and releasing stores during increased oxygen demands or decreased oxygen availability.

• Isbister JP. Physiology and pathophysiology of blood volume regulation. Transfus Sci. 1997; (Sep;18(3)):409-423
THE SPLEEN

• The spleen stores blood to a volume that may amount to about 200–300 ml, with 80% of the content consisting of hematocrite (Laub et al., 1993).

• Journal of Human Kinetics volume 32/2012, 197-210
THE SPLEEN

• During the breath-hold, the spleen contracts to the same extent, regardless of whether the diver is above or underwater, pumping blood to the cardiac system, and with this, aggregated erythrocytes

  (Bakovic et al., 2005, Schagatay et al., 2007). Journal of Human Kinetics volume 32/2012, 197-210
THE SPLEEN

• The resultant blood oxygen capacity enables an increase in O2 concentration by 2.8–9.6% and more intense oxygen transport inter alia to the chest and other organs essential to breath-hold diving.

THE SPLEEN

- Spleen contraction develops quickly, as it occurs in the first repetition of the breath-hold, and after the next 3 to 4, it reaches its maximum and is very variable (20–46%) and depends on changes in the hypoxia rate

THE SPLEEN

• With every apnea the spleen contracts, releasing successive amounts of blood containing red blood cells.

• Journal of Human Kinetics volume 32/2012, 197-210
THE SPLEEN

• An additional number of erythrocytes circulating in blood due to spleen contraction may be equally important to the following: an increase of the O2 reserve and available O2 supply

• Journal of Human Kinetics volume 32/2012, 197-210
THE SPLEEN

• Repeated, multiple breath hold dives intensify the spleen contraction effect. It shows that hypoxemia enhances spleen and kidney function, increasing Hct and Hb circulating in blood (Schagatay et al., 2007, De Bruijun et al., 2008).

• Journal of Human Kinetics volume 32/2012, 197-210
THE SPLEEN

- During breath holding, large amounts of erythrocytes are excreted from the spleen, which raises Hct and Hb concentration from 2 to 5% (Jelkmann, 1992).

- *Journal of Human Kinetics* volume 32/2012, 197-210
APNEIC SPLEEN CONTRACTION

- Five maximum breath holds with their face immersed in cold water, and each breath hold was separated by a two-minute rest- Spleen size decreased by 20%.

APNEIC SPLEEN CONTRACTION

• Researchers concluded that the "results show rapid, probably active contraction of the spleen in response to breath hold in humans."

APNEIC SPLEEN CONTRACTION

• Results showed a 6.4% increase in hematocrit (Hct) and a 3.3% increase in hemoglobin concentration (Hb) following five breath holds.

APNEIC SPLEEN CONTRACTION

• Significant splenic contraction has been found to take place with even very short breath holds of 30 seconds

• However, the strongest contractions of the spleen are shown following maximum breath holds

• Kurt Espersen, Hans Frandsen, Torben Lorentzen, Inge-Lis Kanstrup, Niels J. Christensen. The human spleen as an erythrocyte reservoir in diving-related interventions. Journal of Applied Physiology. 2002; (May; 92(5)): 2071-9
APNEIC SPLEEN CONTRACTION

• Apnoea should be used directly before a race because its effects (i.e. increased Hct) disappear in 10 minutes after the last apnoea.

EPO

- The narrowing of the blood vessels, caused by the activation of the sympathetic nervous system during breath-hold diving, causes decreased blood circulation to organs that are more resistant to an absence of oxygen, especially the extremities, and to the decrease in PO2 in pulmonary alveola and in arterial blood (Fagius and Sundlof, 1986).

- Journal of Human Kinetics volume 32/2012, 197-210
As a result of decreased blood perfusion, local ischaemia occurs in the kidneys, causing anoxia (absence of O2), which also stimulates EPO production (Balestra et al., 2006). EPO stimulates proliferation and maturation of bone marrow’s red blood cells.

Journal of Human Kinetics volume 32/2012, 197-210
BREATH HOLDING INCREASES EPO

• 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.

• (Three sets of five maximum duration breath holds, with each set separated by ten minutes of rest.) de Bruijn R, Richardson M, Schagatay E. Increased erythropoietin concentration after repeated apneas in humans. Eur J Appl Physiol 2008;102:609–13.
HYPERCAPNIC-HYPOXIC TRAINING
HYPERCAPNIC- HYPOXIC TRAINING

• Research to establish the effects of 8 week hypercapnic-hypoxic training program in elite male swimmers, 30 to 45 minutes, three times a week.

HYPERCAPNIC- HYPOXIC TRAINING

• Each test subject has withheld breath individually, by a subjective feeling, for as long as possible.

HYPERCAPNIC- HYPOXIC TRAINING

• The condition is that each breath hold must be above the minimum values which describe hypercapnia, that is, the values of carbon dioxide in the exhaled breath had to be over 45 mmHg, which was controlled by a capnometer.

HYPERCAPNIC- HYPOXIC TRAINING

• Besides the swimming training sessions the control group was subjected to additional aerobic training sessions on a treadmill. The program was conducted three times a week for eight weeks.

HYPERCAPNIC- HYPOXIC TRAINING

<table>
<thead>
<tr>
<th></th>
<th>Experiment</th>
<th>Control</th>
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<tbody>
<tr>
<td>Pre: Hb (g/L)</td>
<td>144.63</td>
<td>147.75</td>
</tr>
<tr>
<td>Post: Hb (g/L)</td>
<td>152.38</td>
<td>145.38</td>
</tr>
</tbody>
</table>

5.35% higher Hb

## HYPERCAPNIC- HYPOXIC TRAINING

<table>
<thead>
<tr>
<th></th>
<th>Experiment</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>VO2 Max Pre:</td>
<td>63.80</td>
<td>59.46</td>
</tr>
<tr>
<td>VO2 Max Post:</td>
<td>70.38</td>
<td>60.81</td>
</tr>
</tbody>
</table>

10.79% increase to VO2 max

HYPERCAPNIC- HYPOXIC TRAINING

• 15 middle distance runners

• (600- 3000m) over six weeks

• Runners participated in official athletics competition before and after

• Fortier E, Nadeau. Peterborough, Canada
HYPERCAPNIC- HYPOXIC TRAINING

• First group- normal breathing +.03% improvement

• Fortier E, Nadeau. Peterborough, Canada
HYPERCAPNIC- HYPOXIC TRAINING

• Second group- 15 to 20 minutes of breath holding on the exhalation once per week: +1.27% improvement

• Third group- 15 to 20 minutes of breath holding on the exhalation twice per week: +1.33% improvement

• Fortier E, Nadeau. Peterborough, Canada
HYPERCAPNIC- HYPOXIC TRAINING

• Runners trained 3 times per week with VHL over a 4 week period

• 85% of the runners who applied VHL improved their maximum velocity attained at the end of a treadmill test by .5km/h on average.

• Mean improvement of VHL group: + 2.4%

• Normal breathing group - no change

• Woorons X. Effects of 4 week training with voluntary hypoventilation carried out at low pulmonary volumes.
HYPERCAPNIC- HYPOXIC TRAINING

• Over a 5-week period, sixteen triathletes (12 men, 4 women) were asked to include twice a week into their usual swimming session one with hypoventilation at low lung volume (VHL group) or with normal breathing (CONT group).

HYPERCAPNIC- HYPOXIC TRAINING

• Before (Pre-) and after (Post-) training, all triathletes performed all-out front crawl trials over 100, 200 and 400m.

HYPERCAPNIC- HYPOXIC TRAINING

• Time performance was significantly improved in trials involving breath holding following an exhalation in all trials but did not change in CONTROLS.

• 100m: – 3.7 ± 3.7s

• 200m: – 6.9 ± 5.0s

• 400m: – 13.6 ± 6.1s

SIMULATE HIGH ALTITUDE TRAINING
Demonstration - Walking
LONG TERM EFFECTS
LONG TERM EFFECTS OF BREATH HOLDING

• Resting Hb mass in trained breath hold divers was 5% higher than untrained. In addition breath hold divers showed a larger relative increase to Hb after three apneas.

LONG TERM EFFECTS OF BREATH HOLDING

• Pre-test hemoglobin tended to be higher in the diver group than both skiers and untrained. (divers 150.1 g/L; skiers 145.5 g/L; untrained 146.9 g/L)

EFFECT ON RUNNING ECONOMY
EFFECT ON RUNNING ECONOMY

- The amount of energy or oxygen consumed while running at a speed that is less than maximum pace.

Typically, the less energy required to run at a given pace, the better – if your body is able to use oxygen efficiently, it is indicative of a high running economy.
EFFECT ON RUNNING ECONOMY

• Running economy has been linked to success in distance running, such that faster runners are more economical (Morgan et al., 1995; Lavin et al., 2012) and better metabolic efficiency preserves glycogen and delays the onset of fatigue (Rapoport, 2010).

EFFECT ON RUNNING ECONOMY

• Eighteen swimmers comprising of ten men and eight women who were assigned to two groups. The first group was required to take only two breaths per length and the second group seven breaths.

EFFECT ON RUNNING ECONOMY

• Researchers found that running economy improved by 6% in the group that performed reduced breathing during swimming.

Reduced Acidosis
REDUCED ACIDOSIS

- Fatigue- physiological- breaking point at which the athlete cannot continue exercise intensity.
REduced Acidosis

• Metabolism produces CO$_2$ - dissociates to H+ and HCO$_3^-$

• Sufficient oxygen to the muscles - H+ is oxidised in the mitochondria to generate water

• Insufficient oxygen - all H+ cannot be oxidised and associates with pyruvic acid to form lactic acid
REDUCED ACIDOSIS

• 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.
**REDUCED ACIDOSIS**

- Repeated exposure to increased acidosis forces the body to adapt to it.
- To neutralise H+, buffering capacity improves.
REDUCED ACIDOSIS

• 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.

Xavier Woorons, Pascal Mollard, Aurélien Pichon, Alain Duvallet, Jean-Paul Richalet, Christine Lamberto. Effects of a 4-week training with voluntary hypoventilation carried out at low pulmonary volumes. Respiratory Physiology & Neurobiology 160 (2008) 123–130
ANEROBIC TRAINING

• It can be traumatizing to repeatedly perform exercises at high intensities to stimulate an anaerobic state.

• Training at a moderate intensity with breath holding could reduce the risk of injury.
CENTRAL GOVERNOR

- Central Governor theory- the heart is the most important organ to protect against over exercising.
- Governor in the brain which monitors oxygenation of the heart, and possibly the brain and diaphragm.
- If oxygen levels drop too much, the brain will send messages to slow down the athlete.
CENTRAL GOVERNOR

• The body experiences fatigue, burning or pain. The athlete slows down and thus the heart is protected.
CENTRAL GOVERNOR

- Acidosis impairs homeostasis. Breath holding conditions the brain to tolerate strong acidosis - teaches the brain that the body can go harder and faster without over doing it.
RESPIRATORY MUSCLE FATIGUE
RESPIRATORY MUSCLE TRAINING

• During heavy exercise, breathing frequency rises to 40 to 50 breaths per minute. Tidal volume is 3 to 4 litres. This gives a minute volume of 120 to 160 litres.

• For Olympic class male endurance athletes, tidal volume can be as high as 5 litres resulting in a minute ventilation of 200 to 250 litres.

• McConnell. A. Breathe Strong. Perform Better.
RESPIRATORY MUSCLE TRAINING

• During intense exercise, the demands on proper functioning of the respiratory system are markedly increased. Research has shown that the respiratory system often “lags behind,” while cardiovascular function and skeletal muscle improve with aerobic training (Bye et al., 1983; Wagner, 2005).

The lungs do not respond to physical training. Training does not increase lung volumes, improve lung function or enhance the ability of the lungs to transfer oxygen to the blood. (Wagner 2005)
RESPIRATORY MUSCLE TRAINING

• 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)

• Tim Noakes. The Lore of Running.
RESPIRATORY MUSCLE TRAINING

• The ventilatory response during heavy exercise, which is often accompanied and impaired by expiratory flow limitations and dynamic hyperinflation (Johnson et al., 1992), requires substantial increases in both inspiratory and expiratory muscle work, often leading to respiratory muscle fatigue.

RESPIRATORY MUSCLE TRAINING

• As the respiratory muscles fatigue they require an increasing amount of blood flow and oxygen in order to continue. As fatigue sets in, the respiratory muscles are thought to potentially monopolize the blood flow needed for the locomotor muscles.

• The Effects of Inspiratory Muscle Training on Anaerobic Power in Trained Cyclists By Courtenay McFadden Accepted in Partial Completion of the Requirements for the Degree Master of Science
RESPIRATORY MUSCLE TRAINING

• To stimulate any muscle to undergo adaptation, the muscle must be overloaded. This means forcing it to do something that it is not accustomed to. Most aerobic training is within the comfort of working muscles. High intensity training would be best- but cannot be sustained long enough to provide an effective overload.

• McConnell A. Breathe Strong, Perform Better.
BREATH HOLD TRAINING

- The "extradiaphragmatic" shift in inspiratory muscle recruitment may reflect an extreme loading response to breathing against a heavy elastance (i.e., closed glottis). In addition, the relative intensity of diaphragmatic and inspiratory rib cage muscle contractions approaches potentially "fatiguing" levels by the break point of maximal breath holding.

BREATH HOLD TRAINING

• Limiting breath frequency during swimming further stresses the respiratory system through hypercapnia and mechanical loading and may lead to appreciable improvements in respiratory muscle strength.

BREATH HOLD TRAINING

• 20 competitive college swimmers were randomly divided into either the CFB group that breathed every 7 to 10 strokes, or a control group that breathed every 3-4 strokes. Pooled results demonstrated a 12% decrease in MIP (maximum inspiratory mouth pressure) at 46s post-race. The training intervention included 5-6 weeks.

After four weeks of training, only the CFB group prevented a decline in MIP values pre to 46 s post-race. CFB training appears to prevent inspiratory muscle fatigue yet no difference was found in performance outcomes.

BREATH HOLD TRAINING

- Eighteen subjects (10 men), were randomized to either CFB or stroke-matched (SM) condition. Subjects completed 12 training sessions, in which CFB subjects took two breaths per length and SM subjects took seven.

• Post-training, maximum expiratory pressure improved by 11% (15) for all 18 subjects (P < 0.05) while maximum inspiratory pressure was unchanged.

BREATH HOLD TRAINING

- Swimmers, who were subjected to the hypercapnic-hypoxic regimen, had significantly improved strength of their inspiratory muscles in comparison to swimmers in the control group.

BREATH HOLD TRAINING

• Experimental group have improved the inspiratory muscle strength values (MIP) for 14.9% and the expiratory muscle strength values (MEP) for 1.9% in relation to the control group.

• Dajana KARAULA 1, Jan HOMOLAK 2, Goran LEKO. Effects of hypercapnic-hypoxic training on respiratory muscle strength and front crawl stroke performance among elite swimmers. Turkish Journal of Sport and Exercise. Year: 2016 - Volume: 18 - Issue: 1 - Pages: 17-24
BREATH HOLD TRAINING

• Voluntary holding of breath may have resulted in involuntary contractions of intercostal muscles during the hypercapnic-hypoxic practice. It is also assumed that above mentioned contraction occurrence has resulted in hypertrophy of intercostal muscles.

• Dajana KARAULA 1, Jan HOMOLAK 2, Goran LEKO. Effects of hypercapnic-hypoxic training on respiratory muscle strength and front crawl stroke performance among elite swimmers. Turkish Journal of Sport and Exercise. Year: 2016 - Volume: 18 - Issue: 1 - Pages: 17-24
BREATH HOLD TRAINING

• Such practice may have enlarged diaphragm thickness which plays an important role in respiratory system and sports performance.

• Dajana KARAULA 1, Jan HOMOLAK 2, Goran LEKO. Effects of hypercapnic-hypoxic training on respiratory muscle strength and front crawl stroke performance among elite swimmers. Turkish Journal of Sport and Exercise. Year: 2016 - Volume: 18 - Issue: 1 - Pages: 17-24
BREATH HOLDING IN PRACTISE
BREATH HOLDING IN PRACTISE

• World-renowned Brazilian track coach Luiz De Oliveira used breath hold training with Olympic athletes Joaquim Cruz and Mary Decker, who set six world records in 800 metre to one-mile distance running events.
BREATH HOLDING IN PRACTISE

• De Oliveira, "The most important thing you can do in the race no matter how exhausted you get is to maintain your form."

• Tom Piszkin. Interview with Luiz De Oliveira. Email to: Patrick McKeown. (patrick@buteykoclinic.com) November 2012
BREATH HOLDING IN PRACTISE

• The legendary Eastern European athlete Emil Zatopek, described by the New York Times as perhaps one of the greatest distance runners ever also incorporated breath holding into his regular training.
On the first day, he held his breath until he reached the fourth poplar. On the second day he held his breath until he reached the fifth poplar, increasing the distance of his breath hold by one poplar each day until he could hold his breath for the entire line of trees. On one occasion, Emil held his breath until he passed out.
1952 Helsinki Olympics brought Emil much fame and adoration after he won the 5,000 metres, the 10,000 metres and the marathon, which he decided to run on a whim, having never completed the distance before.
BREATH HOLDING IN PRACTISE

• Galen Rupp – the current American record holder of the 10,000 metres, indoor 3,000 metres, and silver medal winner at the 2012 Summer Olympics – had recently collapsed during training. Rupp’s headphones had fallen off and “he was unable to hear his coach reminding him to breathe”.
GETTING A BETTER NIGHT’S SLEEP

• Avoid blue light – smart phone and laptop
• Sleep in a cool and airy bedroom
• Don’t eat late at night or drink alcohol
• Switch to nasal breathing permanently
• Practise breathing softly for twenty minutes before sleep-parasympathetic NS
• Determine sleeping position
GETTING A BETTER NIGHT’S SLEEP

• Tape mouth closed- 3M micropore tape
• Provide each student with a roll of tape
• Demonstrate how to apply it
• Wear tape for twenty minutes during the day to become comfortable with it
• If mouth naturally moist in the morning, no need for tape
INCREASED CREATIVITY
INCREASED CREATIVITY

• During breath holding, due to O2 consumption and a decrease in its partial pressure in the lung alveola, the flowing blood is less and less oxygenated with time. This does not mean that the brain immediately receives less oxygen.

• Journal of Human Kinetics volume 32/2012, 197-210
INCREASED CREATIVITY

- Oxygen blood saturation is admittedly lower, yet the blood circulation to the brain is higher, which is caused by the dilation of blood vessels in the brain that occurs with increased CO2 concentration.

- Journal of Human Kinetics volume 32/2012, 197-210
INCREASED CREATIVITY

• Yoshiro Nakamats, one of the world's most prolific inventors with over 4,000 patents.

• The floppy disk, the hard disk, and the digital watch.
INCREASED CREATIVITY

• One of his best secrets for coming up with his ideas as: "swim till almost die!"; this technique consists in swimming underwater and "holding your breath as long as possible, therefore forcing more and more oxygen into your brain so that you can think better!"
Nose Unblocking Exercise

Nasal breathing

Benefits of Nitric Oxide

Increased CO₂

Opens blood vessels

Opens airways

Bohr Effect

Improved Oxygenation of the heart

Increased Oxygenation of tissues and organs

Sports Meditation Enter the Zone

Breathing Recovery, Improve Concentration

Simulate High Altitude Training Walking

Simulate High Altitude Training Running, Cycling, Swimming

Advanced Simulation of High Altitude Training

Tolerate strong air shortage during competition

Psychological Preparedness

Reduced lactic acid and fatigue

Kidneys release EPO

Spleen releases red blood cells

Increased oxygen carrying capacity

The Oxygen Advantage

Improved Sports Performance