CLASS 3

OXYGEN ADVANTAGE®

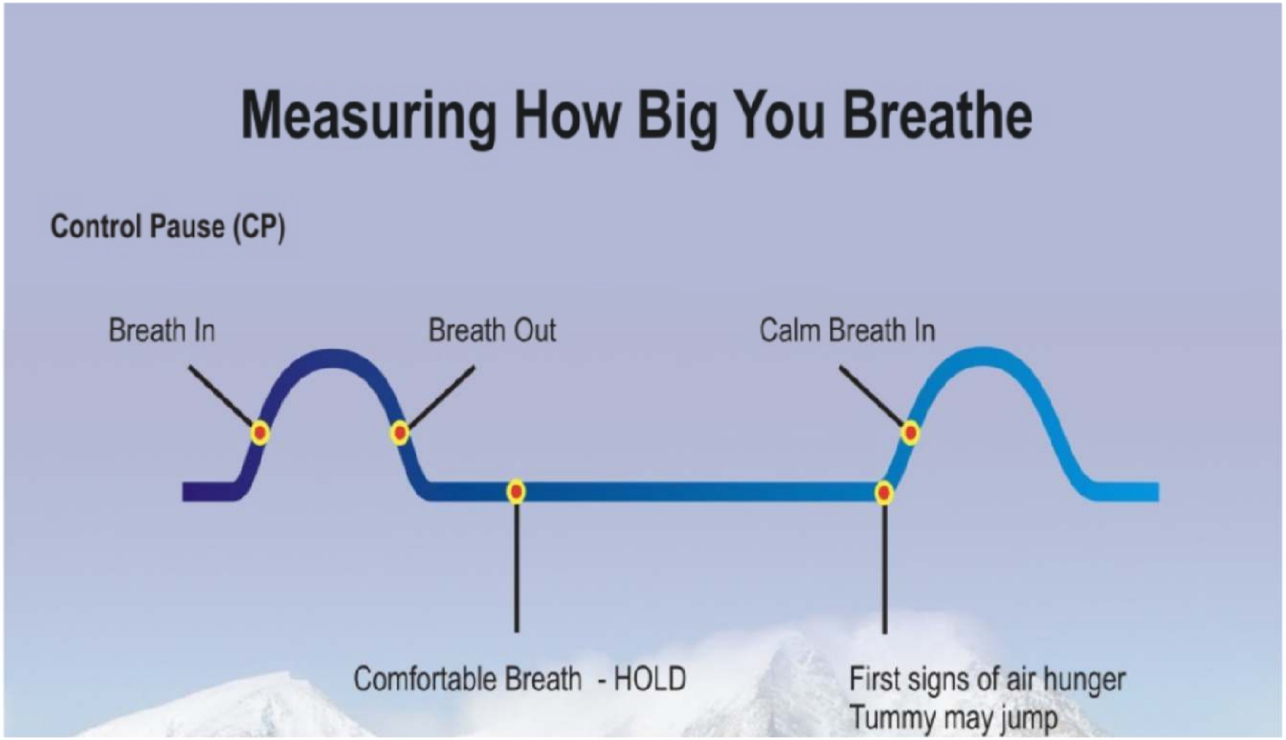
BY PATRICK MCKEOWN

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



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’.
- *Stanley,N.N.,Cunningham,E.L.,Altose,M.D.,Kelsen,S.G.,Levinson,R.S., and Cherniack, N.S. 7) Evaluation of breath holding in hypercapnia as a simple clinical test of respiratory chemosensitivity. Thorax.1975;30():337-343*

- Voluntary breath holding duration is thought to provide an indirect index of sensitivity to CO_2 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.

- *Nishino T. Pathophysiology of dyspnea evaluated by breath-holding test: studies of furosemide treatment. Respiratory Physiology Neurobiology.2009 May 30;(167(1)):20-5*


USA
USA
RUS
5

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."

- *McArdle W, Katch F, Katch V. Exercise Physiology: Nutrition, Energy, and Human Performance. 1st ed. North American Edition. Lippincott Williams & Wilkins; Seventh, (p289) (November 13, 2009)*

Maximum Breathlessness Test (MBT)

- Exhale normally through nose
- Walk at a normal pace while holding the breath
- Count the maximum number of paces that you can hold your breath

- Goal 80 to 100 paces
- Less than 60 paces- significant room for improvement

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?

- Strong ventilatory response to CO_2 – breathing will be intense and heavy. (poor tolerance)
- Reduced ventilatory response to CO_2- breathing will be relatively light.

HOW SHOULD WE BREATHE?

- During strenuous physical exercise, the consumption of oxygen increases, leading to a slightly reduced concentration of O_2 in the blood. At the same time, increased muscle activity and metabolic rate produces more carbon dioxide. (normally ventilation increases proportionately to CO_2 production so actual levels of aCO_2 wont change by much)

HOW SHOULD WE BREATHE?

- The sensitivity of your receptors to carbon dioxide and oxygen will have implications for the way your body copes with physical exercise.

HOW SHOULD WE BREATHE?

- A low hypercapnic drive linked with physiological, biochemical and psychological components to make up an outstanding endurance performer.

McGurk et al. The relationship of hypercapnic ventilatory responses to age, gender and athleticism. Sports Med. 19 (3) 173-183. 1995

HOW SHOULD WE BREATHE?

- One difference between endurance athletes and non-athletes is decreased ventilatory responsiveness to hypoxia (low oxygen) and hypercapnia (higher carbon dioxide).

- *Scoggin CH, Doekel RD, Kryger MH, Zwillich CW, Weil JV. Familial aspects of decreased hypoxic drive in endurance athletes. Journal Applied Physiology1978;(Mar;44(3)):464-8*

HOW SHOULD WE BREATHE?

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

- *See: Martin BJ, Sparks KE, Zwillich CW, Weil JV. Low exercise ventilation in endurance athletes. Med Sci Sports.1979;(Summer;11(2):):181-5*

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.

- *X. Woorons1, P. Mollard1, A. Pichon1, C. Lamberto1,2, A. Duvallet1,2, J.-P. Richalet. Moderate exercise in hypoxia induces a greater arterial desaturation in trained than untrained men. Scand J Med Sci Sports 2007: 17: 431–436*

HOW SHOULD WE BREATHE?

- Hypercapnic ventilatory drive might be lowered by severe physical training.

McGurk et al. The relationship of hypercapnic ventilatory responses to age, gender and athleticism. Sports Med. 19 (3) 173-183. 1995

EFFECT ON VO_2 MAX

EFFECT ON VO_2 MAX

- The maximum capacity of your body to transport and utilise oxygen in one minute during maximal exercise.

EFFECT ON VO_2 MAX

- Affected by amount of red blood cells, muscle and how much blood your heart can pump.
- If your body can take in more oxygen and deliver it to your working muscles- higher VO_2 max.
- (Increase oxygen carrying capacity, and improve tolerance to carbon dioxide (reduced ventilatory response))

EFFECT ON VO_2 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 VO_2 max.

- *Byrne-Quinn E, Weil JV, Sodal IE, Filley GF, Grover RF. Ventilatory control in the athlete. J Appl Physiol.1971 ;(Jan;30(1):91-8*

EFFECT ON VO_2 MAX

- CO_2 responsiveness was found to correlate negatively with maximum oxygen uptake in four out of the five trained subjects.

- *Miyamura M, Hiruta S, Sakurai S, Ishida K, Saito M. Effects of prolonged physical training on ventilatory response to hypercapnia. Tohoku J Exp Med.1988;(Dec;156 Suppl:):125-35*

INTERMITTENT HYPOXIC HYPERCAPNIC TRAINING (IHHT)

IHHT

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

- *J Hum Kinet. 2011 Jun; 28: 91–105.*

IHHT

- 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.

- Millet GP[1], Roels B, Schmitt L, Woorons X, Richalet JP. Combining hypoxic methods for peak performance. *Sports Med 2010; 40 (1): 1-25*

IHHT

- The Voluntary Hypoventilation Low lung volumes (VHL) technique has recently been included in the updated nomenclature of altitude training methods.

- *Girard, O., Brocherie, F., & Millet, G. P. (2017). Effects of Altitude/Hypoxia on Single- and Multiple-Sprint Performance: A Comprehensive Review. Sports Medicine (Auckland, N.Z.). https://doi.org/10.1007/s40279-017-0733-z*

IHHT

- Craig, Dicker, Holmer reported that reduced frequency breathing would not achieve hypoxemia
- Yamamoto et al. 1987 reported a decrease to 87% SpO_2 when breath holding was performed at functional residual capacity. (FRC)

- Respiratory Physiology & Neurobiology 158(1):75-82

IHHT

- A difference of exercise intensity may have a significant impact on SaO2%
- The harder you exercise, the stronger the effect.

- Respiratory Physiology & Neurobiology 158(1):75-82

IHHT

- 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.

- Andrzej Ostrowski,[1] Marek Strzała,[1] Arkadiusz Stanula,[2] Mirosław Juszkiewicz,[1] Wanda Pilch,[3] and Adam Maszczyk· The Role of Training in the Development of Adaptive Mechanisms in Freedivers. J Hum Kinet. 2012 May; 32: 197–210.

IHHT

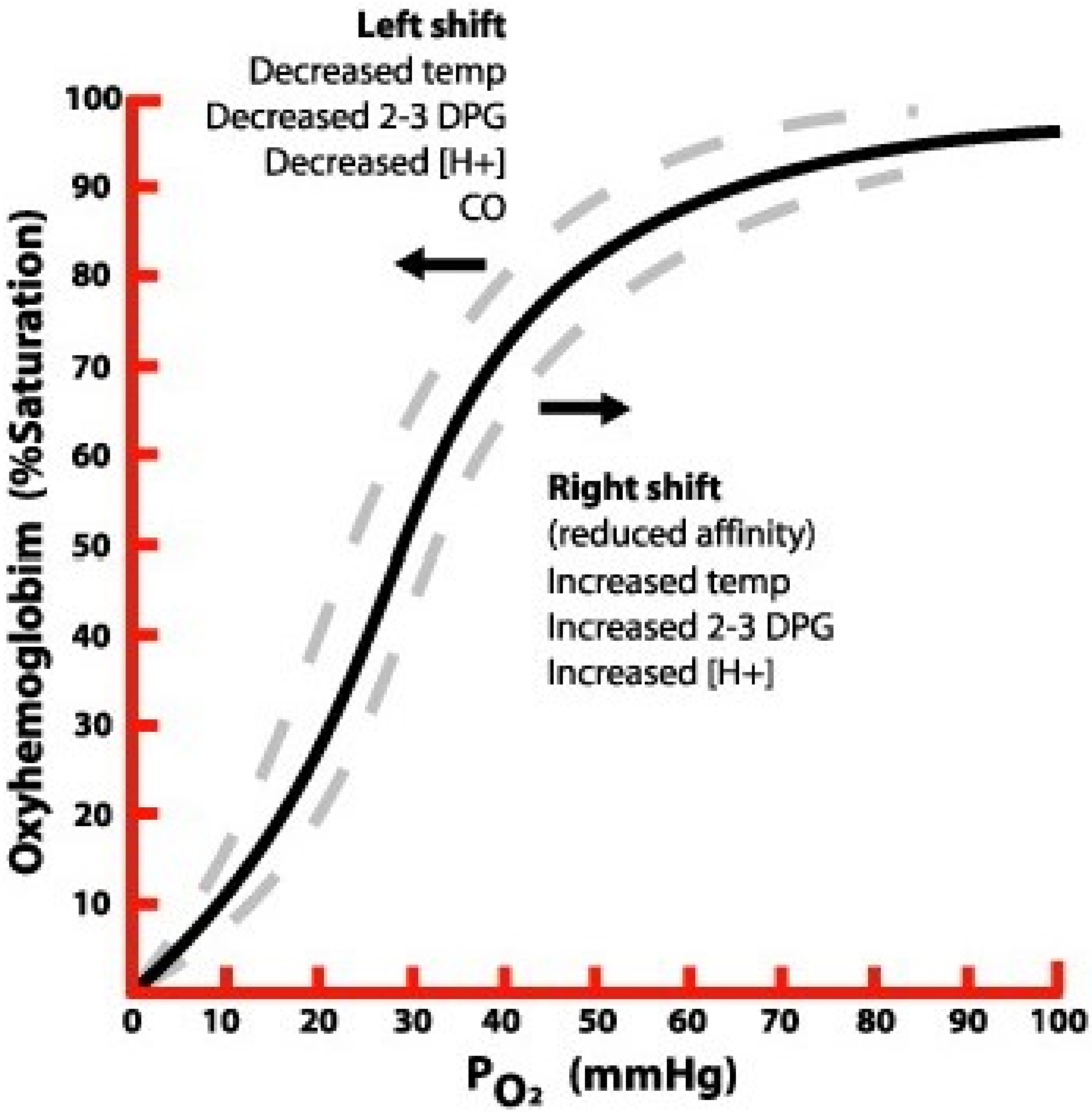
- Not all researchers have reported improvements to aerobic capacity. More research is required.

- No change in Hb after training

Xavier Woorons , Pascal Mollard, Aur´elien 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

IHHT

- 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.



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Right shift
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Increased temp
Increased 2-3 DPG
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90
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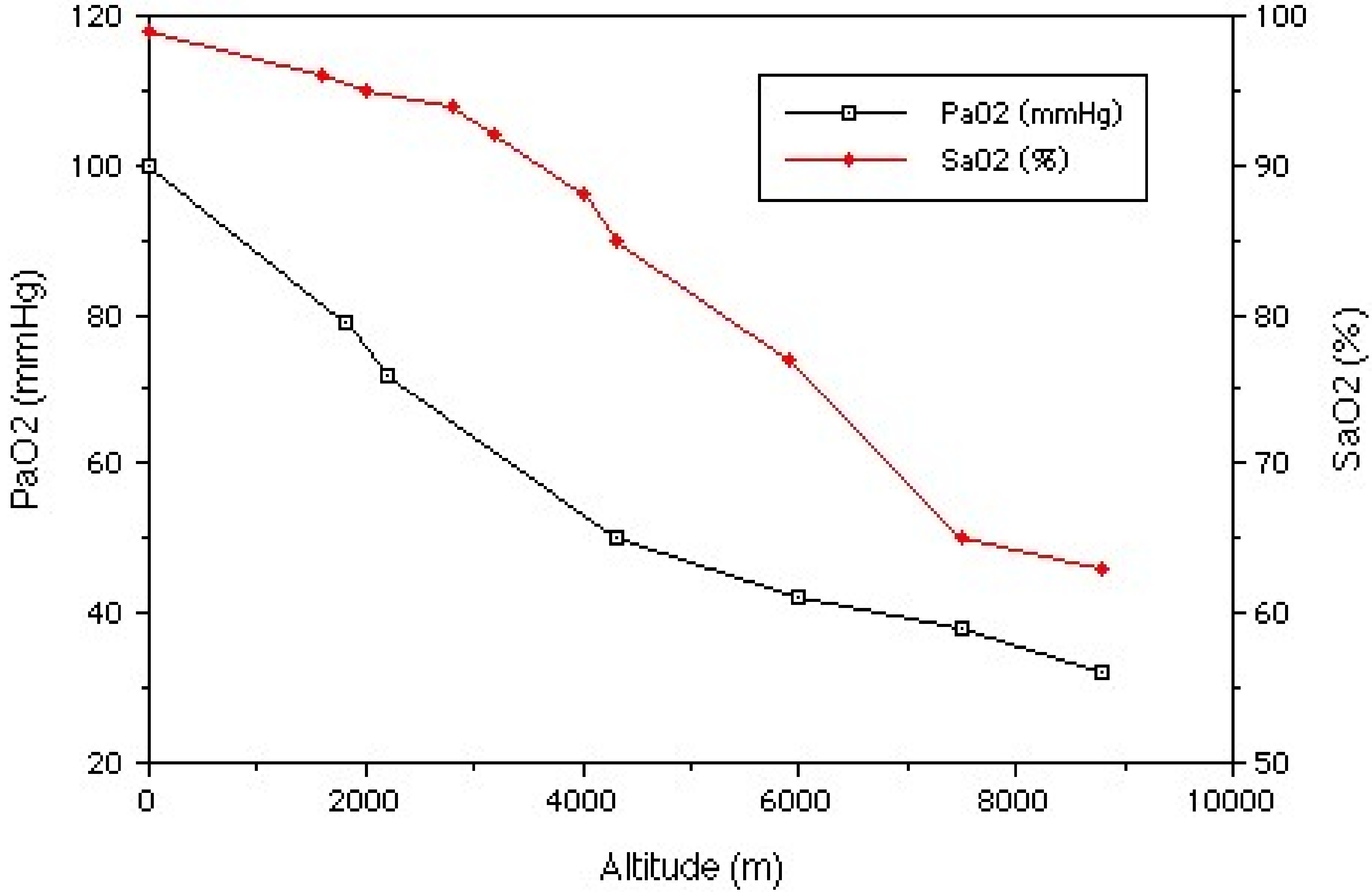
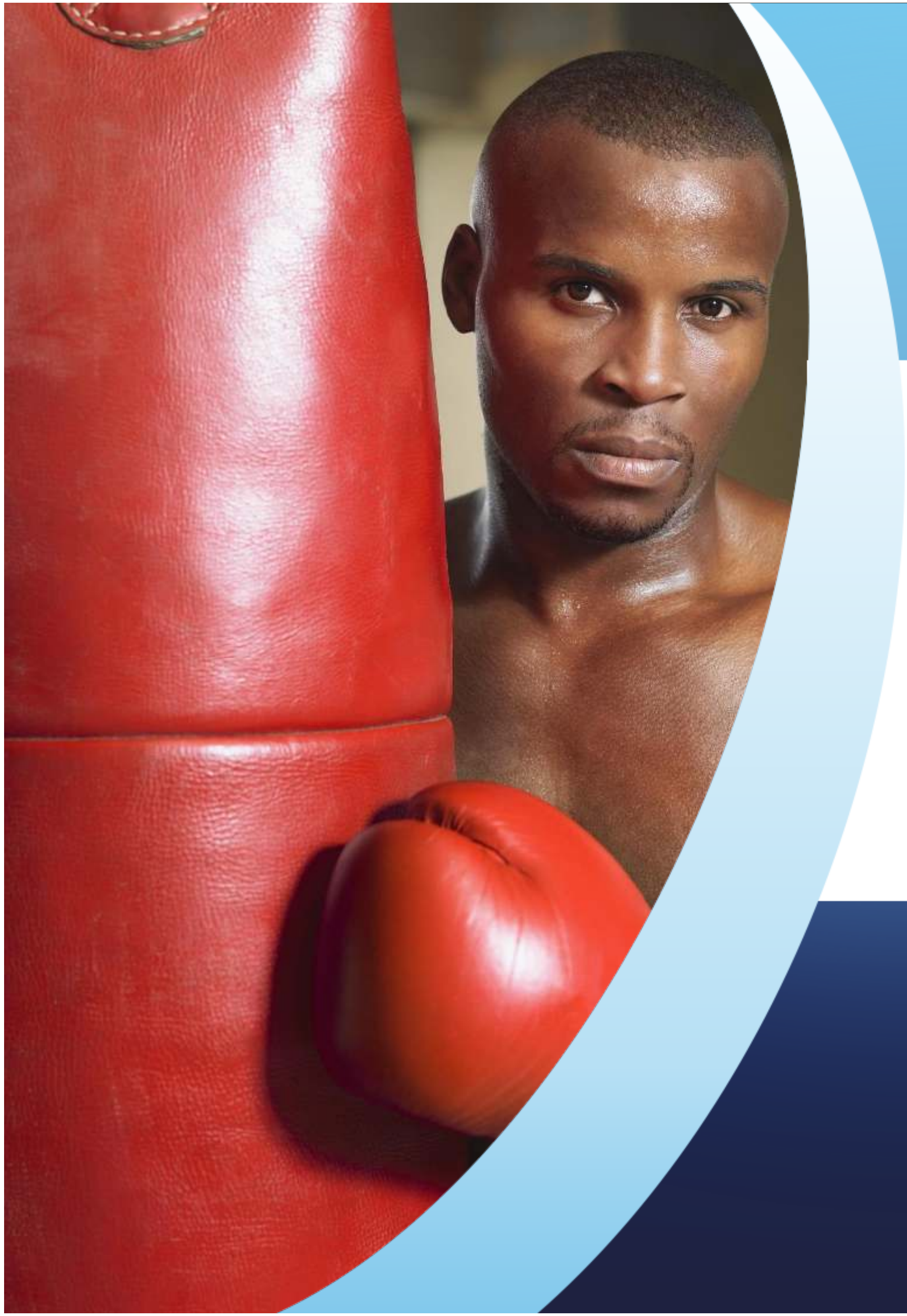
100
P_{O_2} (mmHg)

Oxygen Saturations at Altitude





BENEFITS FOR RUNNING, SWIMMING, CYCLING & TEAM SPORTS

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).

- *Scand J Med Sci Sports 2015: 25: 16–24*

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.

- *See: Lavin, K. M.; Guenette, J. A.; Smoliga, J. M.; Zavorsky, G. S. Controlled-frequency breath swimming improves swimming performance and running economy. Scandinavian Journal of Medicine & Science in Sports 2013 Oct 24*

EFFECT ON RUNNING ECONOMY

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

- *Lavin, K. M.; Guenette, J. A.; Smoliga, J. M.; Zavorsky, G. S. Controlled-frequency breath swimming improves swimming performance and running economy. Scandinavian Journal of Medicine & Science in Sports*

Swimming

HYPERCAPNIC- HYPOXIC TRAINING

- 8 week hypercapnic-hypoxic training program in elite male swimmers, 30 to 45 minutes, three times a week.

- Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466

HYPERCAPNIC- HYPOXIC TRAINING

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

- *Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466*

HYPERCAPNIC- HYPOXIC TRAINING

- 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.

- *Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466*

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.

- *Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466*

HYPERCAPNIC- HYPOXIC TRAINING

	Experiment	Control
Pre: Hb (g/L)	144.63	147.75
Post: Hb (g/L)	152.38	145.38

5.35% higher Hb

- *Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466*

HYPERCAPNIC- HYPOXIC TRAINING

	Experiment	Control
VO2 Max Pre:	63.80	59.46
VO2 Max Post:	70.38	60.81

10.79% increase to VO2 max

- *Darija Baković, Zoran Valic, Davor Eterović, Ivica Vuković, Ante Obad, Ivana Marinović-Terzić, Zeljko Dujić. Spleen volume and blood flow response to repeated breath-hold apneas. Journal of Applied Physiology.2003;(vol. 95 no. 4):1460-1466*

HYPERCAPNIC- HYPOXIC TRAINING

Saunders et al. (2013). 1% Hb increase after altitude training eventually results in .6 - .7% VO2 max increase.

- Zoretić, D., Grčić-Zubčević, N. and Zubčić, K.: THE EFFECTS OF HYPERCAPNIC-HYPOXIC TRAINING.

Running
Cycling
Swimming

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).

- *Woorons X, Mucci P, Richalet JP, Pichon A. Hypoventilation Training at Supramaximal Intensity Improves Swimming Performance. Med Sci Sports Exerc. 2016 Jun;48(6):1119-28*

HYPERCAPNIC- HYPOXIC TRAINING

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

- *Woorons X, Mucci P, Richalet JP, Pichon A. Hypoventilation Training at Supramaximal Intensity Improves Swimming Performance. Med Sci Sports Exerc. 2016 Jun;48(6):1119-28*

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
- *Woorons X, Mucci P, Richalet JP, Pichon A. Hypoventilation Training at Supramaximal Intensity Improves Swimming Performance. Med Sci Sports Exerc. 2016 Jun;48(6):1119-28*

Team Sports

HYPERCAPNIC- HYPOXIC TRAINING

- To determine the effects of repeated sprint training in hypoxia induced by voluntary hypoventilation at low lung volume (VHL) on running repeated sprint ability (RSA) in team-sport players.

Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- Twenty-one highly trained rugby players performed, over a 4-week period, 7 sessions of repeated 40m sprints either with VHL (RSH-VHL, n = 11) or with normal breathing (RSN, n = 10).

Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- Repeated sprint ability (RSA), which represents the ability to reproduce performance during maximal or near maximal efforts interspersed with brief recovery intervals, is considered a key factor in team sports.

Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- First two sessions, subjects performed two sets of 8 x 40m. The number of repetitions was then progressively increased over the course of the training period (two more repetitions per week on average) to reach 3 x 8 sprints at the last session.

- Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- Each set was separated by three minutes of semiactive recovery (i.e. walking). The RSN group performed the repeated sprint training with normal breathing while RSH-VHL group completed the repetitions with VHL (except the recovery between sets which was performed with normal breathing).

- Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- Before (Pre-) and after training (Post-), performance was assessed with a RSA test (40-m all-out sprints with a departure every 30s) until task failure (85% of the peak velocity of an isolated sprint).

Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

Normal exhalation just before the start of each sprint, then to hold their breath until the end of the 40-m sprint and finally to perform the second exhalation to empty the remaining air from the lungs. (8 reps per set)

Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- The number of sprints completed during the RSA test was significantly increased after the training period in RSH-VHL (9.1 vs. 14.9) but not in RSN (9.8 vs. 10.4).but not in RSN.
- Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- Maximal velocity was not different between Pre- and Post- in both groups whereas the mean velocity decreased in RSN and remained unchanged in RSH-VHL.
- Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018

HYPERCAPNIC- HYPOXIC TRAINING

- The mean SpO2 recorded over an entire training session was lower in RSH-VHL than in RSN (90.1 ± 1.4 vs. 95.5 ± 0.5 %, $p<0.01$).
- RSH-VHL appears to be an effective strategy to produce a hypoxic stress and to improve running RSA in team sport players.
- Repeated sprint training in hypoxia induced by voluntary hypoventilation improves running repeated sprint ability in rugby players. European Journal of Sport Science · January 2018