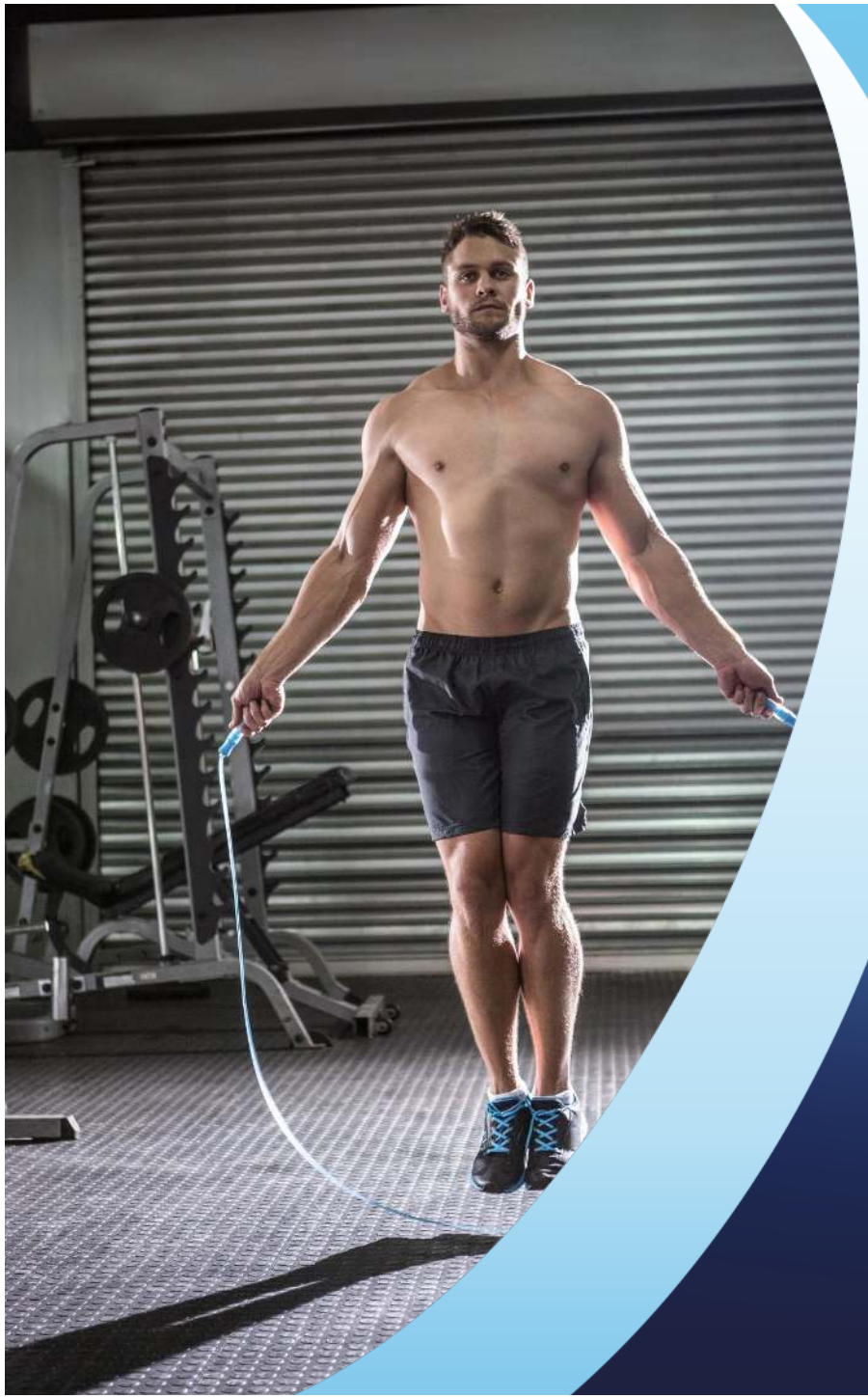
CLASS 4

OXYGEN ADVANTAGE®

BY PATRICK MCKEOWN



INCREASE AEROBIC CAPACITY

INCREASE AEROBIC CAPACITY

- Blood is made up of three parts: oxygen-carrying red cells, white blood cells and plasma.
- Hemoglobin is a protein found within the red cells.

INCREASE AEROBIC CAPACITY

- Hematocrit refers to the percentage of red blood cells in the blood. Under normal conditions, hematocrit will relate closely to the concentration of hemoglobin in the blood. Hematocrit is usually found to be 40.7- 50% for males and 36.1- 44.3% for females.

INCREASE AEROBIC CAPACITY

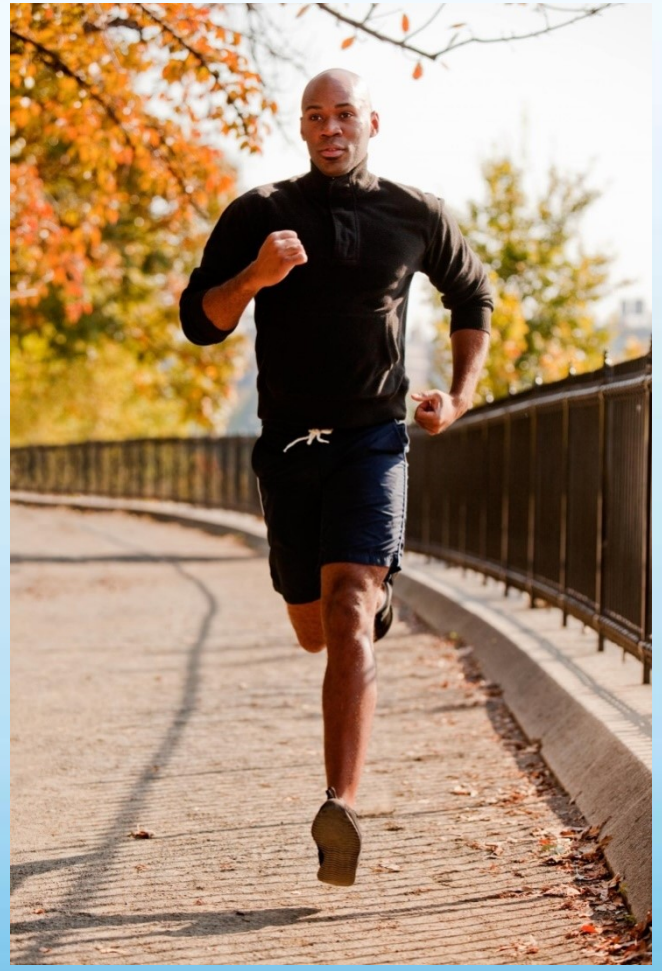
- Performance improves with an increase in hemoglobin and hematocrit, which increases oxygen carrying capacity of the blood thus improving aerobic ability.

- *J Appl Physiol. 1972 Aug;33(2):175-80. Response to exercise after blood loss and reinfusion. Ekblom B, Goldbarg AN, Gullbring B.*

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).

- 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.

THE SPLEEN

- During the breath-hold, the spleen contracts to the same extent, regardless of whether the diver is above or under water.

- 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.

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

- 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.

THE SPLEEN

- The resultant blood oxygen capacity enables an increase in O2 concentration by 2.8–9.6%.

- 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.

THE SPLEEN

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

- 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.

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).

- 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.

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).

- 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.

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%.

- *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*

APNEIC SPLEEN CONTRACTION

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

- *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*

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.

- *Schagatay E, Andersson JP, Hallén M, Pålsson B.. Selected contribution: role of spleen emptying in prolonging apneas in humans. Journal of Applied Physiology.2001;(Apr;90(4)):1623-9*

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

- Five maximal breath holdings with cold face immersion spleen contracts 20% after the first apnea and only partially recovers following 60min of recovery from the last apnea.

- Palada I**, Eterovic D, Obad A, Bakovic D, Valic Z, Ivancev V, Lojpur M, Shoemaker JK, Dujic Z.** Spleen and cardiovascular function during short apneas in divers. **J Appl Physiol** *103*: 1958–1963, 2007.

APNEIC SPLEEN CONTRACTION

- Ten trained apnea divers and 10 intact and 7 splenectomized untrained persons repeated five maximal apneas.
- Duration of apneas peaked after apnea 3 all three groups
- A rapid decrease in spleen volume (approximately 20% in both apnea divers and intact persons) was mainly completed throughout the first apnea.

- 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

APNEIC SPLEEN CONTRACTION

- For a single maximal breath holding it took 8 min for the full recovery of the splenic volume, an observation that was later confirmed by Schagatay et al.
- This slow recovery of spleen volume may contribute to the prolongation of successive apneas by increasing the pool of available red blood cells.

- Palada I, **Eterovic D, Obad A, Bakovic D, Valic Z, Ivancev V, Lojpur M, Shoemaker JK, Dujic Z.** Spleen and cardiovascular function during short apneas in divers. **J Appl Physiol** *103*: 1958–1963, 2007.

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EPO

EPO

- As a result of decreased blood perfusion, local ischaemia occurs in the kidneys, causing anoxia (absence of O2), which stimulates EPO production (Balestra et al., 2006). EPO stimulates proliferation and maturation of bone marrow's red blood cells.

- 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.

BREATH HOLDING INCREASES EPO

- The hormone erythropoietin (Epo) is essential for red blood cell (RBC) production.
- First described by the French anatomist Francois-Gilbert Viault in 1890 (Viault, 1890), who observed a rise in RBC numbers on a journey to the highlands of Peru (Morococha, about 4500 m).

- Wolfgang Jelkmann. Regulation of erythropoietin production. J Physiol. 2011 Mar 15; 589(Pt 6): 1251–1258.

BREATH HOLDING INCREASES EPO

- Epo production increases under hypoxic conditions in the kidneys and, in minor amounts, in distinct other organs such as the liver and the brain.
- Wolfgang Jelkmann. Regulation of erythropoietin production. J Physiol. 2011 Mar 15; 589(Pt 6): 1251–1258.

BREATH HOLDING INCREASES EPO

- Ten healthy volunteers
- 15 maximal duration apneas, divided into three sets of five apneas, each set separated by 10 min of rest.
- Apneas within sets were separated by 2 min and preceded by 1 min of hyperventilation to increase apnea duration and arterial oxygen desaturation.

- *(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.*

BREATH HOLDING INCREASES EPO

- Apnea started after a full exhalation and a deep, but not maximal inhalation. Subjects were instructed to try to reach below 85% SaO2 during each apnea and received continuous visual feedback on their SaO2 levels.
- *(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.*

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.*

BREATH HOLDING INCREASES EPO

- Our 24% increase in EPO is comparable to an increase of 24% found by Ge and associates (2002) after 6 h at an altitude of 1,780 m.

- *(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.*

BREATH HOLDING INCREASES EPO

- The erythropoiesis is slow, because it takes a lot of cell division. After an acute rise of EPO in the blood it takes 3-4 days until a significant higher amount of young red blood cells (reticulocytes) release from the bone marrow into the blood. Different hormones boost the EPO effect.

- Wolfgang Jelkmann. Regulation of erythropoietin production. J Physiol. 2011 Mar 15; 589(Pt 6): 1251–1258.

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Delay the onset of lactic acid & fatigue

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

- Both the hypoxic and hypercapnic effects are responsible for the rise in H+ during BH.
- CO2 accumulates within muscle - converted into HCO3-, H+ ions are automatically produced
- A proportion of H+ ions are neutralised within the muscle by buffering substances which the most important are proteins and phosphate.

REDUCED ACIDOSIS

- Increased carbon dioxide: Increased H+ and HCO3-
- 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, 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

REDUCED ACIDOSIS

- Main Buffering:
- Blood- Haemoglobin and bicarbonate
- Skeletal muscle- proteins, phosphates (60%) and to a lesser extent bicarbonate (18%)
- Possibly, enhanced buffering capacity in muscle compartments- lowering diffusion of H+ to the blood.
- Woorons X

REDUCED ACIDOSIS

Increased H+ ions in the muscle. Increased H+ ions in the blood

A STRONG ACIDITY WITHIN THE MUSCLE TISUE IS A MAJOR CONSEQUENCE OF EXERCISE WITH BH. IT IS THE MAIN CAUSE OF ADAPTATIONS THAT OCCUR AFTER BH TRAINING.

Increased acidosis. When this occurs repeatedly, adaptation mechanisms are triggered to reduce acidosis.

The buffer systems have the fastest action- enhanced blood and or muscle buffering capacity.

Woorons

INCREASED LACTATE MAX

- In breath holding following an exhalation, maximal lactate concentration (+ 2.35 ± 1.3 mmol.L-1 on average) and the rate of lactate accumulation in blood (+ 41.7 ± 39.4%) were higher at Post- than at Pre- in the three trials whereas they remained unchanged in CONTROLS.

- *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*

INCREASED LACTATE MAX

- Increased Lactate max reflects an improved anaerobic capacity and may be due to a greater ability to tolerate high concentrations of lactate and high level of acidosis, as reported after high-intensity training.

- *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*

REDUCED ACIDOSIS

- 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.

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.

- *Lemaître F, Joulia F, Chollet D. Apnea: a new training method in sport? Med Hypotheses. 2010;(Mar;74(3)):413-5*

LONG TERM EFFECTS OF BREATH HOLDING

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

- *Richardson M, de Bruijn R, Holmberg HC, et al. Increase of hemoglobin concentration after maximal apneas in divers, skiers, and untrained humans. Can J Appl Physiol 2005;30:276–81*

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.

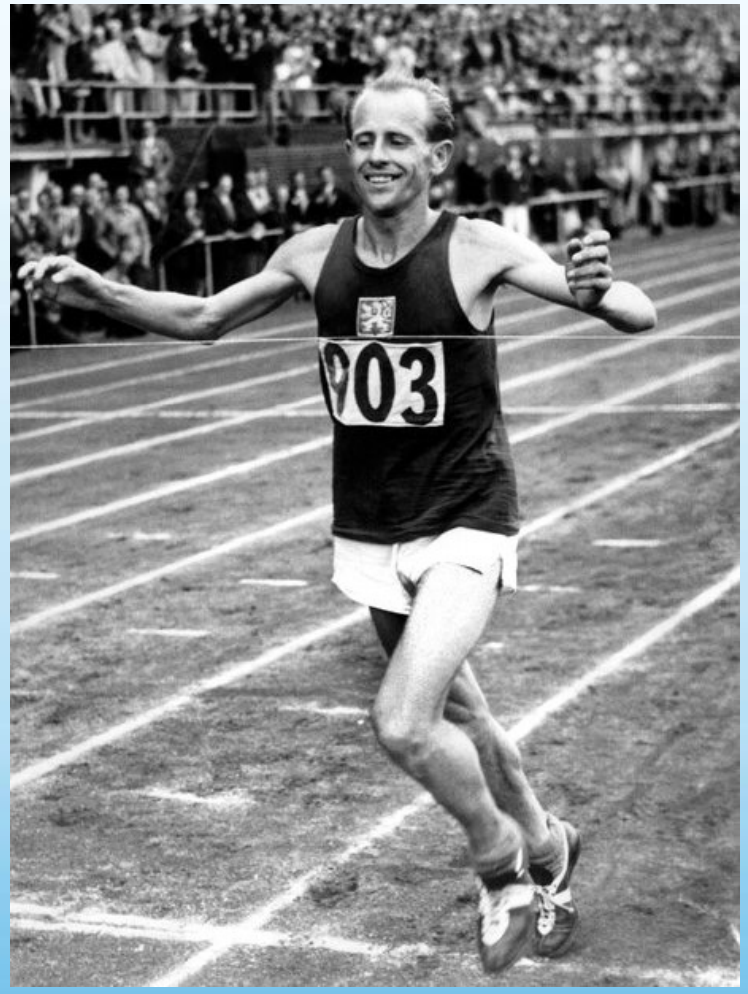
BREATH HOLDING IN PRACTISE

- 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.



BREATH HOLDING IN PRACTISE

- 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.

BREATH HOLDING IN PRACTISE

- 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.

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