Examining the paper: Hypoventilation Training at Supramaximal Intensity Improves Swimming Performance
Woorons X, Mucci P, Richalet JP, Pichon A.

HYOXIA HYPERCAPNIA

• In studies in which swimmers applied hypoventilation at high lung volume (i.e. inhale-hold), that is the classical technique used since the 1970's, no hypoxic effect occurred and lactate concentration was not different.
HYOXIA HYPERCAPNIA

- Improved performance reported after several weeks of training with reduced breathing frequency, but the changes were not greater than in the group who trained with normal breathing.

- No difference- probably because these studies used hypoventilation at high lung volume.
HYOXIA HYPERCAPNIA

• Irrespective of the lung volume, exercising with hypoventilation always caused a hypercapnic effect, that is elevated alveolar and arterial blood partial pressure of carbon dioxide (5,15,16,32,34,35,38).
HYOXIA HYPERCAPNIA

• Hypercapnia alone may not represent a sufficient stimulus to induce highly beneficial adaptations to performance, as confirmed by another study that dealt with reduced breathing frequency in biking.

HYOXIA HYPERCAPNIA

- One could expect more significant alterations when hypercapnia is combined with hypoxia. In runners, four weeks of moderate-intensity training with VHL enabled blood and probably muscle acidosis to be delayed, which could be favourable for anaerobic performance.
HYOXIA HYPERCAPNIA

• With regard to its hypoxic effect, VHL training can be considered as an intermittent hypoxic training (IHT).
HYOXIA HYPERCAPNIA

• Although some studies have demonstrated that IHT could be more effective for improving sea-level aerobic or anaerobic performance than the same training performed in normoxia (8,24,31), many others failed to find so (9,14,26,29,33).
HYOXIA HYPERCAPNIA

• When thoroughly analysing the literature dealing with IHT, it emerges that intensity *per se seems to be the key factor for improving performance.*
HYOXIA HYPERCAPNIA

- The majority of the controlled studies that reported advantageous effects used exercise intensities equal to or above the second ventilatory threshold (very high intensity exercise where blood lactate accumulates significantly more than it can be cleared).
HYOXIA HYPERCAPNIA

• Furthermore, some remarkable effects have been highlighted these last two years after training with repeated sprint (i.e short all-out exertions) in hypoxia (RSH) (11,13), which could be considered as a superior form of IHT.
HYOXIA HYPERCAPNIA

• One could assume that such results could be reproduced through VHL training at high intensity, especially since the intermittent hypercapnic effect may play an additional role in the physiological adaptations leading to improved performance.
HYOXIA HYPERCAPNIA

• In swimming, most of the competitive trials are performed at intensities beyond maximal oxygen consumption (VO2 max), thus primarily involving the anaerobic metabolism and stimulating the glycolytic fast-twitch (FT) fibers.
HYOXIA HYPERCAPNIA

• Since it appears that the effectiveness of the IHT/RSH approach is dependent on the maintenance of high FT fibers recruitment (10), the aim of the present study was to ascertain the effects of a 5-week training with VHL at supramaximal intensity (i.e. beyond VO2max) on swimming performance.
HYOXIA HYPERCAPNIA

- Sixteen triathletes (12 men, 4 women)
- Twice a week over the 5-week period, one set of 12 to 20 x 25 m front crawl swimming was included in the regular one-hour training sessions of the subjects. The number of 25-m repetitions was progressively increased over the course of the training period according to the rate of perceived exertion (RPE).
HYOXIA HYPERCAPNIA

- Depending on the performance level of the athletes, the turnaround time for each 25 m was set at 30 s or 35 s so that the resting period was always between 10 and 15 s.
HYOXIA HYPERCAPNIA

- CONT performed the whole set with normal breathing while the VHL group completed the set with hypoventilation at low lung volume.
HYOXIA HYPERCAPNIA

HYPO

Just before starting each lap, the athletes had to:

- Exhale down to functional residual capacity (passive breath out)
- Swim by holding one's breath until a strong urge to breathe
- Exhale the remaining air
- Then take an inhalation and reproduce the same exhale-hold procedure till the end of the lap.
HYOXIA HYPERCAPNIA

• It is important to note that the subjects were not recommended to hold their breath for as long as possible in order to avoid asphyxia and to maintain a high swimming velocity throughout the set.
RESULTS

• Δperf was always greater in VHL than in CONT in the three trials

• 100 m: - 3.7 ± 3.7 s vs + 0.24 ± 2.5 s

• 200 m: - 6.9 ± 5.0 s vs − 0.69 ± 5.7 s

• 400 m: - 13.6 ± 6.1 s vs − 0.27 ± 6.5 s
RESULTS

- This study was the first to investigate the physiological consequences of VHL training at supramaximal intensity in swimming as well as its effects on performance. The main result was that after 5 weeks of such training, swimming performance was significantly improved over distances of 100, 200 and 400 m.
RESULTS

• On the other hand, the same training carried out under normal breathing conditions did not alter performance in already well-trained triathletes.

• The increased [La]max and [La]Rt in the VHL group represents another original finding. It suggests that the performance improvement could be attributed, at least in part, to a greater activity of the anaerobic glycolysis.
RESULTS

• So far, the studies that investigated the effects of hypoventilation training had not convincingly demonstrated that this method could be more effective for improving performance than training under normal breathing conditions.
RESULTS

• In the present study, it is likely that the use of supramaximal intensity during VHL training played a key role in the increase in swimming performance, especially since distances over 100 and 200 m are mainly glycolytic and require high swimming speeds.
Therefore, on the basis of all the current knowledge, we suggest that for an effective VHL training, athletes should predominantly use exercise intensities at least as high as the intensity of their targeted competitive time.
RESULTS

• The increases in [La]max and [La]Rt that were recorded in all swimming trials after VHL training represent an interesting result. Such findings had never been reported so far by studies dealing with hypoventilation training.
RESULTS

• The authors concluded that VHL training could have positive effects on the anaerobic glycolysis.

• This phenomenon was probably the consequence of the combined effect of hypoxia and hypercapnia.
RESULTS

• In the present experiment, data collected during VHL training confirmed the appearance of a severe hypoxemia (SpO2 < 88%) during the 25-m repetitions. Besides it is remarkable that the levels of SpO2 were even lower than in previous studies (35,37,38), likely due to the high exercise intensities.
RESULTS

• Thus it is likely that repeated bouts of tissue hypoxia undergone during the supramaximal sets with VHL induced adaptations leading to higher [La]Rt and [La]max. The higher [La]Rt in particular is very reflective of a greater contribution of the anaerobic glycolysis (6).
• On the other hand, the increased $[\text{La}]_{\text{max}}$ 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 (20,27).
RESULTS

• It is very likely that the greater anaerobic glycolysis induced by VHL training played a role in the increased performance.