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Oxygen and Performance

Sauerstoff und Leistung

EDITORIAL

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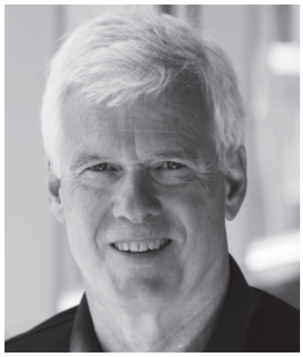
In addition to prevention and rehabilitation, elite sports are in the focus of research in sports medicine. Knowledge of adaptation mechanisms to acute stress, training and various environmental effects are often used in the development of modern training methods. In this, ethical principles must be adhered to in order to avoid transgressing the often narrow boundary to manipulation.

Since the Olympic Games in Mexico City, it is generally known that oxygen availability determines endurance performance but can also lead to extensive adaptation expressions. This is apparent in stays at high altitudes, which lead to acute changes in organ function with reduced performance and in mid-term to acclimatization processes. When ethnic groups live for long periods, sometimes over thousands of years, at high altitudes - as is the case in East Africa, the Himalayas and the Andes in South America – there are adaptations with genetic changes in addition to the acclimatization processes. The direction and extent in the three populations cited above are expressed to very different degrees and probably dependent on the length of time (between 10,000 and maximum 200,000 years) (eg. (1))). In Böning's introductory article, all segments of oxygen transport in the body is analyzed for the three high-altitude groups and their relevance for performance capacity examined. The "typical" increase in hemoglobin concentration in brief stays at high altitudes and among residents of the Andes is missing among Tibetans and some Ethiopians up to 4000 m. They compensate this by increased respiration and increased perfusion, whereby nitrogen monoxide plays an important role. A left-shift of the oxygen-binding curve, as in high-altitude animals (birds, lamas) was observed. Surprisingly, however, high-altitude origin does not seem to be the sole decisive factor for the excellent performance capacity of East African runners. Favorable anthropometric prerequisites and regular endurance training starting in the first year of school play an important role.

Lowland athletes have been trying to improve their endurance performance by high-altitude training for about 50 years. The originally-applied concept "live high – train high" was increasingly modified by combining life in hypoxia with training sessions in normoxia or vice-versa; life in normoxia with hypoxic training sessions (7). Meanwhile, hypoxia training is no longer used alone to improve oxygen transport capacity based on an increase in the erythropoiesis rate, but rather additional cellular adaptations to hypoxic stimulus is intended to improve performance in the strength and rapid-strength area. For about 6 years, the concept of "repeated sprint training in hypoxia" has been propagated in this context, which supposedly brings among other things, the team athlete performance-enhancing effects in the form of improved sprint performance in competition. The article by Millet et al. from Lausanne shows an overview of the current status of this method.

One disadvantage of training under hypoxia is the reduction of the absolute training intensity. This is the background which led to the concept of training under hyperoxia. The higher intensity and greater training volume in this could make the muscular adaptation even more effective. The admittedly still meager results available are examined in a meta-analysis by Zinner and Sperlich. After several weeks of hyperoxia training, statistically-demonstrable improvements in performance were apparent under normoxic test conditions. It thus appears that another palette of location and training methods in environments with a wide variety of oxygen contents is available to the athletes. Which training method is most effective and whether there are individual preferences cannot yet be adequately answered.

If performance improvements can be achieved by altering the environmental conditions, there is a danger that the subsequent regulation mechanisms at the cellular and molecular level might be imitated by pharmacological substances. An infamous example of this is erythropoietin, which is endogenously formed when tissues are not sufficiently supplied with oxygen, but which is also abused as a doping agent. Before erythropoietin was available as a medication, anemic states had been treated for more than three decades with oral administration of ionized cobalt, but this was beset with very severe side effects (4). Similar to under hypoxic conditions, cobalt stabilizes the hypoxia-inducible factor α (HIFα), leading to increased endogenous production of erythropoietin. Since the World Antidoping Agency (WADA) assumes that cobalt was used as a doping agent for this reason, it was included in the list of banned substances in 2015. Presently, cobalt is found in several nutrient supplements which are touted as "Performance Boosters", whereby it is often not declared or falsely declared (10). In the fourth article presented here, Schmidt et al. describe the erythropoietic effect of low-dosed cobalt and the possibility of detecting abuse. ›



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What they demand from the WADA is that limits for cobalt in urine and possibly in blood be immediately defined and systematic tests performed.

The effect desired in high-altitude training or even in blood manipulation is an increase in the erythrocyte counts and thus optimization of the oxygen transport capacity. Up to about 30 years ago, however, quantification of the erythrocyte volume was hardly possible, since only detection methods using radioactive markers were available. In 1991, the CO-reuptake method, which had been described as early as 1899, was again applied after micromethods to measure carboxy-hemoglobin in blood were developed (11) and further optimized by our research team in the successive years (3,6,9). The initial high-altitude studies in which this method was applied were published in 1997 by Böning et al. (2) and in 1998 by Gore et al. (5). Meanwhile the method has become established in sports medicine and sports physiology and extensive data material has been collected on the effect of high-altitude and hypoxia training on the formation of blood.

Measurement of the hemoglobin mass is also very important in the clinic. Anemia, which is frequently observed in intensive care, in cardiac failure and in liver diseases, can often not be differentiated by measurement of hemoglobin concentration and hematocrit values from a pseudo- or dilution anemia. During and after surgical interventions, too, both parameters are limited in their informational value. Current studies by Otto et al. (8) and others have shown in a number of diseases that determination of the erythrocyte volume and hemoglobin mass can differentiate pseudonanemia from real anemia and lead to modified therapy. It is therefore certainly to be expected that a further measuring method first applied in sports medicine will also be used in clinical medicine. ■

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