

Prof. Grégoire P. Millet

ISSUL, Institute of Sport Sciences, University of Lausanne, Switzerland

High-intensity exercise and differences between normobaric and hypobaric hypoxia : two issues revisited

Twenty years ago, the main altitude/hypoxic training method used for performance enhancement was “live high - train high” (LHTH) ^[1] in hypobaric hypoxia (HH; $F_{iO_2} = 20.9\%$; $PB < 760$ mmHg) by endurance athletes. It was modified mid-90s by the development of “live high - train low” (LHTL) ^[2]; sleeping at altitude to gain the hematologic adaptations (haemoglobin mass, Hb_{mass}) while training at sea level to maximize performance (maintenance of sea level training intensity and oxygen flux). This LHTL method can be accomplished via a number of methods and devices: natural/terrestrial altitude (HH) or in “simulated altitude” (normobaric hypoxia, NH; $F_{iO_2} < 20\%$; $PB \sim 760$ mmHg) using nitrogen dilution or oxygen filtration ^[3]. Another hypoxic intervention is “live low - train high” (LLTH) mainly in NH, including intermittent hypoxic exposure at rest (IHE) or during intermittent hypoxic training sessions (IHT). Noteworthy, most of the available studies were conducted with endurance athletes (i.e. cyclists, triathletes, cross-country skiers, runners, swimmers, kayakers, rowers). Recently, our research group challenged two points (1) that normobaric and hypobaric hypoxia can be used interchangeably, both in medicine and in sport (2) that altitude training benefits are limited to Hb_{mass} and to aerobic sports.

1. Based on the existing data ^[4] relating to differences in ventilatory responses, fluid balance, acute mountain sickness severity and/or nitric oxide metabolism, it is likely that HH induces different physiological responses than NH. Recently, we reported that both 24 h ^[5] and 18 days ^[6] of LHTL in either NH or HH differentially affect oxidative status of athletes. Furthermore, Saugy et al. ^[7] reported that LHTL (2250 – 1100 m) while sleeping in HH versus NH induced different responses and a larger performance enhancement. Sleeping pattern also differs between NH and HH ^[8].

2. Recently, we ^[9-11] defined a new hypoxic method (RSH, repeated sprint training in hypoxia) leading to improved repeated-sprint ability (RSA). Therefore, we logically proposed ^[9] to divide the LLTH paradigm in four subsets; i.e. IHE, CHT (continuous >30 min low-intensity training in hypoxia), IHT, and RSH since each method is likely based on different mechanisms; e.g. increased oxidative capacity (CHT), buffering capacity (IHT) or compensatory fiber-selective vasodilation (RSH). Faiss et al. showed larger improvements in cycling ^[12] or cross-country skiing ^[13] RSA following few (6-8) RSH sessions compared to similar training in normoxia. Finally, Brocherie et al. ^[14] reported that in elite team-sport players, the combination of LHTL and RSH (“live high train low and high”, LHTLH) for 14 days enhances both $Hb_{mass} \sqrt{VO_{2max}}$ and RSA, with the benefits lasting for at least three weeks post-intervention.

To conclude, we aim to present and discuss the recent updates on altitude/hypoxic training (advancements and limitations) and will suggest potential transfers for therapeutic use of these methods.

1. Mellerowicz H, et al. *Schweiz Zeitschrift Sportmed* 1971;Suppl:5-17
2. Levine BD & Stray-Gundersen J. *J Appl Physiol* 1997;83(1):102-12
3. Millet GP, et al. *Sports Med* 2010;40(1):1-25
4. Millet GP, et al. *J Appl Physiol* 2012;112(10):1783-4
5. Faiss R, et al. *Med Sci Sports Exerc* 2013;45(2):253-60
6. Debevec T, et al. 2015; In review
7. Saugy JJ, et al. *PLoS One* 2014;9(12):e114418
8. Heinzer R, et al. *Sleep Med* 2013;14(Suppl 1):e285
9. Millet GP, et al. *Br J Sports Med* 2013;47 Suppl 1:i6-i7
10. Faiss R, et al. *Br J Sports Med* 2013;47 Suppl 1:i45-i50
11. Brocherie F, et al. *J Strength Cond Res* 2015;29(1):226-37
12. Faiss R, et al. *PLoS One* 2013;8(2):e56522
13. Faiss R, et al. *Med Sci Sports Exerc* 2015; in press
14. Brocherie F, et al. *Med Sci Sports Exerc* 2015; in press

Contact: gregoire.millet@unil.ch