Disruptiveness in Sport Sciences – A retrospective view on recent history of altitude training

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Résumé

Introduction – In "sport sciences", as in all scientific areas, there is an exponential expansion in the volume of knowledge produced in the last decades (e.g. 87 journals in Clarivate JCR in 2013 vs. 127 in 2023). However, this is accompanied by a slowdown in innovation with research becoming less disruptive, including in "life sciences and biomedicine" (Park et al., 2023). "Standing on the shoulders of giants" does not appear to be a prerequisite for boosting future discoveries.
Methods – This talk is based on the observation of the last 30 years of controversies and findings in the "altitude training" field. We overview the continuous advancement in knowledge, and explain how/why it opened doors to "hypoxia conditioning" in clinical populations.

Results / Discussion – Four hot debates structured the development of knowledge in recent history of altitude training

- **Altitude training considered as a doping method** - in 2000s there were lively debates between those in favour of banning normobaric hypoxia (NH, simulated altitude) (Sanchis-Gomar et al., 2010) and those opposed (Boning, 2010; Levine, 2006). The "final whistle" (i.e., the recent lift of the ban by Norway and Italy, the last two countries that prohibited the use of hypoxic devices) clarified the situation.
- **Altitude training was a matter of debate on its effectiveness** – Altitude training was presented as non-effective, at least in elite endurance athletes who may have reached a "physiological ceiling" in haemoglobin mas (Hbmass)s and VO2max values (Lundby & Robach, 2016; Robach & Lundby, 2012). This viewpoint was contradicted for several reasons: First, it was partly based on inaccurate measurements (Millet et al., 2019); second, elite athletes can benefit of significant 3-4% increase in Hbmass with appropriate monitoring in altitude (Hauser et al., 2018); Third, at the recommended altitudes for training (2000-3000 m), the maladaptive responses observed at high-altitude (Dempsey & Morgan, 2015) are mainly speculative (Millet & Brocherie, 2020); fourth, altitude training is considered as "*a very important component of their training regime*" by most (75%) of the elite endurance athletes (Turner et al., 2019).
- **Simulated altitude is a surrogate of terrestrial altitude** - With the development of various NH devices/facilities, a debate opposed those who claim that barometric pressure exerts an influence on physiological responses (Millet & Debevec, 2020) and those who support the equivalent air altitude model (i.e. that only PIO2 is influential) (Richalet, 2020). Agreement was found that daily accurate report of both barometric pressure and oxygen fraction values is valuable to better assess the intra- or inter-variability in responses to hypoxia.

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- **Altitude/Hypoxic training is beneficial only in endurance sports** – For long, due to its erythropoietic effect, altitude training was recommended for endurance athletes only (Levine & Stray-Gundersen, 2005) even if non-haematological mechanisms (e.g. muscle buffering) were early reported (Gore et al., 2007). An innovative hypoxic method (repeated sprint training in hypoxia, RSH) was developed recently (Faiss et al., 2013) and is now extensively studied (> 100 articles on RSH since 2013) and used (in team-, racket- and combat sports) (Faiss et al., 2024). Based on peripheral (vascular and muscular) acute responses (e.g. microcirculatory vasodilation to compensate the lower capillary PvO2), it opens door to further protocols based on exercise in hypoxia in clinical populations (hypertensive, elderlies, peripheral artery disease,...) (Lavier et al., 2021).

Conclusions and perspectives – Disruptive findings and hot controversies were paramount in recent "altitude training" history. Scholars in "sport sciences" are encouraged to read widely, participate to stimulating debates in order to challenge the established knowledge (including mine) and "think out of the box".