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REPLY

Hypoxic dose, intensity distribution, and fatigue monitoring are paramount for "live high-train low"

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Abbreviations

HRV Heart rate variability
LHTL Live High-Train Low

Potentially important points are raised by Brocherie et al. with regard to the interpretation of our recently published findings, including that normobaric live high-train low (LHTL) does not increase time trial performance above the 3% detection limit. We address the raised concerns below.

(1) Hypoxic exposure

It is questioned whether the hypoxic dose was adequate based on current recommendations. First of all, the knowledge in the field is not strong enough to provide a general recommendation and exclude all other strategies of hypoxic exposure. The hypoxic exposure used in the present study is extensively discussed in the paper and was chosen based on existing knowledge and a feasibility criterion for the participating athletes. Obviously, we cannot rule out that another protocol would elicit a different result, but to our knowledge, no other normobaric LHTL study has demonstrated a significant improved time trial (>10 min) performance compared to a control group (see for example Siebenmann et al. 2012; Hauser et al. 2016).

The point raised that exposure to >3000 m may be detrimental to performance enhancement is based on a protocol where athletes lived at 2800 m for 4 weeks and primarily trained at 1800–3000 m, while only intense training was performed at 1250 m (Chapman et al. 2014). We argue that the protocol is incomparable to our normobaric hypoxic exposure corresponding to ~3.500 m and lasting 8 h per day for 2 weeks. Moreover, the notion that exposure to >3.000 m is detrimental to acclimatization is unsubstantiated, because acclimatization and thereby an increase in arterial oxygen saturation is likely to have been induced by the preceding 12 days exposure to 2000–2500 m (Brugniaux et al. 2006). All in all, it remains an open question whether a less hypoxic dose during the last 2 weeks of our study would have resulted in a clear performance enhancing effect albeit we hypothesize it to be unlikely.

Another concern of Brocherie et al. is whether sleeping in a tent with normobaric hypoxic air may increase sleep apneas and induce hypercapnia with suggested negative effects on acclimatization. The concerns are valid, but very little scientific knowledge exists to address the raised questions. It is of importance to note that the concern is based on findings from a single night of normobaric hypoxia. Thus, the raised concern would require further investigations.

(2) Training distribution

Brocherie et al. are also concerned that an inadequate balance of training intensity was utilized. In this regard, it is important to note that the current scientific knowledge of the interaction between hypoxic exposure and training strategy is non-existing albeit several athletes adhere to anecdotal evidence for a reduced training intensity during

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the initial exposure period. Thus, it is impossible to evaluate whether the utilized training strategy was optimal or not, but it appears unlikely that only one potentially successful LHTL training strategy exists. Moreover, low-intensity training was defined as <83% of maximal heart rate by Tonnesen et al. (2014), whereas we used <65% of maximal heart rate as cutoff in our study, which may largely explain the apparent difference.

(3) Fatigue monitoring

We appreciate the concern that inadequately balanced training and recovery may hamper adaptation. However, the numerical difference in peak power output between baseline and post LHTL is likely to be a random error more than a systematic effect, since all other performance parameters did not follow the same pattern. The statement that fatigue monitoring is recommended in elite athletes is based on a single study of heart-rate variability in 57 skiers where no evidence for an interaction between heart rate variability (HRV) indexes and adaptability or performance is provided. Although indications that training prescription based on HRV indexes may enhance the training outcome exist, no studies of the usefulness of HRV in prescribing training when combined with hypoxic exposure exist to our knowledge.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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