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Results

Hbmass increased (p<0.001) in the AG and was 797±96 g (T1), 826±110 g (T2), 852±114 g (T3), 876±120 g (T4), 897±116 g (T5) and 902±123 g (T6) as well as in the CG (p<0.001) from 766±95g (T1) to 797±90g, 833±100g (T3), 845±94g (T4), 855±95g (T5) and 868±98g (T6). There were no differences between the groups in the initial Hbmass level and in the rate of increase per year between the AG (5.2±2.1%) and the CG (5.6±4.7%). This rates of increase were highly individually different and ranged between 2.5 and 9.3% in the AG and between 1.2 and 16.9% in the CG. Correlation between increase in Hbmass and increase in body weight was r=0.81 (p<0.01). Body weight related Hbmass increased (p<0.05) during the measurement period from 12.7±1.0 g/kg (T1) to 13.1 ±1.3 g/kg (T6) in the AG as well as from 12.1±0.9 g/kg (T1) to 12.6±0.7 g/kg (T6) in the CG (p<0.05).

Discussion

Hbmass increases in male adolescents between age 16 to 18.5yrs. The increase in Hbmass is strongly correlated with the increase in bodyweight, but also body weight related Hbmass slightly increases at this age. The increase rates of Hbmass seem to be highly individually different in athletes as well as in untrained controls, while the amount of endurance training has virtually no influence on the development of Hbmass. Other unknown factors like the individual genetic predisposition may be responsible for these different increase rates among the subjects at this age. An estimation of a male athlete's Hbmass level as a senior seems therefore not possible before the end of growth (before 20 yrs).

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Hemoglobin mass response to normobaric and hypobaric altitude training in senior male athletes

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Theoretical Background

One main physiological adaptation to altitude training is an increase in hemoglobin mass (Hbmass). Recently, a meta-analysis has calculated that an increase in Hbmass of ~1.1%/100 h of hypoxic exposure at ≥2100 m can be expected (1). During the last decades, several types of altitude training have been developed, which can be performed under either hypobaric hypoxia (HH) or normobaric hypoxia (NH). Whether NH and HH can be used equally for an altitude training camp on Hbmass adaptations is still unclear.

Research Questions

Does normobaric and hypobaric altitude training evoke similar Hbmass responses and is there a substantial inter-individual variability in Hbmass response?

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Methods

To compare mean and individual Hbmass responses during an 18-day live high-train low (LHTL) altitude training camp in either NH or HH, we designed a randomized matched controlled (n=28) (2) and a crossover (n=15) (3) study with endurance athletes. To more precisely quantify the individual Hbmass response to altitude training, we implemented error-reducing duplicate Hbmass measures. Furthermore, the hypothesis that athletes with a high initial Hbmass starting an altitude sojourn will have a limited ability to further increase their post-altitude Hbmass in endurance and team-sport athletes (n=58) was tested (4).

Results

Hbmass increased similarly in HH (+4.4% and +4.5%, p<0.001) and in NH (+4.1% and +3.8%, p<0.001) following an 18-day LHTL camp. A wide range of individual Hbmass responses to altitude exposure was observed, i.e., individual responsiveness (individual variation free of technical noise) was ±0.9% in HH and ±1.7% in NH. While there was no relationship (r=0.02, p=0.91) between absolute initial Hbmass (g) and percent absolute Hbmass increase, a moderate relationship (r=-0.31, p=0.02) was detected between initial relative Hbmass (g/kg) and percent relative Hbmass increase.

Discussion

The findings indicate that hypobaric and normobaric LHTL camps evoke similar mean Hbmass increases. Among the mean Hbmass change, there was a notable variation in individual Hbmass responses between athletes, indicating the importance of individual evaluation of Hbmass responses to altitude training. Lastly, it was shown that even athletes with higher initial Hbmass can reasonably expect Hbmass gains post-LHTL.

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