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Do male athletes with already high initial hemoglobin mass benefit from 'live high–train low' altitude training?

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What is the central question of this study?

It has been assumed that athletes embarking on an LHTL camp with already high initial Hb$_{\text{mass}}$ have a limited ability to further increase their Hb$_{\text{mass}}$ post-intervention. Therefore, the relationship between initial Hb$_{\text{mass}}$ and post-intervention increase were tested with duplicate Hb$_{\text{mass}}$ measures and comparable hypoxic doses in male athletes.

What is the main finding and its importance?

There were trivial to moderate inverse relationships between initial Hb$_{\text{mass}}$ and percentage Hb$_{\text{mass}}$ increase in endurance and team-sport athletes after LHTL camp, indicating that even athletes with higher initial Hb$_{\text{mass}}$ can reasonably expect Hb$_{\text{mass}}$ gains post-LHTL.

Abstract

It has been proposed that athletes with high initial values of hemoglobin mass (Hb$_{\text{mass}}$) will have a lower Hb$_{\text{mass}}$ increase in response to ‘live high-train low’ (LHTL) altitude training. To verify this assumption, the relationship between initial absolute and relative Hb$_{\text{mass}}$ values and their respective Hb$_{\text{mass}}$ increase following LHTL in male endurance and team-sport athletes was investigated. Overall, 58 male athletes (35 well-trained endurance athletes and 23 elite male field hockey players) undertook an LHTL training camp with similar hypoxic doses (200-230 h). Hb$_{\text{mass}}$ was measured in duplicate pre- and post-LHTL with the carbon monoxide rebreathing method. While there was no relationship (r = 0.02, $P = 0.91$) between initial absolute Hb$_{\text{mass}}$ (g) and percentage increase in absolute Hb$_{\text{mass}}$, a moderate relationship (r = -0.31, $P = 0.02$) between initial relative Hb$_{\text{mass}}$ (g·kg^{-1}) and percentage increase in relative Hb$_{\text{mass}}$ was detected. Mean absolute and relative Hb$_{\text{mass}}$ increased to a similar extent ($P \geq 0.81$) in endurance (from 916 ± 88 to 951 ± 96 g, +3.8%, $P < 0.001$ and from 13.1 ± 1.2 to 13.6 ± 1.1 g·kg^{-1}, +4.1%, $P < 0.001$) and team-sport (from 920 ± 120 to 957± 127 g, +4.0%, $P < 0.001$ and from 11.9 ± 0.9 to 12.3 ± 0.9 g·kg^{-1}, +4.0%, $P < 0.001$) athletes following LHTL. The direct comparison study using individual data of male endurance and team-sport athletes and strict methodological control (duplicate Hb$_{\text{mass}}$-measures, matched-hypoxic dose) indicated that even athletes with higher initial Hb$_{\text{mass}}$ can reasonably expect Hb$_{\text{mass}}$ gain post-LHTL.

Key words: LHTL, hypoxia, CO rebreathing method

Introduction

Paragraph Number 1 Many elite endurance athletes perform altitude training with the aim to enhance their oxygen-carrying capacity and eventually their sea-level performance (Wilber, 2007; Bonetti & Hopkins, 2009; Millet *et al.*, 2010). During the last decade, hypoxic/altitude training interventions have become increasingly popular in team sports and innovative methods fitting their physical requirements (combination of aerobic and anaerobic adaptations) have been introduced (McLean *et al.*, 2014; Brocherie *et al.*, 2017). Compared to endurance athletes, team-sport athletes are generally characterised by a lower maximal aerobic capacity (Girard *et al.*, 2013) and possess lower relative hemoglobin mass ($\mathrm{Hb_{mass}}$) (Heinicke *et al.*, 2001; Wachsmuth *et al.*, 2013a). The potential main benefit derived from the popular 'live high–train low' (LHTL) altitude training intervention seems to rely on an increase in $\mathrm{Hb_{mass}}$ (Levine & Stray-Gundersen, 2005; Gore *et al.*, 2013; Wehrlin *et al.*, 2016). In a particular sport (e.g. endurance or team sports), considerable individual variation in $\mathrm{Hb_{mass}}$ response to altitude training has been reported (Friedmann *et al.*, 2005; Garvican *et al.*, 2012; Siebenmann *et al.*, 2012; Garvican Lewis *et al.*, 2013; Wachsmuth *et al.*, 2013b) and quantified as a standard deviation (SD) from the mean change of ±1.7% to ±2.2% (McLean *et al.*, 2013; Hauser *et al.*, 2017). Although sources of this variability still remain unclear, aspects such as erythropoietic response to hypoxia (Chapman *et al.*, 1998; Friedmann *et al.*, 2005), genetic predisposition (Wilber *et al.*, 2007), residual fatigue and training history (Garvican *et al.*, 2007) and/or intra-individual conditions (Wachsmuth *et al.*, 2013b) likely play a role.

Paragraph Number 2 Another suggested reason for this variability relies on the individual's initial $\mathrm{Hb_{mass}}$ level before embarking upon the altitude training camp. Hence, it has been proposed that athletes with already high initial $\mathrm{Hb_{mass}}$ have a limited ability to further increase (i.e. ceiling effect) their $\mathrm{Hb_{mass}}$ following altitude training (Gore *et al.*, 1998; Robach & Lundby, 2012; McLean *et al.*, 2013). A recent analysis of nine LHTL studies (Robach & Lundby, 2012) demonstrated a high correlation ($r = 0.86$, $P < 0.01$) between initial relative (expressed in $\mathrm{g \cdot kg^{-1}}$) $\mathrm{Hb_{mass}}$ and post-intervention percentage increase in relative $\mathrm{Hb_{mass}}$. However, this analysis had several important limitations, which limit the strength of comparison between the different LHTL training studies. First, different methods (Evans blue dye vs. CO-rebreathing methods) for the determination of $\mathrm{Hb_{mass}}$, with different accuracy/reliability levels, have been used (Wehrlin *et al.*, 2016). Furthermore, these studies examined different genders - female athletes demonstrate a 10% lower level of $\mathrm{Hb_{mass}}$ compared to male athletes (Schmidt & Prommer, 2008), and 'hypoxic doses' varied greatly – between a total of 200–500 hours of hypoxic exposure. Lastly, the data analysis was based on averaged values and not on individual values. Nevertheless, one should be cautious when interpreting group mean data since considerable inter-individual variation in $\mathrm{Hb_{mass}}$ response to altitude training exists (Friedmann *et al.*, 2005; Garvican *et al.*, 2012; McLean *et al.*, 2013; Hauser *et al.*, 2016).

Paragraph Number 3 Since LHTL is primarily used by elite endurance athletes typically presenting elevated $\mathrm{Hb_{mass}}$ values compared to team-sport athletes, the hypothesis that athletes embarking on an LHTL camp with already high initial $\mathrm{Hb_{mass}}$ have a limited ability to further increase their $\mathrm{Hb_{mass}}$ post-intervention (or at least to a lower extent than their team-sport counterparts) needs to be tested with a more robust study design. Thus, the aim of the present study, which reanalyzed already existing data, was to examine the relationship between individual initial Hb_{mass} prior to LHTL (absolute and relative values) and percentage Hb_{mass} increase following a LHTL camp with comparable hypoxic doses in male endurance and team-sport athletes.

Methods

Ethical approval

Paragraph Number 4 All altitude training studies were approved by the local ethical committees: Commission Cantonale Valaisanne d'Ethique Médicale, CCVEM (Agreement 051/09), French National Conference of Research Ethics Committees (N°CPP EST I: 2014/33; Dijon, France) and by the Anti-Doping Lab Qatar institutional review board (SCH-ADL-070; Doha, Qatar). All experimental procedures were conducted in accordance with the Declaration of Helsinki guidelines, and all athletes provided written informed consent to participate in the respective studies. The study was not registered in a database.

Study design

Paragraph Number 5 Data from three altitude training interventions (studies I, II and III), with similar hypoxic doses (200–230 h) and identical Hb_{mass} measurement procedures, were re-analysed to determine the nature of the association of individual Hb_{mass} increase the individual initial absolute and relative Hb_{mass}. The details of the experimental design of the three altitude training interventions have been published elsewhere (see Study I (Saugy *et al.*, 2014), Study II (Hauser *et al.*, 2016) and Study III (Brocherie *et al.*, 2015)).

Participants

Paragraph Number 6 For studies I and II, 35 well-trained male endurance athletes (age 24.0 ± 4.5 years, height 177.9 ± 4.8 cm, weight 70.2 ± 6.2 kg, training10-12 h per week) were recruited. For study III, 23 elite male field hockey players (age 24.4 ± 4.0 years, height 179.7 ± 9.1 cm, weight 77.5 ± 8.7 kg, training 7-9 h per week) were included. A total of 58 athletes were included in the final sample. Inclusion criteria for analysis were as follows: initial ferritin levels >30 $\mu g \cdot L^{-1}$ (sufficient ferritin stores), male (exclusion confounding factor 'gender'), endurance or team sport athlete (guarantee high and low initial Hb_{mass} values within the data analysis) and completion of an LHTL altitude training camp with all Hb_{mass} measures done in duplicate by the same investigator prior to and after the intervention.

Altitude interventions

Paragraph Number 7 For studies I and II (normobaric groups), 24 endurance athletes performed an 18-d LHTL altitude training camp under normobaric hypoxic conditions (~12.5 $h \cdot day^{-1}$ and 225 ± 9 h total hypoxic dose), during which the athletes trained at <1200 m and were exposed to normobaric hypoxia equivalent to 2250 m (Wehrlin *et al.*, 2016) in hypoxic rooms (P_iO_2 111.9 ± 0.6 mm Hg; F_iO_2 18.1 ± 0.1%; P_B 666.6 ± 3.6 mm Hg; 1150 m). For study II (hypobaric group), since normobaric and hypobaric hypoxia induces similar Hb_{mass} and endurance performance responses after LHTL altitude training (Saugy *et al.*, 2014; Hauser *et al.*, 2016), an additional 11 endurance athletes were included, who completed a 13-d LHTL camp under hypobaric hypoxic conditions with similar total hypoxic hours (230 ± 1 h, ~17.5 $h \cdot day^{-1}$). Those athletes lived at 2250 m (P_iO_2 111.7 ± 0.7 mm Hg; F_iO_2 20.9%, P_B 580.8 ± 3.3 mm Hg) and trained twice daily at < 1200 m. For study III, all 23 field hockey players performed a 14-d LHTL training camp under normobaric hypoxic conditions (> 14 $h \cdot day^{-1}$ and ~198 h total hypoxic dose); thereby they trained at sea level and slept in normobaric hypoxic rooms, and simulated altitude was gradually increased from 2500 m (P_iO_2 108.3 mm Hg; F_iO_2 15.1%, P_B 768.0 mm Hg) up to 3000 m (P_iO_2 101.7 ± 0.8 mm Hg; F_iO_2 14.2 ± 0.1%, P_B 765.3 ± 1.5 mm Hg) during the 14 days. In addition, they performed six repeated-sprints training sessions during the 14-d training camp either in normoxia (F_iO_2 20.9%; n=12) or normobaric hypoxic conditions (3000 m; F_iO_2 ~14.5%; n=11). In summary, according to the definition of Garvican-Lewis *et al.* (2016), the metrics for hypoxic dose (in km.h) between the LHTL groups were similar and differed within 6%, assuming that the present hypoxic doses were comparable (table 1).

Table 1 near here

Hemoglobin mass

Paragraph Number 8 In all athletes, Hb_{mass} was measured in duplicate using a slightly modified version (Steiner & Wehrlin, 2011) of the optimised carbon monoxide (CO)-rebreathing method described by Schmidt and Prommer (2005). For details, see Hauser *et al.* (2016) and Brocherie *et al.* (2015). Both measurements were performed on two consecutive days (12–24 h time lag between the measures), and the results were averaged. The typical error (TE) was calculated from duplicate measurements as the SD of the difference score divided by √2 (Hopkins, 2000). In our mobile laboratories, the TEs ranged between 1.6% and 2.0%. Since duplicate measurements reduce the TE by a factor of 1/√2 (Hopkins, 2000), the TEs for averaged duplicate Hb_{mass} measurements ranged between 1.1% and 1.4%. For each athlete, Hb_{mass} measures were performed by the same investigator throughout the studies.

Data analysis

Paragraph Number 9 Values are presented as means ± SD. All data were checked for normality (Shapiro-Wilk test). A sample size estimation for a power of 0.8 (80%), a significance level at $P = 0.05$ and a correlation coefficient of r = 0.4 was performed and resulted in a minimal number of 46 subjects. Linear regressions were used to determine the Pearson's product-moment correlation coefficients (r) between initial absolute and relative Hb_{mass} and their respective percent changes in Hb_{mass}, as well as for percent changes between body weight and Hb_{mass}. The standard error (SE) of the slope of the linear regression was calculated by bootstrapping. Correlation size was interpreted using the correlation classification of Hopkins (Hopkins *et al.*, 2009): trivial ($r < 0.1$), small ($0.1 < r <$

0.3), moderate ($0.3 < r < 0.5$), large ($0.5 < r < 0.7$), very large ($0.7 < r < 0.9$), nearly perfect ($r > 0.9$) and perfect ($r = 1.0$). Multiple linear regression analysis was used to determine the effect of body weight changes and initial Hb_{mass} ($g \cdot kg^{-1}$) on percent changes in relative Hb_{mass}. Paired *t*-tests were conducted to compare pre- and post-values in Hb_{mass} and body weight within the athlete group. An unpaired t-test was performed to compare percent changes between endurance and team-sport athletes. The level of significance was set at $P < 0.05$. All analyses were processed using Sigmaplot 11.0 (Systat Software, San Jose, CA) and the statistical software package R (Vienna, Austria).

Results

Relationship between initial Hb_{mass} and Hb_{mass} increase

Paragraph Number 10 There was no relationship between the absolute initial Hb_{mass} (g) and the percentage increase in absolute Hb_{mass} ($r = 0.02$, $P = 0.91$) (Figure 1 A). The linear regression equation for absolute Hb_{mass} was $y = -0.0004x + 3.5$ and the SE of the slope was ± 0.003. A moderate negative correlation between the relative initial Hb_{mass} ($g \cdot kg^{-1}$) and the percentage increase in relative Hb_{mass} ($r = -0.31$, $P = 0.02$) was observed (Figure 1 B). The linear regression equation for relative Hb_{mass} was $y = -0.98x + 16.4$ and the SE of the slope was ± 0.348. When, including body weight changes (%) to the multiple linear regression model (initial Hb_{mass} ($g \cdot kg^{-1}$) × body weight changes (%)) the initial relative Hb_{mass} ($g \cdot kg^{-1}$) was no longer significantly associated with percentage increase in Hb_{mass} ($g \cdot kg^{-1}$) ($P = 0.4$).

Figure 1 near here

Mean Hb_{mass} response

Paragraph Number 11 Mean absolute Hb_{mass} increased to the same extent in endurance (916 ± 88 to 951 ± 96 g, +3.8 ± 2.9%, $P < 0.001$) and team-sport (920 ± 120 to 957± 127 g, +4.0 ± 2.9%, $P < 0.001$) athletes ($P = 0.81$). Mean relative Hb_{mass} increased equally in endurance (13.1 ± 1.2 to 13.6 ± 1.1 $g \cdot kg^{-1}$, +4.1 ± 4.2%, $P < 0.001$) and team-sport (11.9 ± 0.9 to 12.3 ± 0.9 $g \cdot kg^{-1}$, +4.0 ± 3.2%, $P < 0.001$) athletes ($P = 0.94$).

Body weight

Paragraph Number 12 The mean pre-body weight for endurance and team-sport athletes was 70.2 ± 6 kg and 77.5 ± 9 kg, respectively, while the mean post-body weight was 70.0 ± 6 kg and 77.4 ± 8 kg, respectively. The changes pre- to post-body weight did not differ between the groups ($P \geq 0.53$). There was no relationship ($r = -0.006$, $P = 0.96$) between individual percent changes in body weight and absolute $\mathrm{Hb_{mass}}$ (Figure 2 A). A large inverse relationship (r = -0.64, $P < 0.001$) occurred between individual percent changes in body weight and relative $\mathrm{Hb_{mass}}$ (Figure 2 B). Further, the multiple linear regression model for percent changes in relative $\mathrm{Hb_{mass}}$ (initial $\mathrm{Hb_{mass}}$ ($\mathrm{g \cdot kg^{-1}}$) × body weight changes (%)) showed that percent changes in body weight were significantly associated with percent changes in $\mathrm{Hb_{mass}}$ ($\mathrm{g \cdot kg^{-1}}$) ($P < 0.001$).

Figure 2 near here

Discussion

Paragraph Number 13 To our knowledge, the present study is the first to demonstrate trivial (absolute values) to moderate (relative values) relationships between initial $\mathrm{Hb_{mass}}$ and percentage change in $\mathrm{Hb_{mass}}$ following LHTL altitude training in male endurance and team-sport athletes using individual data. Mean absolute and relative $\mathrm{Hb_{mass}}$ increased to the same extent in endurance and team-sport athletes following sport-specific LHTL interventions. Further, a large inverse relationship occurred between individual percent changes in body weight and relative $\mathrm{Hb_{mass}}$.

Effect of absolute initial $\mathrm{Hb_{mass}}$ on $\mathrm{Hb_{mass}}$ response

Paragraph Number 14 The observed trivial relationship (r = 0.02) between absolute initial $\mathrm{Hb_{mass}}$ and percentage changes in absolute $\mathrm{Hb_{mass}}$ might suggest that absolute initial $\mathrm{Hb_{mass}}$ in our athlete cohort had no impact in regard to further $\mathrm{Hb_{mass}}$ improvements following LHTL. Thus far, no study has focused on this relationship using absolute $\mathrm{Hb_{mass}}$ values, with the rationale that absolute $\mathrm{Hb_{mass}}$ values are not an indicator for an individual's maximal aerobic capacity (Gore *et al.*, 1998; Lundby *et al.*, 2012; Robach & Lundby, 2012). However, to precisely evaluate the sole effect of initial $\mathrm{Hb_{mass}}$ on $\mathrm{Hb_{mass}}$ response to altitude training both absolute and relative $\mathrm{Hb_{mass}}$ values should be assessed to exclude the confounding factor 'body weight changes' during altitude training. Further, the average percentage increase in absolute $\mathrm{Hb_{mass}}$ was of a similar magnitude in endurance and team-sport athletes (+3.8 vs. +4.0%). This increase is in accordance with LHTL studies of similar total hypoxic hours (230–240 h), showing a measurable mean absolute $\mathrm{Hb_{mass}}$ increase in elite triathletes (+3.2%) (Humberstone-Gough *et al.*, 2013) and semi-professional Australian Footballers (+6.7%) (Inness *et al.*, 2016). Furthermore, to better fit the team sport's physical requirements, some team-sport athletes in the present study performed a combination of LHTL and repeated-sprints training sessions in hypoxia, the so-called 'live high–train low and high' method (Brocherie *et al.*, 2015). However, since mean $\mathrm{Hb_{mass}}$ response did not differ between the two hypoxic groups (LHTL vs. LHTL and high), it seems that the additional hypoxic sprints had no beneficial effect on mean $\mathrm{Hb_{mass}}$ response. Overall, in the present sample absolute initial $\mathrm{Hb_{mass}}$ demonstrated no adverse effect for further absolute $\mathrm{Hb_{mass}}$ improvement following LHTL.

Effect of relative initial Hb_{mass} on Hb_{mass} response

Paragraph Number 15 We found a moderate inverse correlation between initial relative Hb_{mass} and percentage increase in relative Hb_{mass} ($r = -0.31$) following LHTL. Compared to the analysis of Robach and Lundby (2012) and a classic altitude training study on Australian footballers (McLean *et al.*, 2013), the present correlation coefficient was much smaller than in those studies ($r = -0.51$ to -0.86). The above mentioned studies suggested that athletes starting with high relative Hb_{mass} levels have smaller chances to further increase their relative Hb_{mass} following altitude training, with the rationale that those athletes would already have maximized their relative Hb_{mass} level by training at sea level (Robach & Lundby, 2012; McLean *et al.*, 2013). However, in the present study it seems that the moderate inverse relationship between initial relative Hb_{mass} and percent change in relative Hb_{mass} could not be attributed to the physiological limit of an athlete.

Paragraph Number 16 Changes in an individual's body weight from pre- to post- intervention could explain the moderate relationship between initial relative Hb_{mass} and its percentage Hb_{mass} increase following LHTL. There was a large inverse relationship ($r = -0.64$) between individual percent changes in body weight and relative Hb_{mass}, whereas no relationship between individual percent changes in body weight and absolute Hb_{mass} occurred. Further, percent changes in body weight were significantly associated with percent changes in relative Hb_{mass} ($P < 0.001$) in contrast to initial relative Hb_{mass} ($P = 0.4$). This assumes that, primarily, individual changes in body weight from pre- to post LHTL camp led to the moderate relationship between initial relative Hb_{mass} and percent change in Hb_{mass} following LHTL camp. Whether the body weight changes were due to alterations in fat and/or muscle mass or because of the weekly fluctuation in body weight/fluid (Orsama *et al.*, 2014) remains unclear. With a lack of significant relationship between individual changes in body weight and absolute Hb_{mass}, it can be assumed that body weight alterations did not negatively influence absolute Hb_{mass} response in the present study. Thus, we propose that lean body mass-adjusted relative Hb_{mass} values would be a better unit for future comparisons.

Paragraph Number 17 A further point that must be considered when assessing the relationship between change and initial values, is the statistical phenomon 'regression to the mean' (Galton, 1886; Bland & Altman, 1994). Although in the present study there was no relationship between initial absolute Hb_{mass} and percent changes in absolute Hb_{mass}, the 'regression to the mean' effect could have still appeared. Further, since individual changes in body weight from pre- to post-LHTL camp occurred, it could also be possible that the 'regression to the mean' effect arose within the relationship between initial body weight and body weight changes. This makes the speculation that part of the inverse relationship between initial relative Hb_{mass} and percent changes in relative Hb_{mass} following LHTL camp could be due to the statistical phenomenon 'regression to the mean'. However, this needs to be confirmed with a larger dataset, involving athletes of different performance levels and from various sport disciplines as well as using different altitude training paradigms with various characteristics (e.g., duration, altitude severity, hypobaric vs. normobaric hypoxia). Lastly, one should also keep in mind that the chosen metric for total 'hypoxic dose', i.e., 'kilometre hours' (Garvican Lewis *et al.*, 2016), is still debated in the literature (Millet *et al.*, 2016).

Conclusion

Paragraph Number 18 Our results indicate that trivial (absolute values) to moderate (relative values) relationships occurred between initial Hb_{mass} and Hb_{mass} increase following LHTL altitude training in endurance and team-sport athletes. This indicates that even athletes with higher initial Hb_{mass} can reasonably expect Hb_{mass} gains post-LHTL. Further, it seems that in the present study the moderate relationship between initial relative Hb_{mass} and percentage increase in relative Hb_{mass} following LHTL could be attributed to changes in body weight and possibly to the statistical phenomenon 'regression to the mean', rather than to a pure physiological effect.

Additional information

Conflict of Interest

The authors have no conflicts of interest.

Author Contributions

All authors performed the research and analysed or interpreted the data for the work. JPW, GPM, OG, LS and AH conceived and designed the research. AH, ST, JPW and GPM drafted the manuscript. All authors edited and revised the manuscript critically and approved the final version of the manuscript. All authors agree to be accountable for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed.

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Table 1. Characteristics of the altitude training interventions

Data source	n	Sport	Altitude mode	Hypoxic mode	Altitude (m)	Duration (days)	Daily exposure (h)	Hypoxic dose (h)	Hypoxic dose (km.h)
Study I & II	24	triathlon	LHTL	NH	2250	18	12.5	225	506
Study II	11	triathlon	LHTL	HH	2250	13	17.5	230	518
Study III	11	hockey	LHTL	NH	2500-3000	14	14	200	545
	12	hockey	LHTL+RSH	NH	2500-3000	14	14	200	545

LHTL = live high-train low; RSH = repeated-sprints in hypoxia; NH = normobaric hypoxia; HH = hypobaric hypoxia.

Figure legends

Figure 1. (A) Linear regression between the individual's initial absolute Hb$_{mass}$ (g) and the individual's absolute Hb$_{mass}$ change (%) following LHTL. **(B)** Linear regression between the individual's initial

relative Hb_{mass} (g/kg) and the individual's relative Hb_{mass} change (%) following LHTL. Regression slope (solid line) and 95% confidence limits (dashed lines) are shown. n = 58. LHTL = live high–train low, RSH = repeated-sprints in hypoxia, NH = normobaric hypoxia, HH = hypobaric hypoxia.

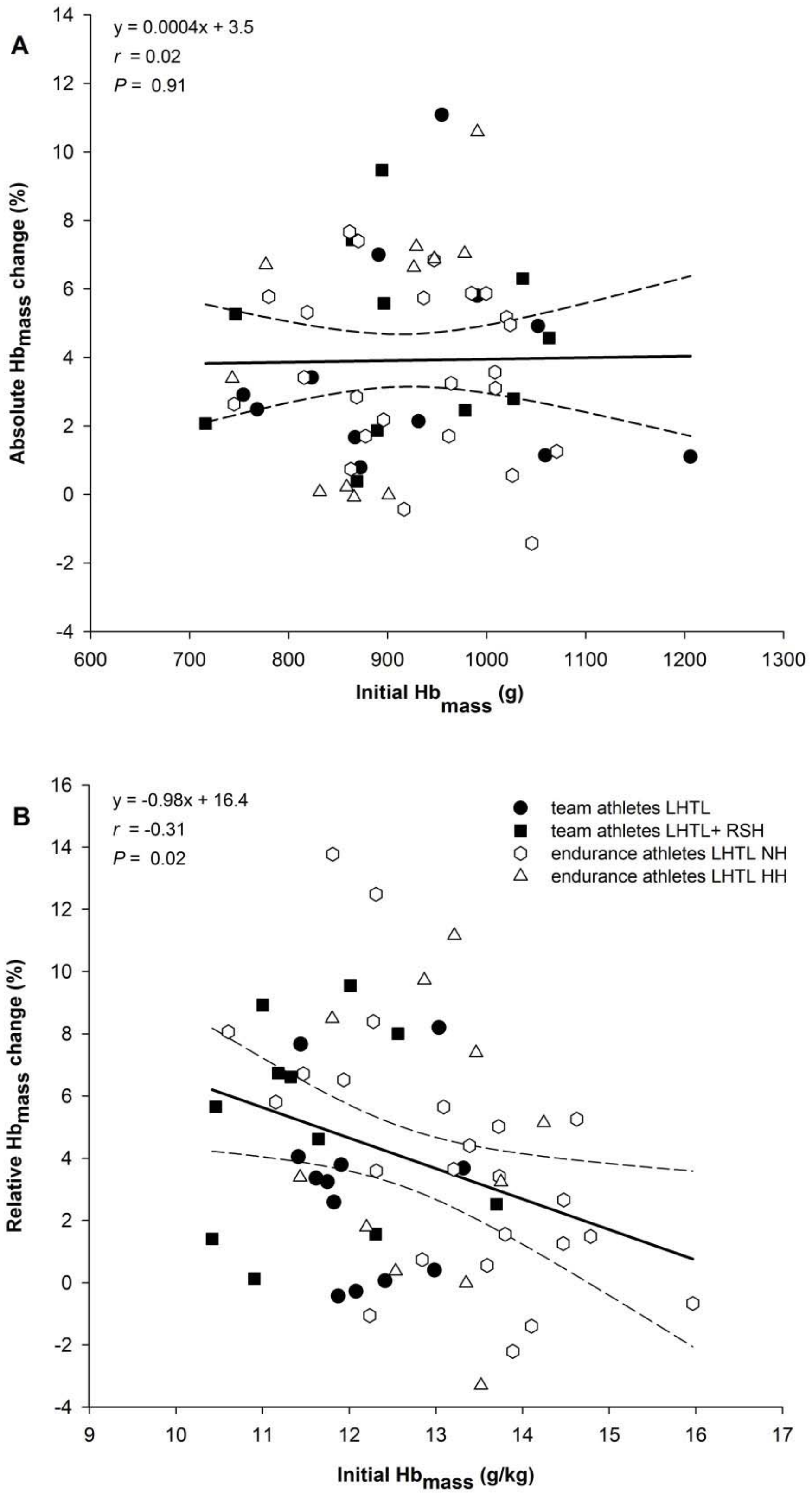

Figure 2. Linear regression between individual body weight change (%) and **(A)** individual absolute Hb_{mass} change (%) and **(B)** individual relative Hb_{mass} change (%) following LHTL. Regression slope (solid line) and 95% confidence limits (dashed lines) are shown. n = 58.