Exercise-induced increase in hemoglobin concentration at intermediate and high altitudes in Andeans, Tibetans and Han Chinese

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An acute increase in hemoglobin concentration ([Hb]) has been previously reported under the condition of exercise-induced hypoxemia in sea-level individuals and has been attributed to splenic contraction.

To determine whether, and to what extent, [Hb] changes in response to exercise in long-term residents at high altitude, we compared hemoglobin concentration pre- and post- exercise in male Andean (n = 14; 4330 m) and Tibetan (n = 21; 4200 m) native highlanders, whose ancestors have resided for hundreds of generations at altitude, as well as Han Chinese (n = 9; 4200 m) high-altitude residents. In the latter two populations, we further examined male (Tibetan n = 10; Han n = 8) and female (Tibetan n = 9; Han n = 10) individuals both at a resident altitude of 2200 m and simulated altitude of 4200 m in a hypobaric chamber.

For both studies during exercise, we measured subjects' hemoglobin concentration at resting state ($[\mathrm{Hb}]_r$), submax exercise levels ($[\mathrm{Hb}]_s$), and peak exercise ($[\mathrm{Hb}]_p$), as well as their Cardiac Output (QT), VO_2 and body weight index (BMI) and compared 1) $[\mathrm{Hb}]_m - [\mathrm{Hb}]_r$, denoted as $\Delta[\mathrm{Hb}]$, for male Andeans at 4300 m, male Tibetans and Han Chinese resident at 4200 m, male and female Tibetans and Han Chinese resident at 2200 m and under simulated 4200 m.

[Hb] significantly increased after exercise in all groups. For male Andeans at 4300 m, $\Delta[\mathrm{Hb}]$ is significantly greater (1.11 g/dL, $p < 0.001$).

At 2200 m, the change in $[\mathrm{Hb}]$ is significantly greater than zero ($p < 0.001$) at 1.09 g/dL and 0.94 g/dL for male Han Chinese and Tibetan, respectively, and 1.17 g/dL and 1.01 g/dL for female Han Chinese and Tibetans, respectively.

At 4200 m, the change in $[\mathrm{Hb}]$ is also significantly greater than zero ($p < 0.001$) at 1.20 g/dL and 0.87 g/dL for male Han Chinese and Tibetans, respectively, and 0.90 g/dL and 0.69 g/dL for female Han Chinese and Tibetans, respectively.

Post-exercise increases in [Hb] are more pronounced in Han Chinese and Tibetan males at 2200 m versus 4200 m ($p = 0.004$, $p < 0.001$) than in female ($p > 0.11$, $p > 0.49$). There is no significant correlation between $\Delta[\mathrm{Hb}]$ and BMI nor $[\mathrm{Hb}]_r$. In conclusion, we observed an increased [Hb] at high altitude among Andeans, Tibetans and Han Chinese. The trend persisted in the latter two populations at intermediate altitude. Thus, measurement of [Hb] in-situ during hypoxia/exercise experiments are important to incorporate in studies of O2 transport.