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

[1]Gu W, [2]Wuren T, [3]Villafuerte FC, [2]Wei G, [3]Anza-Ramirez C, [3]Vizcardo-Galindo G, [1]Wagner HE, [2]Qin G, [2]Yan M, [3]Macarlupu JL, [1]Wagner PD, [2]Ge RL, [1]Simonson TS

[1]Department of Medicine Division of Physiology, University of California San Diego, La Jolla, CA, USA, [2]Research Center for High-Altitude Medicine, Qinghai Medical College, Xining, Qinghai, People's Republic of China, [3]Departamento de Ciencias Biológicas y Fisiológicas, Universidad Peruana Cayetano Heredia, Lima, Peru.

An acute increase in hemoglobin concentration ([Hb]) up to 1.6 g/dL has been previously reported under the condition of exercise-induced hypoxemia in sea level individuals with COPD (Schagatay et.al 2015). Changes in [Hb] have been attributed to splenic contraction.

To determine whether, and to what extent, [Hb] changes ACUTELY in response to exercise in long-term residents at high altitude, we compared hemoglobin concentration AT REST and DURING 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.

We measured [Hb] at rest ($[\mathrm{Hb}]_{\mathrm{r}}$), and peak exercise ($[\mathrm{Hb}]_{\mathrm{p}}$), as well as blood oxygen saturation ($S_a\mathrm{O}_2$), cardiac output (QT), VO_2 and body mass index (BMI) and compared $[\mathrm{Hb}]_{\mathrm{m}} - [\mathrm{Hb}]_{\mathrm{r}}$, 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 with exercise in all groups (P < 0.001 each) except for Han Chinese and Tibetan females at 4200 m. For male Andeans at 4300 m, $\Delta[\mathrm{Hb}]$ was 1.11 g/dL. For Han Chinese and Tibetans at 2200 m, $\Delta[\mathrm{Hb}]$ was 1.09 g/dL and 0.94 g/dL, respectively (males), and 1.17 g/dL and 1.01 g/dL respectively (females). For Han Chinese and Tibetans at 4200 m, $\Delta[\mathrm{Hb}]$ was also significant (p < 0.001) at 1.20 g/dL and 0.87 g/dL respectively in males, but in females the increases were not. No significant difference of $\Delta[\mathrm{Hb}]$ is observed across different ethnic groups regardless of sex at high altitude.

The correlation between $\Delta[\mathrm{Hb}]$ and $S_a\mathrm{O}_2$ at maximum exercise level is found to be positive in the Andeans (p = 0.007) and not detected in Tibetans or Han Chinese. In addition, there is no significant correlation found between $\Delta[\mathrm{Hb}]$ and BMI, $[\mathrm{Hb}]_{\mathrm{r}}$, QT_{max} or VO_{2max}.

In conclusion, we observed an exercise-induced increased [Hb] among Andeans, Tibetans and Han Chinese at high altitude and Tibetans and Han Chinese only at intermediate altitude. Thus, measurement of [Hb] in-situ during hypoxia/exercise experiments are important to incorporate in studies of O2 transport. Furthermore, larger $\Delta[\mathrm{Hb}]$ can be potentially beneficial to maintaining higher oxygen saturation at high altitude during acute exercise.