Name of research institute or organization:

Institute of Sport Sciences, University of Lausanne

Title of project:

Performance and physiological responses in acute hypoxia: normobaric vs. hypobaric hypoxia

Project leader and team:

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Project description:

The main objective of this study was to identify the magnitude of the differences in physiological responses and performance during exercise in normobaric (NH) vs. hypobaric (HH) hypoxia. To assess the mechanisms involved in such differences, we hypothesized that there is a relationship between changes in NO metabolism and oxydative stress inducing different vascular and endothelial responses and secondly, different systemic responses. In addition, this study aimed at determining the practical significance of the potential cardio-vascular and respiratory differences on endurance performance; e.g. cycling time-trial (TT of 250 kJ).

16 trained subjects spent 3 sessions of ~ 26 h in a randomized order in the following conditions:
1/Hypobaric Hypoxia (HH): at the JungfrauJoch, 3570m, FiO2 = 20.93%, PiO2= 94.2 mmHg
2/Normobaric Hypoxia (NH): in an hypoxic chamber (CRR, Sion or CSS, Lausanne) at 500m, FiO2 = 13.2%, PiO20 94.2 mmHg
3/ Normobaric Normoxia (NN) - Blind control condition - in the hypoxic chamber. FiO2 = 20.93%, PiO2= 150 mmHg.

After 24 h of passive rest and measurement of resting passive values each 8 h, the subjects performed a TT where several parameters were recorded as gaz exchanges, time, pulsative oxygen saturation (SpO_2), lactate, Rate of Perceived Exercice. The output power and the pedaling frequency were also assesed.

Main results on the ergocycle time trial (TT):

The total time of the TT was significantly longer in NH and HH than in NN (+ 24.1 ± 9.6 and + 33.2 ± 12.4% for NH and HH respectively, $P<0.001$). In addition, this time was also longer in HH than in NH (+ 7.5 ± 7.5%, $P<0.01$). See figure 1.

The mean oxygen saturation was significantly lower in NH and HH than in NN (-16.9 ± 3 and -20.4 ± 5.5% for NH and HH respectively, $P<0.001$). In addition, the SpO_2 was also lower in HH than in NH (-4.2 ± 6.1%, $P<0.05$). See figure 2.

The TT was then divided in 25 intervals of 10 kJ for assessing different pacing strategies. In the NN condition, subjects constantly increased the effort intensity, as can be seen by the constant decrease in time by 10kJ slices from 20 to 250 kJ. For the hypoxic conditions, the subjects started with high intensity and tended to decrease along the TT. NN was significantly different from NH and HH with shorter time by slices of 10 kJ all along the TT. In addition,

we found differences between NH and HH at the end of the TT. For more details, see figure 3.

There was a difference in the SpO2 mean between NN and the two hypoxic conditions. In addition, we found significant differences at the beginning of the TT (from kJ 10 to 130) between NH and HH. For more details please see figure 4.

With these preliminary results, we can conclude that HH is different than NH and induce a more altered endurance performance. Real altitude appears as more physiologically demanding than simulated altitude for the same ambient PO2.

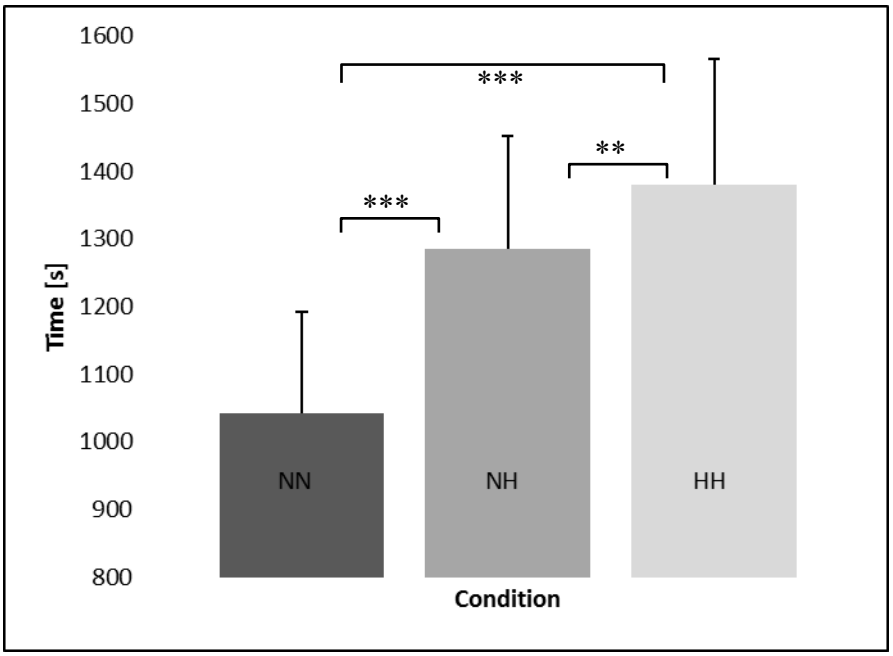

*Figure 1. Performance in seconds on the Time Trial of 250 kJ for each condition. With NN: normobaric normoxia, NH: normobaric Hypoxia, HH: hypobaric hypoxia. ***P<0.001, **P<0.01 for differences between conditions.*

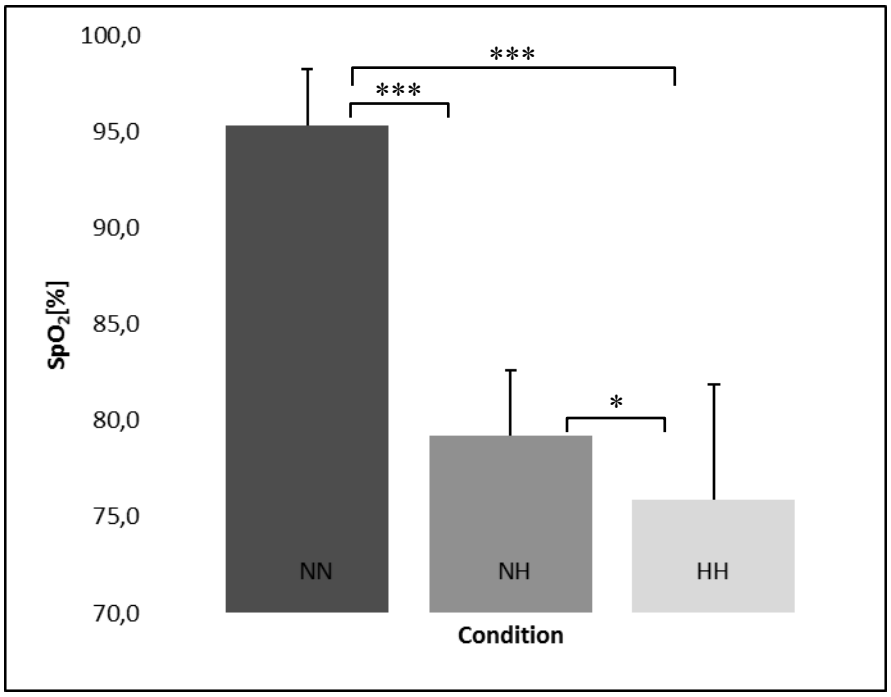

*Figure 2. Mean of peripheral oxygen saturation during the Time Trial of 250 kJ for each condition. With NN: normobaric normoxia, NH: normobaric Hypoxia, HH: hypobaric hypoxia. ***P<0.001, *P<0.05 for differences between conditions.*

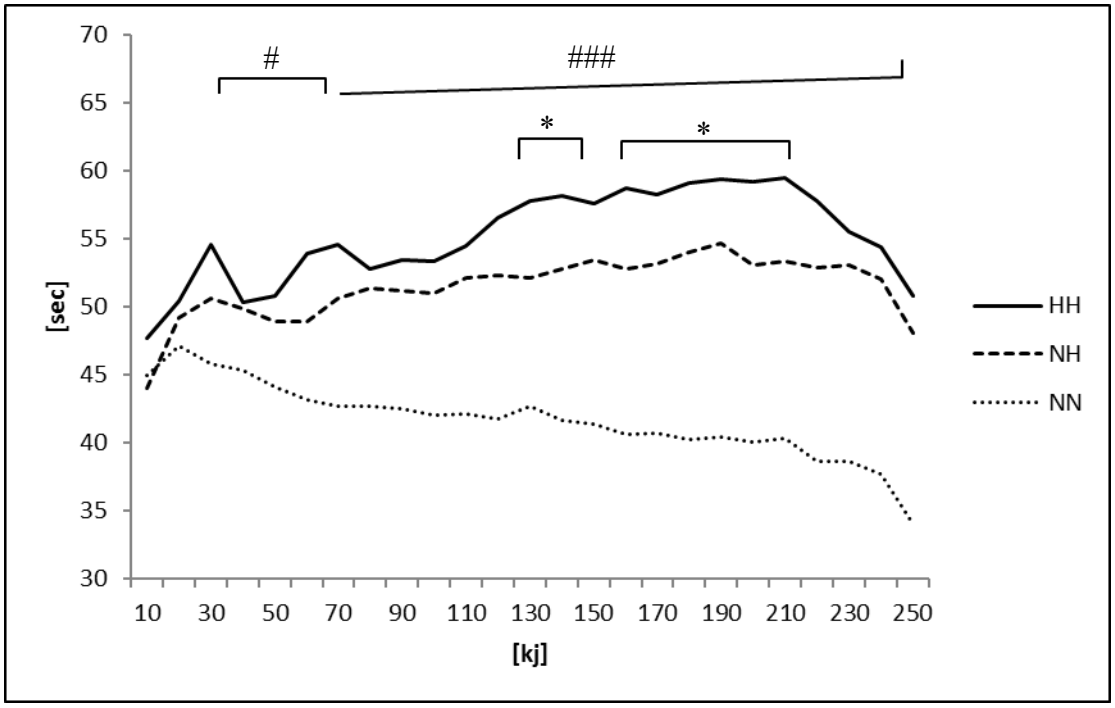

*Figure 3. Evolution of the time by intervals of 10 kJ during the Time Trial of 250 kJ for each condition. With NN: normobaric normoxia, NH: normobaric Hypoxia, HH: hypobaric hypoxia. *P<0.05 for differences between NH and HH. ###P<0.001 and #P<0.05 for differences between NN and the hypoxic conditions.*

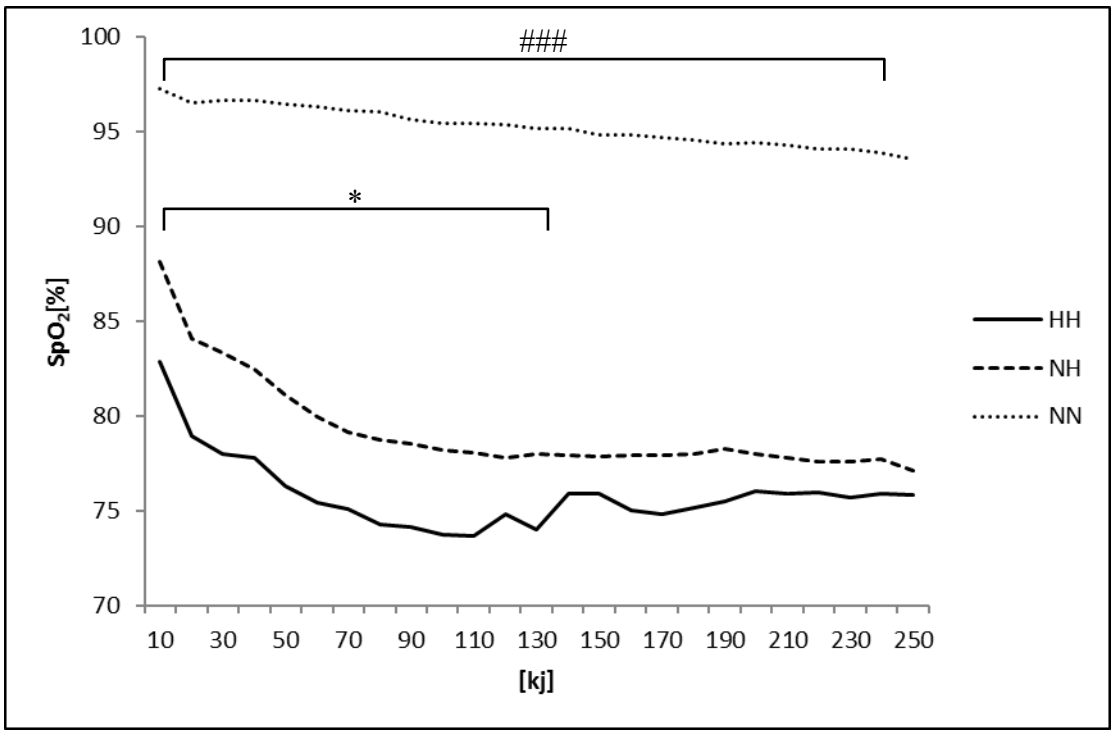

*Figure 4. Evolution of the peripheral oxygen saturation by intervals of 10 kJ during the Time Trial of 250 kJ for each condition. With NN: normobaric normoxia, NH: normobaric Hypoxia, HH: hypobaric hypoxia. *P<0.05 for differences between NH and HH. ###P<0.001 for differences between NN and the hypoxic conditions.*

Key words:

Normobaric hypoxia, hypobaric hypoxia, exercise physiology, performance, altitude

Collaborating partners/networks:

University of Lausanne, University of Geneva, SUVA CRR Sion

Scientific publications and public outreach 2013:

Conference papers

Heinzer R., Saugy J., Tobback N., Rupp T., Haba-Rubio J., Millet G.P. (2013), Effects of Real vs Simulated Altitude on Sleep and Sleep Disordered Breathing, 5th World Congress on Sleep Medicine, Valencia, Spain, 28 Sept – 2 Oct, 2013.

Radio and television

"CQFD: entrainement en altitude", Interview with physiologist Grégoire Millet, Jonas Saugy and Raphael Faiss, UNIL Lausanne at Jungfraujoch by Stéphane Délétroz, Radio RTS, "CQFD", March 18, 2013.

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