Heart rate variability ¿A predictor of aerobic work capacity in hypobaric hypoxia?

Carla Edith Basualto

Lab. Ambientes Extremos, Progr. de Fisiología y Biofísica, ICBM, Fac. Med., Univ.de Chile

Tutors: Claus Behn (Universidad de Chile) and Ginés Viscor (Universitat de Barcelona)

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Aerobic work capacity appears to be diminished in newcomers to high altitude (Cerretelli, 2001; Grant et al., 2002; Basnyat & Murdoch, 2003; Calbet et al., 2003). Understanding the decrease of aerobic work capacity at high altitude (HA) opens perspectives in order to optimize human tolerance to the latter condition. Heart rate variability (HRV) is investigated in the present study as a potentially predictive parameter of human tolerance to HA, particularly whether HA induced changes in HRV interrelate with concomitant changes in oxygen transport and/or utilization. HRV is already considered as an indicator of integral functional reserve of the cardiovascular system (Malik et al., 1996). HRV can easily be measured and evaluated under conditions of hypobaric hypoxia, both in the field, as well as under laboratory conditions (Bernardi et al., 1998, Cornolo et al., 2004, Guger et al., 2005). 27 healthy, early adult volunteers of both genders, distributed in three groups, were studied both under field conditions, as well as, in the laboratory (hypobaric hypoxia vs. normobaric hypoxia) including the application of a standardized test of tolerance to hypoxia (Ricart et al., 2005). Hypobaric hypoxia effects were additionally studied concerning their possible modification by Sildenafil (100mg in a single oral dosis). Maximal oxygen consumption (VO2max) was measured with a portable spirometer (Metamax 3B) on a Monark cycloergometer (Monark). For HRV registration a Polar® s810i heart rhythm monitor was applied. HRV data were evaluated with the help of “Software Polar S-series Precision Performance Version 4.02.034 (Polar®) and “HRV Analysis Software 1.1” (Kuopio University, Finland).

VO2max diminished by exposure to HA (group 1) from 50.4 ± 3.74 ml/kg/min at 680 m asl to 44.5 ± 4.41 ml/kg/min at 2,800 m asl (p<0.05). HRV changes by HA exposure (pNN50) appeared to be related to concomitant changes of VO2max (r = -0.74 ; p<0.05). Absolute HRV values (pNN50) at 680 m asl (M1) appeared to be related (r = -0.75; p<0.05) with HA induced changes of this parameter (M2-M1). In group 2, HRV (SDNN) appeared directly to be related with oxygen saturation of hemoglobin (SatO2) as observed under resting conditions in hypobaric hypoxia. In normobaric hypoxia, on the contrary, above relation is not observed. Under exercise conditions in hypobaric hypoxia (r = -0.81; p<0.05), as well, as in normobaric hypoxia (r = -0.78; p<0.05) SatO2 and HRV (HF%) appear inversely to be related. An inverse relation was also observed between SatO2 under exercise conditions in hypobaric hypoxia and HRV (HF%) previously registered in normoxia (r = -0.82 ; p<0.05). SatO2, as measured under exercise conditions in normobaric hypoxia did not correlate with previously under normoxic conditions registered HF(%). At an altitude of 5,000 m asl, simulated in an hypobaric chamber, SatO2 under resting conditions, appeared directly to be related with HRV (HFun) as previously registered under normoxic conditions. This relation does not change under the influence of Sildenafil. HRV evaluated as HF(un) under normoxic conditions appears to be related with HA induced change in SatO2 (r = 0.76 ; p< 0.05). Under the influence of Sildenafil above relation is lost. Oxygen consumption (VO2) and CO2 production (VCO2) under resting conditions at 5,000 m asl and under placebo, appear inversely to be related with HF(un) as previously registered under normoxic conditions (r = -0.76 ; p<0.05 and  r = -0.93 ; p<0.01, respectively). The latter relation appears to be lost under the influence of Sildenafil.

HRV and oxygen transport and/or utilization parameters appear to be related under given circumstances of exposure to hypobaric hypoxia, as observed in three different experimental models. Above relations appear under conditions where oxygen availability can be expected to be particularly low. An increase in oxygen availability (normobaric hypoxia, as compared to hypobaric hypoxia and Sildenafil application) implicate the loss of above relations. It is concluded that HRV, as analized in the time and frequency domain, shows some relation with certain parameters referring to oxygen transport and/or utilization under conditions of low oxygen availability. Such relations underscore the potential of HRV as a parameter possibly to be applied in prediction and follow up of tolerance to aerobic work at HA.-