Research on Heart Rate Variability in the Prediction of Acute Mountain Sickness

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1. Project Description

In the summer of 2019 a total of ten students from the Ludwig-Maximilian-University in Munich visited the research station at the Jungfraujoch in Switzerland in order to investigate the changes in autonomic nervous activity in the human body taking place when going from normoxic to hypoxic conditions. The aim of these investigations was the examination of a possible relationship between those autonomic changes and the occurrence of acute mountain sickness (AMS) during the three day stay at the Jungfraujoch. Results could then possibly become a useful component in prediction of AMS before an actual stay at high altitude.

A series of parameters reflecting the activity of the autonomous nervous system had already been measured under normoxic, as well as normobaric hypoxic conditions back in Munich. For the latter, an altitude generator producing oxygen-deficient air equivalent to an altitude of 4000m had been used. The parameters measured comprised the heart rate, the arterial blood pressure, the peripheral oxygen saturation as well as the heart rate variability (HRV). Focus was put on the heart rate variability since this parameter has lately not only gained centre stage in research on autonomic nervous activity but has also entered the field of high altitude medicine. Broadly speaking, HRV parameters can be divided in such reflecting parasympathetic activity and such showing activity of the sympathetic branch of the autonomous nervous system. The so called "Total Power" (TP) of HRV mirrors the ANS activity as a whole.

The students were between 22 and 31 years old and female and male in equal shares. All of them felt well upon arrival at the lower terminus of the mountain railway in Grindelwald, Switzerland. During the course of the stay at the research station, however, a total of seven should develop AMS, which was diagnosed using the Lake Louise Symptom Score.

Results were collected on day two and three in the morning, i.e. after the first and second night spent at high altitude.

The conducted research resulted in the main finding of a higher adaptability of the autonomous nervous system of those subjects staying healthy during the stay at high altitude. This conclusion was drawn from higher differences between the values measured under normoxic and hypoxic conditions with nearly all of the obtained parameters, excluding the heart rate and the peripheral oxygen saturation. Most importantly, all of the four main HRV parameters obtained reflected this observation. The assumption behind these findings is that, in order to adapt to the new and unfamiliar hypoxic conditions, the ANS has to alter all of the parameters above. The greater the change, the greater its ability to help the human body adapt to the new conditions.

Due to the small sample size, no assertion can be made regarding the statistical significance of these results. They do, however, possibly constitute an interesting starting point for further research on the relationship between impaired autonomous nervous activity and the development of AMS.

2. Figures

All of the differences below were calculated, subtracting the value measured in normoxia from the value measured under hypobaric hypoxic conditions at the Jungfraujoch.

dTP (ms^2)			AMS-	AMS+
	N	Valid	3	7
		Missing	0	0
	Mean		-3989,3333	-452,2857
	Minimum		-12177,50	-990,00
	Maximum		1292,00	702,00

Table 1. Difference of Total Power (TP) of HRV between normoxic and hypobaric hypoxic conditions. Differences are greater among those subjects not developing AMS symptoms during the stay at Jungfraujoch suggesting greater adaptability of the ANS.

dHRV_LF (ms^2)			ABK-	ABK+
	N	Valid	3	7
		Missing	0	0
	Mean		-1057,3333	-150,5000
	Minimum		-3695,00	-835,00
	Maximum		*803,00*	*763,00*

Table 2. Difference of Low Frequency Power (LF-Power) of HRV between normoxic and hypobaric hypoxic conditions. The LF-Power is frequently being used as a parameter reflecting the sympathetic branch of the ANS. Greater differences among the healthy subjects

suggest greater changes in sympathetic activity within this group compared to subjects developing AMS.

dHRV_HF (ms^2)			ABK-	ABK+
	N	Valid	3	7
		Missing	0	0
	Mean		-2914,3333	-246,3077
	Minimum		-8204,50	-683,50
	Maximum		184,00	200,50

Table 3. Difference of High Frequency Power (HF-Power) of HRV between normoxic and hypobaric hypoxic conditions. The HF-Power is an indicator of parasympathetic activity. There is greater change in parasympathetic activity within the group of healthy individuals.

dHRVratio (LF/HF ratio)			ABK-	ABK+
	N	Valid	3	7
		Missing	0	0
	Mean		1,6603	1,0909
	Minimum		0,67	-1,08
	Maximum		3,23	3,39

Table 4. Difference of the LF/HF ratio between normoxic and hypobaric hypoxic conditions. A great LF/HF ratio indicates a predominantly sympathetic influence, whereas a small LF/HF ratio is a sign of mostly parasympathetic activity. A greater positive result after subtraction of the value in normoxia of the value in hypoxia shows a greater shift towards sympathetic activity among the healthy individuals.

dBP_syst (mmHg)			AMS-	AMS+
	N	Valid	3	7
		Missing	0	0
	Mean		6,5000	3,2857
	Minimum		-2,00	-14,50
	Maximum		19,50	12,50

Table 5. Difference of systolic arterial blood pressure between normoxic and hypobaric hypoxic conditions. Systolic blood pressure varies less with subjects developing AMS symptoms.

dBP_dia (mmHg)			AMS-	AMS+
	N	Valid	3	7
		Missing	0	0
	Mean		13,5000	5,8571
	Minimum		6,00	-6,50
	Maximum		21,00	14,00

Table 6. Difference of diastolic arterial blood pressure between normoxic and hypobaric hypoxic conditions. Diastolic blood pressure varies less with subjects developing AMS at the Jungfraujoch.

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