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ORIGINAL ARTICLE

Chronobiological changes in arterial blood pressure in participants of the 5th and 6th Czech Antarctic Scientific Expeditions

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Abstract

OBJECTIVE: To evaluate potential changes in arterial blood pressure (ABP) and heart rate (HR) during a 2-month stay in Antarctica, using chronobiological analysis.
METHODS: An observational study performed at Mendel research base, Antarctica, during 2011 and 2012. The studied group consisted of 24 participants of the 5th and 6th Czech Antarctic Scientific Expeditions. Three series of 24-hour ABP monitoring were performed, of these two in Antarctica and one in the Czech Republic. Chronobiological analyses of the data were performed (Halberg Chronobiology Center, Minnesota) using population-mean cosinor. The values of MESOR (Midline Estimating Statistic Of Rhythm), double amplitude and the acrophase were obtained for SBP (Systolic Blood Pressure), DBP (Diastolic Blood Pressure) and HR. These rhythm characteristics were compared between the two locations by parameter tests and by the paired *t*-test.
RESULTS: On the average, the MESORs of SBP, DBP and HR were significantly higher in Antarctica than in the Czech Republic, as were the double amplitudes of the 12-hour component of SBP and DBP. High prevalence of CHAT (Circadian Hyper-Amplitude-Tension) was detected in Antarctica (8/24 = 33%); only 2 persons had CHAT in the Czech Republic (χ^2=3.945, p=0.047).
CONCLUSIONS: A prolonged stay in Antarctica clearly affected certain chronobiological parameters of ABP and HR.

INTRODUCTION

Arterial hypertension (AH) is one of the most frequent cardiovascular diseases and a major health problem worldwide. The major health risks coupled with AH include cerebrovascular disease, acute or chronic heart failure, coronary artery disease or chronic renal failure (Aronow *et al.* 2011). Prevalence of AH differs by country, mainly due to socioeconomic characteristics of the region.

Rapid development of new technologies and of transportation in the last few decades has led to a significant increase in the number of people visiting the polar regions. This trend can be observed for tourism, sports events and for working opportunities. As an example, the number of tourists visiting Antarctica increased from 6,704 persons in the 1993–94 austral summer season to 26,509 in the 2011–12 austral summer season (http://iaato.org/tourism-statistics).

Limited evidence exists on how work and long-term stay in polar regions (particularly in Antarctica) affect arterial blood pressure. Only a few studies addressing this problem have been performed.

Chronobiological analysis of arterial blood pressure (ABP) recordings enables the detection of specific changes during a 24-hour day cycle. Basic chronobiological variables of ABP and heart rate (HR) include the MESOR (Midline Estimating Statistic Of Rhythm) – a rhythm-adjusted mean, the double amplitude (2A) – a measure of the extent of predictable change within a cycle and the acrophase (φ) – a measure of the timing of overall high values recurring in each cycle.

Another important parameter is CHAT (Circadian Hyper-Amplitude-Tension) defined as a 2A of the 24-hour component above the upper 95% limit in clinically healthy peers matched by gender and age. The importance of these variables lies in the fact that acute cardiovascular events are more likely to occur in specific periods of day.

The aim of our study was to assess the effects of a 2-month stay in Antarctica on chronobiological parameters of ABP and HR measured by 24-hour ABP monitoring.

MATERIALS AND METHODS

Data collection

ABP monitoring was performed in 24 subjects (19 men and 5 women) at Mendel research base, James Ross Island, Antarctica. Median age was 36 years. One subject had AH using daily 50mg of metoprolol, the other subjects were healthy. The persons included in the study were not restricted in any kind of physical activity or work.

ABP was measured using Spacelabs Healthcare 90217 devices (oscillometric method) and the ABP Report Management System (ABP RMS) software. The devices were set to measure systolic BP (SBP), diastolic BP (DBP) and HR at 20-minute intervals between 6 a.m. and 10 p.m. (local time) and 60-minute intervals between 10 p.m. and 6 a.m.. All recordings were continuous, average duration of monitoring being 25 hours.

The first series of recordings were performed within the first 2 weeks of the stay at Mendel base. The second series took place in the last two weeks of the stay. Control measurements were performed in the Czech Republic within 3 months after return from Antarctica.

The collected data were transferred from the memory of the monitoring device using the ABP RMS sofware (made by Spacelabs Healthcare). Later on, the data were transferred to Microsoft EXCEL and sent to the Halberg Chronobiology Center, Minnesota, US, where chronobiological analyses were performed.

Statistical analysis

Mean values, their standard deviation (SD) and 95% confidence intervals (CIs) were calculated. As samples did not deviate from a normal distribution, paired *t*-tests were used to compare data from Antarctica and from the Czech Republic.

Each record was analyzed by cosinor (Bingham *et al.* 1982). The data were fitted by least-squares with a model consisting of cosine curves with periods of 24 and 12 hours, yielding estimates for the following parameters: the MESOR, 2A and φ. Local midnight was used as reference time. Results from all subjects monitored in Antarctica and in the Czech Republic were further summarized by population-mean cosinor for comparison by parameter tests (Bingham *et al.* 1982). Statistical significance was evaluated using a Pearson correlation coefficient. Results were considered to be statistically significant when $p<0.05$.

Ethics

The study has been approved by the local ethics committee (University Hospital Brno).

RESULTS

We have found statistically signicifant differences in the MESOR of SBP, DBP, and HR between records collected in Antarctica or in the Czech Republic by paired t tests. Parameter tests also found the MESOR of SBP to differ between the two locations. The 24-hour acrophase of HR was delayed in Antarctica ($p=0.015$), as was the 12-hour acrophase of SBP ($p=0.044$), Table 1.

CHAT was detected in 8 individuals during the stay in Antarctica (5 subjects with CHAT for both SBP and DBP and 3 subjects with DBP CHAT). In the Czech Republic, CHAT (for both SBP and DBP) was present in one subject and DBP-CHAT in another ($\chi^2=3.945$, $p=0.047$).

DISCUSSION

During a stay in the polar regions, human organism is exposed to extreme climatic conditions including cold, strong wind, extreme air humidity, periodic changes of polar day and night or high levels of UV radiation.

Tab. 1. Mean values, standard deviations of circadian rhythm parameters and results from comparison between Antarctica and the Czech Republic.

Parameter	Antarctica[1] (N=24)	Antarctica[2] (N=23)	Czech Republic (N=24)	Paired *t* (*p*-value)	Parameter tests: F (*p*-value)
SBP-M [95% CI]	128.4 ± 8.3 [124.9, 131.8]	129.9 ± 9.3 [123.9, 135.8]	120.3 ± 6.4 [117.6, 123.1]	**4.941 (<0.001)**	**14.003 (<0.001)**
SBP-2A(24h) [95% CI]	25.4 ± 10.7 [21.0, 29.8]	30.2 ± 11.6 [22.9, 37.6]	24.5 ± 7.4 [21.3, 27.7]	NS	NS
SBP-ϕ (24h) [95%CI]	−232 [−222, −244]	−243 [−227, −262]	−222 [−214, −232]	–	NS
SBP-2A(12h) [95% CI]	19.6 ± 6.6 [16.9, 22.3]	16.8 ± 5.8 [13.1, 20.5]	14.0 ± 8.6 [11.5, 16.4]	**3.484 (0.002)**	NS
SBP-ϕ (12h) [95%CI]	−308 [−275, −329]	−330 [−318, −341]	−271 [−253, −290]	–	**4.305 (0.044)**
DBP-M [95% CI]	77.8 ± 5.5 [75.5, 80.1]	78.8 ± 6.9 [74.4, 83.2]	75.8 ± 4.1 [74.1, 77.6]	**2.097 (0.048)**	NS
DBP-2A(24h) [95% CI]	20.6 ± 9.0 [16.9, 24.3]	22.2 ± 9.4 [16.2, 28.1]	22.4 ± 6.2 [19.7, 25.1]	NS	NS
DBP-ϕ (24h) [95%CI]	−230 [−219, −241]	−240 [−228, −253]	−219 [−211, −228]	–	NS
DBP-2A(12h) [95% CI]	15.2 ± 5.3 [13.1, 17.4]	13.4 ± 3.5 [11.2, 15.7]	12.8 ± 4.6 [10.8, 14.8]	**2.248 (0.035)**	NS
DBP-ϕ (12h) [95%CI]	−294 [−263, −319]	−321 [−305, −334]	−268 [−252, −283]	–	NS
HR-M [95% CI]	75.7 ± 8.7 [72.1, 79.3]	74.9 ± 8.7 [69.4, 80.5]	72.7 ± 11.6 [67.7, 77.8]	**2.161 (0.042)**	NS
HR-2A(24h) [95% CI]	22.4 ± 15.1 [16.2, 28.6]	22.3 ± 11.1 [15.2, 29.4]	19.5 ± 10.9 [14.8, 24.2]	NS	NS
HR-ϕ (24h) [95%CI]	−233 [−219, −246]	−222 [−198, −254]	−207 [−186, −223]	–	**6.360 (0.015)**
HR-2A(12h) [95% CI]	12.9 ± 6.3 [10.3, 15.5]	11.5 ± 6.6 [7.2, 15.7]	12.6 ± 10.2 [8.2, 17.1]	NS	NS
HR-ϕ (12h) [95%CI]	−307 [−257, −347]	−333 [−290, −11]	−267 [−237, −298]	–	NS

Data are reported as mean values ± 1 SD and [95% CI]. Statistically significant differences are in bold.
Abbreviations: SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate; M: MESOR; 2A: double amplitude; ϕ: acrophase; CI: confidence interval; NS: non-significant.
M and 2A in mmHg (SBP and DBP) or beats/min (HR); f in (negative) degrees, with 360° equated to period length (24 or 12 hours), 0° set to local midnight. Results are shown with 1 decimal as they represent averages across 23 or 24 subjects, each providing an average of 69 measurements per 24-hour profile.
[1] Within the first 2 weeks at Mendel base; [2] Within the last 2 weeks of stay at Mendel base.

Moreover, psychosocial stress, different types of diet with a deficiency of fresh food and impacts of different microbial environments have to be considered. A combination of these conditions might be stressful and may cause e.g. elevation of blood pressure.

Only a minimum of chronobiological studies of changes of ABP have been performed in the polar regions. In a study performed in Antarctica by Italian authors, significant elevation of SBP and also good synchronization of circadian rhythm of ABP and HR to 24-hour cycle in conditions of polar day have been demonstrated (Cugini *et al.* 1997). Polyakov (2004) referred to disorders of haemodynamic circadian rhythms and insufficient decrease of ABP in a group of 317 subjects in subarctic Siberia.

In our study, differences in the MESOR of SBP, DBP, and HR between records collected in Antarctica and in the Czech Republic were present in both series of Antarctic measurements. This finding could be accounted for by a higher level of physical activity in Antarctica. Elevation of SBP during physical activity can lead to physiological decrease of SBP during the following night, resulting in an increase in daily amplitude (post-exercise hypotension). Higher values of ABP and HR MESORs in Antarctica might be also related to low temperatures (winter hypertension).

Using conventional analysis of ABP monitoring, trends for increased ABP were reported in a few published papers. Taylor *et al.* (2004) referred to the high prevalence of initial hypertension in a group of 62 subjects with a trend to gradual decrease in ABP during the 12-month stay at Australian Antarctic stations. Similarly, Belkin and Karasik (1999) observed a gradual decrease in ABP during a 10-month span in the wintering staff of the Mirny Antarctic station. While SBP decreased to reference values, DBP remained significantly higher than in Russia. Harinath *et al.* (2005) referred to significant increases in both SBP and DBP in a group of 30 subjects after arrival from India to Maitri polar station. A clear decreasing trend of SBP and DBP was observed during the 2-month stay at the station. In the 15 subjects of the overwintering group, however, significantly higher values of both SBP and DBP persisted when compared with the control measurements obtained in Delhi, India.

The most interesting finding of our study was a very high prevalence of CHAT (33%) during the stay in Antarctica. In a population study by Cornelissen *et al.* (2005), the prevalence of CHAT varied between 2–20% in different regions of the world, mean values were around 12%. CHAT is not a well-recognized risk factor according to the current AH treatment guidelines. However, an excessive prominence of CHAT (when the 24-hour amplitude of ABP exceeds a threshold in health) has been shown to significantly increase cardiovascular risk (e.g. ischaemic stroke or nephropathy) more than any other risk factor (Halberg *et al.* 2013; Otsuka *et al.* 1997). The clinical importance of our finding is yet unclear.

Our results showed no difference in ABP variables between the 2 series of measurements taken in Antarctica. This means that no acclimation phenomenon was present in the group.

There are several limitations of our study. The study group was rather small (24 subjects). The same applies for the number of performed ABP measurements. A set of ABP measurements performed during the winter in the Czech Republic would be useful. Additional information might be receieved, if the levels of physical activity and the changes in body composition were measured during the monitoring. Another question is the clinical importace of the findings.

In conclusion, our results show that a 2-month stay in Antarctica clearly affects certain chronobiological parameters of ABP. High prevalence of CHAT was present in the studied group. The clinical importance of such a finding should be evaluated.

This research should be continued. Larger study group, together with more ABP measurements in each subject and evaluation of levels of physical activity and of changes in body composition would be useful. The impact of a long-term stay and/or of repeated stays in the polar regions on ABP and on cardiovascular morbidity should be further studied.

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