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CARDIAC AUTONOMIC MODULATION BEFORE PARACHUTE DESCENT

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Abstract

Objective: To analyze if preparation for parachute descent can influence cardiac autonomic modulation of persons undergoing their first parachute descent, how preparation for parachute descent influenced cardiac autonomic modulation of advanced parachutists (more than 200 descents), and if there is a difference in cardiac autonomic modulation during preparation for parachute descent between persons undergoing their first parachute descent and advanced parachutists.

Methods: 23 parachutists of both sexes were divided into two groups. Participants of basic training, who were prepared for the first parachute descent, entered the first group (BT). Sport parachutists with more than 200 drops were placed into the second group (SP). The average age of all parachutists was 26.2 ± 7.0 years.

Results: The results have indicated that ground-based preparation for parachute descent have already significantly decreased cardiac autonomic modulation whereas mental stress before leaving the airplane further intensifies the cardiac autonomic modulation. It has been shown that the changes in the cardiac autonomic modulation were less marked in the SP than in the BP.

Conclusion: Experiences resulting from multi-repetitions of parachute descents can reduce the changes in the cardiac autonomic modulation even in such a stressful situation as leaving the airplane.

Key words: Parachuting, psychological stress, autonomic nervous system, spectral analysis, heart rate variability

Introduction

Chronic psychological stress increases permanent cardiac electric activity that is controlled by the autonomic nervous system (ANS) [1]. It is considered as a risk factor that increases cardiovascular morbidity and mortality [2]. However, psychological stress linked with high-risk sports has a completely different role. Uncomfortable emotions are suppressed by excitation and they can also be handled better [3]. Psychological and physical stress have been shown to act concurrently to increase the levels of beta-endorphins and ACTH [4]. Endorphins production counters the negative effects of stress [5] and can even lead to a positive addiction.

Parachuting is one of the traditional risk sports. The psychological state before the parachute descent causes some physiological changes and reactions associated with the expectation and preparation for the parachute descent. Previously, only the anticipatory effect of an acute highly stressful event such as a parachute jump had been evaluated by the comparison of HRV parameters between the night and the orthostatic test in the morning preceding the jump and the control night and the orthostatic test on a separate day [6]. Hynynen et al. and Roth et al. [6, 7] also studied the HR response to the stress induced by the upcoming parachute descent. However, monitoring of the heart rate variability (HRV) hasn't been used in such a situation yet. So we expected our study to produce additional information regarding changes of the cardiac autonomic

modulation during the preparation for the jump and immediately before the jump. It was predicted that the monitoring of HRV parameters is a sensitive enough method to describe expected changes in autonomic cardiac modulation.

As it was hypothesized, the level of changes in cardiac autonomic modulation depends on physical, mental and technical preparation, and especially on previous experiences. Because of that it is possible to expect significant differences in the changes of the evaluated parameters between beginning and advanced parachutists.

The aim of the study was to analyze if preparation for parachute descent can influence cardiac autonomic modulation of persons undergoing their first parachute descent, how preparation for parachute descent influenced cardiac autonomic modulation of advanced parachutists (more than 200 descents), and if there is a difference in cardiac autonomic modulation during preparation for parachute descent between persons undergoing their first parachute descent and for advanced parachutists.

Methods**Participants**

All participants felt healthy (without acute disease) and were asked to abstain from heavy exercise and alcohol for 24 hours before testing, and refrain from smoking the morning of the testing.

Procedure

The cardiac autonomic modulation was monitored by spectral analysis (SA) of heart rate variability at rest and during preparation for parachute descent on land and immediately before leaving the airplane.

The standard position for HRV testing is most frequently lying down. Because of the impossibility to lie down during testing in airplanes, the parachutists were tested in a sitting position. Measurements of the cardiac autonomic modulation were taken in three situations:

- Measurement M1: out of the landing area, more than 3 hours before drop.
- Measurement M2: in the landing area approximately 20 minutes before boarding.
- Measurement M3: in the airplane between take-off and parachute descent.

All measurements took 10 minutes. The first 5 minutes were used as a time for standardization. The analysis of SA HRV from the start of the 6th minute till the end of the 10th minute was performed and evaluated.

The parachutists were divided into two groups. Participants of basic training, who were prepared for the first parachute descent, entered the first group (BT). Sport parachutists with more than 200 drops were placed into the second group (SP). The parachutists jumped out from the airplane at an altitude of 800 to 4000 meters.

Participants in the BT group took part in all three planned measurements. Measurement M2 was skipped in the SP group because of technical reasons. The starting number of participants was 37. The records of 14 participants contained abnormalities and couldn't be evaluated. Finally, the records of 23 participants were evaluated. Three females and twelve males in the beginners group (BT group) and one female and seven males in the advanced group (SP group) participated in this study. The age of the participants was from 18 to 45 years; the average age of all participants was $26,23 \pm 6,98$ years ($24,10 \pm 5,93$ years in the BT group; $30,5 \pm 6,87$ years in the SP group).

The HR was continuously monitored and stored each R-R period (Polar S 810, Finland). The param-

eters of the spectral analysis of heart rate variability were set by Polar Precision Performance 3.0 software. The limits for frequency components were set to values P_T : 0,01 - 0,40 Hz; P_{VLF} : 0,01 - 0,04 Hz; P_{LF} : 0,04 - 0,15 Hz; P_{HF} : 0,15 - 0,40 Hz. We evaluated total spectral power (P_T) [ms^2], spectral powers of separate frequency components P_{VLF} , P_{LF} a P_{HF} [ms^2], and the ratio between P_{LF} a P_{HF} (LF/HF ratio).

Statistical analysis

Statistical analysis was performed with StatSoft, Inc. (2011), STATISTICA (data analysis software system, www.statsoft.com), version 10. Due to the data not having a normal distribution even after logarithm transformation, we used solely nonparametric tests for statistical analysis. The Friedman ANOVA was used to analyze the differences between the situations M1, M2, M3 in the BT group. The nonparametric Wilcoxon ranks test was used to analyze the differences between the situations M1 and M3 for the SP and for the BT group. To analyze the differences between the groups (BT vs. SP) in the different situations (M1 vs. M3), the Mann-Whitney test was used. *P*-values < 0.05 were considered statistically significant.

Results

Influence of experimental situations on SA HRV parameters in groups

All spectral power parameters (P_T , P_{VLF} , P_{LF} and P_{HF}) were higher in the situation M1 than in M2 and M3 in the BT group. The statistical analysis showed statistically significant differences between all tested situations. On the contrary, the LF/HF ratios were lower in the situation M1 than in M2 and M3 and these differences were not statistically significant (Table 1).

Similar, statistically significant differences were also found while comparing the results of all the spectral power parameters only in the M1 vs. M3 in the BP group. Despite these results, the differences were smaller and statistically significant only for P_T a P_{LF} in the SP group. The LH/HF ratios were higher in the situation M3 than in M1, but the difference wasn't statistically significant in both evaluated groups (Table 2).

Table 1. Comparison of the SA HRV parameters under the conditions M1, M2, and M3 in basic training leavers (BT, *n* = 15)

	M1	M2	M3	<i>P</i>
P_T (ms^2)	5055.0 (3971.7)	2655.7 (2497.0)	581.4 (789.0)	< 0,001
P_{VLF} (ms^2)	1496.0 (1305.6)	1136.1 (1298.4)	254.5 (317.0)	< 0,001
P_{LF} (ms^2)	2521.2 (1773.0)	1238.4 (1042.8)	269.0 (401.9)	< 0,001
P_{HF} (ms^2)	1037.8 (1202.3)	281.2 (300.7)	57.8 (101.3)	< 0,001
LF/HF	6.07 (5.56)	7.34 (5.84)	9.10 (7.74)	0.819

Data are means (SD)

Table 2. Comparison of the SA HRV parameters under the conditions M1, and M3 in sport parachutists (SP, n = 8) and basic training leavers (BT, n = 15). Comparison of the influence of experimental situations between the BT and SP groups

Parameter	(SP, n = 8)			(BT, n = 15)			BT x SP
	M1	M3	P	M1	M3	P	P
P_T (ms ²)	2863.6 (1761.0)	941.2 (815.6)	0.012	5055.0 (3971.7)	581.4 (789.0)	< 0.001	0.049
P_{VLF} (ms ²)	879.3 (482.1)	415.5 (323.6)	0.05	1496.0 (1305.6)	254.5 (317.0)	0.009	0.087
P_{LF} (ms ²)	1603.0 (976.6)	379.3(319.4)	0.012	2521.2 (1773.0)	269.0 (401.9)	< 0.001	0.087
P_{HF} (ms ²)	381.2 (426.3)	146.3 (330.7)	0.208	1037.8 (1202.3)	57.8 (101.3)	0.002	0.100
LF/HF	11.16 (14.84)	12.05 (11.70)	0.779	6.07 (5.56)	9.10 (7.74)	0.423	0.77

Data are means (SD)

Comparison of the influence of experimental situations in the BT and SP groups

The spectral power parameters (except LF/HF ratio) were higher in the BT group than in the SP group in the situation M1, however, any statistical significant differences in the parameters were not ascertained by comparing values between the groups. The spectral parameters decreased and the LF/HF ratios increased in both groups in the airplane before parachute descent (M3) (compare Table 2). Whereas the changes were higher in the BT group than in the SP group, in all evaluated parameters the statistical analysis showed significant difference only in the change of P_T . We assume the differences between groups in other parameters are not statistically significant mainly because of a small number of participants in the groups (Table 2).

Discussion

Total spectral power of HRV is primarily conditioned by the parasympathetic activity that is significantly reduced during situations of mental stress [8]. Whereas a majority of earlier studies used lab-induced stress to study the cardiac autonomic response, our paper is focused on HRV response to a real-life stressful situation.

The design of our experiment was set in such a way that mental stress was gradually increased. The arrival at the landing area, getting dressed and equipped with a parachute, and other necessary materials preparation and the sensation of being at the airport itself caused a significant reduction of cardiac autonomic modulation in inexperienced participants. Our results are in line with the previous study [9] focused on the evaluation of the influence of mental stress on people preparing for their first parachute descent. The algorithms of both experiments were almost identical even though they evaluated mental stress by biochemical markers such as salivary α -amylase and cortisol, testosterone, PRL, LH, and GH in plasma and saliva. These findings appropriately complement the results of Hynynen et al. [6] who did not find any differences in HR, HRV, or stress

hormones during the night or the orthostatic test in the morning preceding the jump and concluded that there is not an anticipatory effect on autonomic modulation of the heart caused by the acute highly stressful event of the parachute jump. Our results add new information regarding changes in HRV parameters and cardiac autonomic modulation hours and minutes before the jump and are in line with the other part of Hynynen et al. [6] study focused on evaluation of the HR values before and during the jump.

In addition, the results of our study focused on the differences in cardiac autonomic response between the groups of beginners (BT) and advanced parachutists (SP) are in line with the previous findings [6, 9]. Our study found differences between the changes of HRV parameters in evaluated situations between the groups; however, not all of them were statistically significant. Reduction of the P_T and power of separate components was smaller in the group of sport parachutists than in the BT group, but the difference was statistically significant only in P_T . However, it is difficult to estimate to what extent the changes of cardiac autonomic modulation were caused by physical stress (e.g. discomfort elicited by a relatively narrow space on the airplane, the weight and size of parachutist's equipment, etc.) and to what extent by mental stress. Complete spectral power is primarily influenced by the vagal activity during mentally-neutral conditions at rest. Under the conditions of mental stress or during anxiety, cardiac vagal activity and also HRV are reduced, indicating higher sympathetic activation [10]. The extent of this reduction is dependent on the intensity of stress. It is likely that differences in activity of the ANS between both groups were caused by different intensities of mental stress since the outside conditions were identical (identical physical stress). A decreased reaction of the ANS associated with repeated exposure to specific stressful situations in the group of sport parachutists can be considered as proof of a specific adaptation of the ANS during stressful conditions.

We assume that differences between groups in other parameters are not statistically significant mainly because of the small number of participants in the groups.

As the conditions needed for such type of study are very specific, it is not easy to maintain the integrity of the study with a higher amount of participants. However, we found it necessary to increase the amount of participants in future studies to confirm our present findings. On the one hand, ANS stress resistance depends on the number of stressful situations, but on the other hand, it is determined by genetic inheritance. Some authors, moreover, suggest that acute mental stress resistance and its impact on cardiac autonomic modulation are influenced by aerobic training and physical fitness [11, 12].

These papers support that the significance of regular physical activity (particularly aerobic types) can decrease the negative influence of chronically-occurring mental stress. Because of that the questions about whether or not the tolerance effect induced by repeated emotions can have a synergistic action still remain unanswered.

As it was mentioned above there are some limitations in the present study. The jumpers in the SP group were older than the jumpers in the BT group as it is difficult to find younger, but experienced enough (more than 200 jumps) parachutists. There were also a smaller number of females among participants and we can also expect differences in the fitness levels among the participants. Although the changes in the parameters of SA HRV monitored in the situations M1, M2, and M3 were primarily evaluated, we are aware of the limitations caused by the influences of the mentioned factors.

Conclusion

The results of our study showed that preparation for a parachute descent can act as mental stressor that reduces cardiac autonomic modulation. In both studied groups (beginners and experienced jumpers) we found changes in HRV parameters indicating higher sympathetic activation immediately before the jump. Contrary to expectations, the differences that were found in the reaction to acute stress between the groups were not statistically significant. Whereas it seems that monitoring of SA HRV could be also used for a quantification of mental stress, it is necessary to carry out the same experiment with a higher number of participants and with repeatedly monitored cardiac autonomic modulation at rest and in conditions of laboratory psychological stress to confirm the preliminary conclusions of this study.

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Declaration of interest

The authors report no conflicts of interest.

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