THE ACTIVITY OF AUTONOMIC NERVOUS SYSTEM AND THE SATURATION OF INNERT GASES IN HUMAN AT HYPERBARIC ENVIRONMENT

Klugar M, Stejskal P*, Drbosalova V*, Štěpaník P**

Department of Kinesiology and Physical Education, College of Education, Valdosta State University, USA.
Center for Kinantropologhy Research, *Department of Functional Anthropology and Physiology, **Department of Biomechanics and Cybernetics, College of Physical Culture, Palacky University in Olomouc, Czech Republic.

INTRODUCTION

The aim of this study was to investigate how the autonomic nervous system (ANS) responds to a hyperbaric environment and if there are any feedback changes in the ANS activity and saturation of inert gases in the organism.
From our study, inquire into the ANS activity at recreational scuba diving (3) follow that recreational scuba dive (non decompression) resulted in global increase of ANS activity thru marginal increase of vagal activity and decrease of the sympathetic activity. On the other hand the study of Hirayanagi et al. (2) evaluated activity of the ANS before and after extremely high pressure exposure in the hyperbaric chamber. The participants had to spend several days on the decompression stop at this exposure. The authors found out almost null vagal activity and very strong activity of sympathetic nervous system. The results of both studies imply as though dynamics of the ANS is influenced by saturation of inert gasses into organism. This hypothesis is unambiguously supported by the study of Baie et al. (1), performed on the swine. The authors caused to the tested swine the decompression sickness and figured out, that after exposure were significantly reduced as parasympathetic so sympathetic nervous system activity. The results of Bai's study also imply that the dynamics of the ANS is very sensitive indicator of saturation of inert gasses into the organism.

MATERIALS AND METHODS

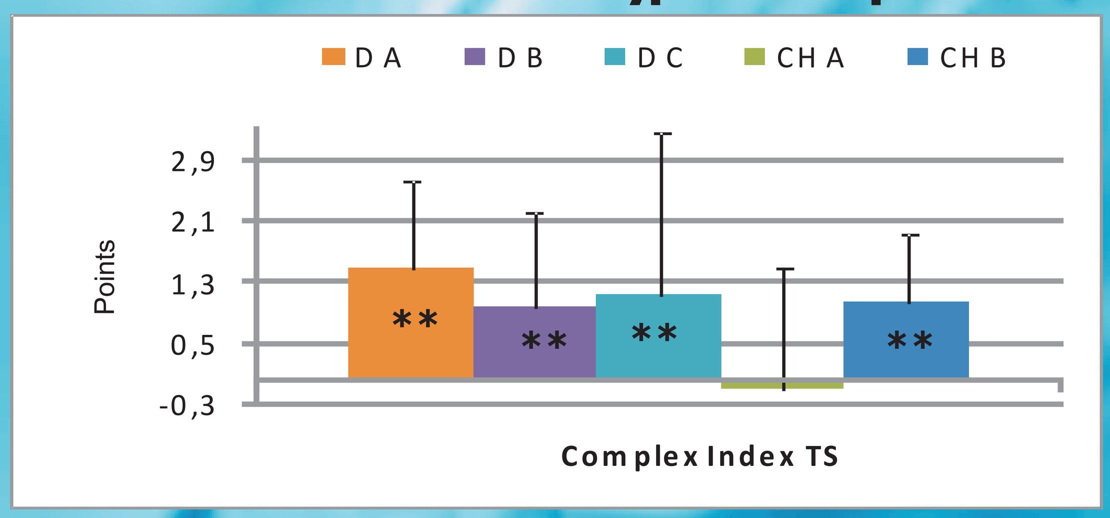
The sample consisted of 64 healthy men of average age 32.1 ± 4.5 years. The participants went thru 5 different experimental situations. They went through two simulated dives in the hyperbaric chamber with different dive profiles (opposite directions); CH (Chamber) A: simulated dive to 5 ATA with experimental dive profile and total time 146.4 ± 8.2 minutes; CH B: simulated dive to 5 ATA with "ideal dive" profile and total time 83.1 ± 7.8 minutes. Furthermore, they did three scuba dives in open water with different dive profiles; D (dive) A: dive with air to 3 ATA with "ideal dive" profile and total time 43.3 ± 2.2 minutes; D B: dive with air to 4 ATA with experimental dive profile and total time 61.2 ± 3.1 minutes and different gasses; D C: dive with EAN 32 to 4 ATA with experimental dive profile and total time 55.9 ± 2.8 minutes. The activity of ANS was monitored by Spectral Analysis (SA) of Heart Rate Variability (HRV) in orthoclinostatic maneuver (supine-standing-supine) with facilities for short EKG records (300 heartbeats and 5 minutes). The standard parameters of SA HRV were supplemented by the complex indexes of the vagal activity (VA), sympathovagal balance (SVB) and total score (TS) (Stejskal et al., 2002). The complex indexes are expressed by the points (range from -5.0 to +5.0 points).
The Repeated Measures ANOVA and Fisher's post hoc test were used to compare the values before and after exposure. In all analyzes the differences were considered significant at $p \leq 0.05$.

Table 1. Differences between arithmetic means of values of complex indexes before and after hyperbaric exposures

Complex Indexes		Hyperbaric environment					p
		D A	D B	D C	CH A	CH B	
Dif: TS	x̄	**1.483****	0.986**	1.124**	*-0.095*	1.039**	**0.0059**
	SD	0.915	1.288	1.88	1.378	0.898	
Dif: VA	x̄	**1.639****	1.000**	1.289**	*-0.126*	1.253**	**0.0083**
	SD	1.16	1.241	2.129	1.568	1.501	
Dif: SVB	x̄	0.941*	**0.958***	0.810*	*-0.036*	0.631	0.4736
	SD	1.765	1.97	1.764	1.925	1.102	

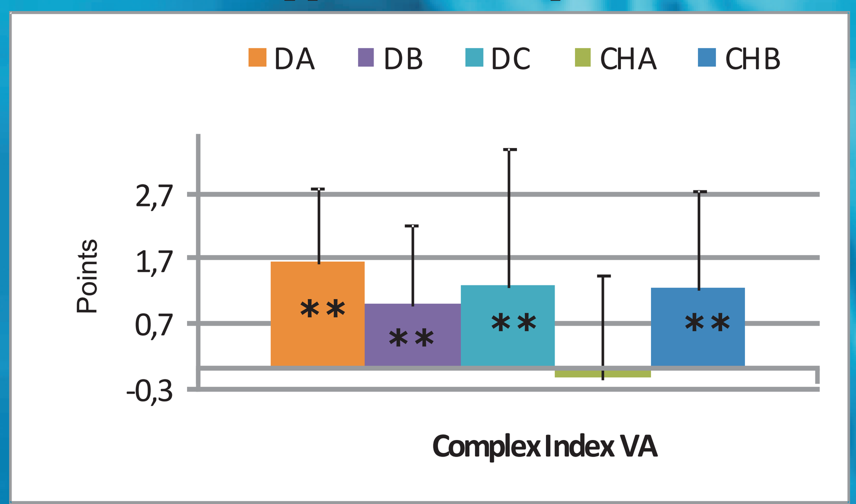
Legend: Dif: TS – difference of TS index before and after exposure, Dif: VA – difference of VA index before and after exposure, Dif: SVB – difference of SVB index before and after exposure, D A – Scuba dive with air and ideal dive profile, 3 ATA; D B – Scuba dive with air and experimental dive profile, 4 ATA; D C, Scuba dive with EAN 32 and experimental dive profile, 4 ATA; CH A – Exposure in hyperbaric chamber with experimental dive profile, 5 ATA; CH B – Exposure in hyperbaric chamber with ideal dive profile, 5 ATA; x̄ – arithmetic mean, SD – standard deviation, p – global level of statistical significance between differences of individual experiments; *level of statistical significance p < 0.05; ** level of statistical significance p < 0.01

Figure 1. Differences between arithmetic means of values of Total Score before and after hyperbaric exposures



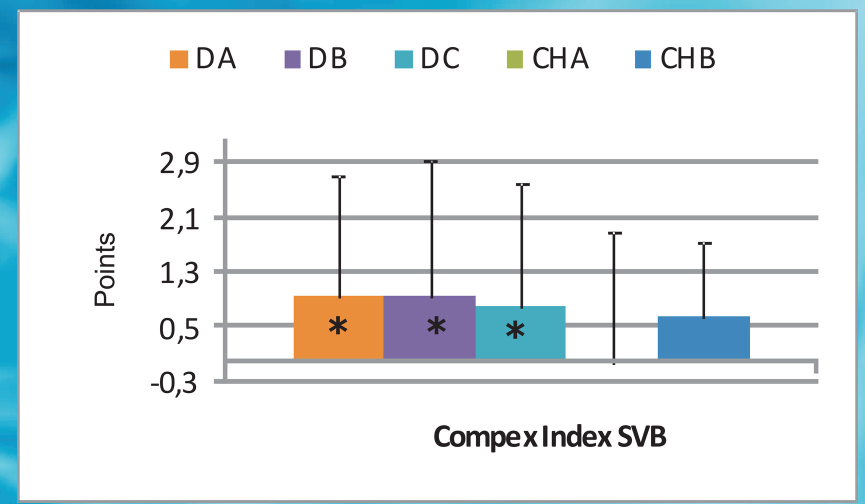
Legend: D A – Scuba dive with air and ideal dive profile, 3 ATA; D B – Scuba dive with air and experimental dive profile, 4 ATA; D C, Scuba dive with EAN 32 and experimental dive profile, 4 ATA; CH A – Exposure in hyperbaric chamber with experimental dive profile, 5 ATA; CH B – Exposure in hyperbaric chamber with ideal dive profile, 5 ATA

Figure 2. Differences between arithmetic means of values of Vagal Activity before and after hyperbaric exposures



Legend: D A – Scuba dive with air and ideal dive profile, 3 ATA; D B – Scuba dive with air and experimental dive profile, 4 ATA; D C, Scuba dive with EAN 32 and experimental dive profile, 4 ATA; CH A – Exposure in hyperbaric chamber with experimental dive profile, 5 ATA; CH B – Exposure in hyperbaric chamber with ideal dive profile, 5 ATA

Figure 3. Differences between arithmetic means of values of Sympatovagal Balance before and after hyperbaric exposures



Legend: D A – Scuba dive with air and ideal dive profile, 3 ATA; D B – Scuba dive with air and experimental dive profile, 4 ATA; D C, Scuba dive with EAN 32 and experimental dive profile, 4 ATA; CH A – Exposure in hyperbaric chamber with experimental dive profile, 5 ATA; CH B – Exposure in hyperbaric chamber with ideal dive profile, 5 ATA

RESULTS

The highest activity of the ANS (the highest average value of TS, Figure 1) was found in the D A experiment. The ANS activity significantly increased after D A. In the comparison of air D B and nitrox D C dive were reached higher activity of ANS in nitrox dive, however both increased significantly. On the other hand, during CH A the highest nitrogen saturated dive from our experiments, we found a non significant decrease in the activity of the ANS. The highest vagal activity (Figure 2) was found again in experiment D A and we can say the other experiments have an almost similar course in VA complex index as in case of TS complex index. The average value of Sympatovagal balance (Figure 3) increased significantly in all experiments in the water, none significantly increased in the CH B and none significantly decreased in the CH A. The highest average value was found out in the D B. The comparison of the differences between complex indexes before and after all experiments is shown in Table 1.

DISCUSION AND CONCLUSIONS

At the scuba dive with the lowest level of saturated nitrogen in the organism D A we figured out the highest significant increase in the ANS and the vagal activity. Otherwise, at hyperbaric exposure with the highest level of saturated nitrogen in the organism CH A we figured out the lowest ANS and vagal activity. During global comparison of all our experiments we figured out an interesting trend. The activity of the ANS and its parasympathetic subsystem were significantly higher in experiments with the lower level of saturated nitrogen in the organism (dives with "ideal dive profile", and with nitrox). Consequently activity of the ANS seems to be sensitive to the nitrogen saturation in the organism. The higher nitrogen saturation in the organism caused a decrease in the ANS activity due to a decrease of vagal activity.
Based on our experience and findings we don't exclude that monitoring of the ANS activity and its subsystems before and after hyperbaric exposure would become useful instrument for detection of very early stadium or signs of decompression sickness.

References

1. Bai Y, Mahon RT, White JC, Brink PR, Chon KH. Impairment of the autonomic nervous function during decompression sickness in swine. J Appl Physiol 106 (3): 1004-9, 2009.
2. Hirayanagi K, Nakabayashi K, Okonogi K, Ohiwa H. Autonomic nervous activity and stress hormones induced by hyperbaric saturation diving. Undersea Hyperb Med 30 (1): 47-55, 2003.
3. Klugar M, Stejskal P, Krejčíř V, Bartáková O, Drbošalová V, Kozáková J, Štěpaník P. Changes in autonomic nervous system activity in connection with scuba diving. Acta Univ. Palacki. Olomuc 39 (2): 7, 2009.

Contact

Miloslav Klugar, Ph.D., PhDr.
miloslav.klugar@email.cz