Blood biochemical parameters in women during long-term simulated hyperoxic diving up to 8 ATA.

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Popova J, Buravkova L. Blood biochemical parameters in women during long-term simulated hyperoxic diving up to 8 ATA. Undersea Hyperb Med 2006; 33(3):211-216. Nowadays an increasing number of women are participating in recreational diving. A special recompression treatment table for delayed pulmonary barotrauma or decompression sickness was developed by V.V. Smolin in the Institute for Biomedical Problems (IBMP, Russia). The aim of our study was to investigate the effect of simulated dives (similar to this recompression treatment table) on biochemical parameters of healthy women. Three healthy female volunteers participated in long-term simulated diving to 8 ATA (0.8 MPa). Blood samples for determination of the biochemical substrate levels and activity of blood enzymes using a Reflotron® analyzer were obtained at the control period, at the beginning of decompression and at the post dive period. No significant changes of serum levels of glucose, triglycerides, cholesterol, HDL cholesterol and urea were found during this experimental period or in comparison with the predive values. There were no significant changes in ALT activity in two volunteers but there was some tendency for an insignificant decrease in AST activity. One of the volunteers had a considerable increase in AST and ALT activities 15 h after the dive, probably due to a modified diet outside the experiment conditions. Thus, the long-term simulated diving recompression treatment table did not lead to a shift in the woman’s serum biochemical status. However, it remains necessary to consider probable dysfunction of liver due to hyperbaric exposure.

INTRODUCTION

Today an increasing number of women are participating in recreational diving. There are various opinions about their susceptibility to decompression sickness (DCS) compared to men. Males and females showed the same incidence of decompression sickness under altitude chamber decompression exposure profiles (1) as well as after 878 air and helium-oxygen dives from 4.64 to 10.1 ATA (2). Other authors have also reported no major differences in DCS symptom incidences, regardless of gender. The incidence of DCS symptoms was about 1.52 for males and 1.27 for females per 1000 dives (3). On the other hand some researchers suggest there is a relationship between menstrual cycle and incidence of decompression sickness in women. F.W. Rudge concluded that women are at higher risk of developing altitude decompression sickness during menses, with the risk decreasing linearly to the end of a menstrual cycle (4). Other authors reported the greatest percentage of incidents occurring in the first week of the menstrual cycle (5). A special recompression treatment table for delayed forms of decompression sickness or pulmonary barotrauma was developed by V.V. Smolin in the Institute for Biomedical Problems (IBMP, Russia). It demonstrated the efficacy in many cases of treatment among male patients (6,7). The present experiment was conducted...
to estimate the influence of the same recompression treatment table on healthy women, and, in particular on their biochemical blood parameters.

**METHODS**

Three healthy female volunteers (A, B, C aged 19-28 years old) participated in this study. They were provided with explanations for all experimental procedures and informed consent was obtained before the beginning of the study. The divers were compressed to 8 ATA (0.8 MPa) by air in a pressure chamber (volume 15 m³). After decompression to 5 ATA, an oxygen-helium-nitrogen mixture with O₂ partial pressure 0.45-0.50 ATA was created in the chamber. Decompression was the conducted with that gas mixture and decompression stops every 0.2 ATA. The O₂ partial pressure was gradually decreased at the end of decompression to 0.28-0.30 ATA. The temperature in the chamber was kept within 27.5-28.5 °C, the humidity 40-80 %. The total time of this long-term stimulated diving was 4 days 7 h 50 min. Blood samples were drawn from the cubital vein in the fasting volunteers twice - once, during the control period (3 and 1 days before dive), at the beginning of decompression (at the stop 4.2 ATA, on second day of dive) and at the recovery period (15 hour and 7 days after the end of decompression respectively). The level of biochemical substrates and activity of blood enzymes were measured by biochemical analyzer Reflotron® (Roche Diagnostics) using standard test-strips. The measured parameters included concentration of glucose, triglycerides, cholesterol, high density lipoprotein (HDL) cholesterol, urea and activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST) and γ-glutamyltransferase (GGT). The program “Statistica Release 7” for Windows was used for statistical analysis. Some pooled data were treated by a nonparametric method (Freedman ANOVA - analysis of variance for comparing multiple dependent samples). The level of significance (p) was at lower 0.05.

**RESULTS**

No statistically significant changes in the metabolic parameters were found during the experiment (Fig. 1 A-H). The individuals’ values are presented in Table 1. Glucose concentration during the pressure exposures did not differ from that of the first day before the simulated dive. However, there is a tendency for a minor decrease in this parameter at 15 h after the high pressure exposure in comparison with above-mentioned periods. Triglyceride concentration was not changed markedly in two of the volunteers during exposure and was increased in female C at the beginning of decompression. As for another component of lipid metabolism, there was a tendency for a rise of total cholesterol in volunteer C during diving (she also had increased levels at normobaric environment), and after the dive in volunteer B. The HDL cholesterol level varied during the experiment with lower values at high pressure. Urea concentration was reduced at 4.2 ATA compared to pre-dive levels, but this was not significant. It was observed that AST and ALT activities had a trend towards a decrease in the hyperbaric environment (especially AST). Female B demonstrated a considerable elevation of both enzymes levels (up to 111 U/l for ALT and 102 U/l for AST) 15 h after the dive. GGT activity had a tendency to increase during the experiment, but it is not significant (p = 0.09).
A. Glucose level
(mmoll/l; normal range 4.22-6.11). p = 0.34 (p > 0.05)

B. Triglyceride level
(mmoll/l; normal range 0.1-2.3). p = 0.76 (p > 0.05)

C. ALT activity
(U/l; normal range lower 40). p = 0.12 (p > 0.05)

D. AST activity
(U/l; normal range lower 40). p = 0.11 (p > 0.05)

E. GGT activity
(U/l; normal range 11-50). p = 0.09 (p > 0.05)

F. Urea level
(mmoll/l; normal range 1.7-8.3) p = 0.19 (p > 0.05)
Fig. 1 (A-H). The blood biochemical parameters during saturation dive up to 8 ATA in hyperoxic helium-oxygen-nitrogen mixture according to recompression treatment schedule (healthy female subjects).

Table 1. The individual blood biochemical parameters during simulated saturation dive up to 8 ATA in hyperoxic helium-oxygen-nitrogen mixture according to recompression treatment schedule (healthy female subjects).
DISCUSSION

It is known, that the high pressure environment may result in changes in biochemical processes and shifts in blood metabolic parameters (8). According to previous studies the lipid metabolism and activities of serum enzymes are most responsible to long-term hyperbaric exposure especially at high “pressures” (9-12).

The activity of serum transaminase in the hyperbaric environment is an important aspect in diving physiology. A number of studies have demonstrated a rise of serum enzymes activities such as ALT and AST during and after saturation dives (9, 13, 14). H. Takeuchi et al. found such changes in four volunteers during 270-300 m dives and attributed it as due to mental stress arising from exposure to the closed environment for a long period of time, rather than effects of hyperbaric helium gas exposure (15). But, there are other data that direct morphological changes in mice hepatocytes after long-term O₂-He hyperbaric exposure to 36 ATA, causing the cell’s dystrophy and a decrease of membrane lipid microviscosity. Perhaps, these cell modifications may cause hepatic disorders in humans after saturation deep dives (16). Furthermore it has been shown, that activities of these enzymes are higher in divers with decompression sickness after a 48-h simulated dive to 18.3 m (17). In a number of cases increased AST and ALT activities occurred along with the occurrence of Doppler bubbles, bends symptoms and gastroenteritis (18) or diarrhoea (15). After short-term dives the elevation of these enzymes activities was observed from the intake of anesthetics during hyperbaric exposure that could lead to changes in the liver function (19). We found AST and ALT activities elevated (5-7 times from basic level approximately) in only one volunteer (C) after a simulated dive. It may be attributed to either a modified diet outside the experimental conditions or the specific effect of the high pressure environment. On the other hand, we point out the slight trend to a decrease in AST and ALT activities at the beginning of decompression. In addition, the biochemical blood studies revealed a fall of the same depressed activities of the same enzymes after saturation dives to 2.4 ATA (but in combination with antiaggregant agents) (20). Other cases of elevations AST and ALT activities were observed after anesthetic administrations during short-term chamber hyperbaric exposure (21).

Investigations of blood biochemical parameters during saturated dive to 5.1 MPa have revealed an increasing intensity of carbohydrate and, especially, lipid metabolism depending on gaseous components of the breathing mixture (22). The authors observed elevated concentration of free fatty acids and activity of blood lipid enzymes and concluded that lipid and carbohydrate catabolism was more intensive in a He-O₂ mixture than that in a He-N₂-O₂ mixture. Other studies during dives to 100 msw (23) and to 250 msw (11) showed a similar trend in lipid metabolism (increasing concentrations of free fatty acids, triglycerides and cholesterol). In our experiment, the insignificant changes in triglycerides and cholesterol levels nevertheless could indicate some shifts in lipid metabolism.

A slight decrease in urea concentration under pressure may be a result of protein synthesis slow down. Such changes after dry saturation dives to 0.56 MPa was shown by J.M. Conway et al and the authors suggested the alteration in liver nitrogen metabolism (24).

CONCLUSIONS

Thus, the majority of investigated biochemical parameters were within normal physiological limits and revealed shifts were reversible on return to the surface. It is therefore concluded that such a saturation dive
according to this recompression treatment table is safe for healthy women, but could lead to some metabolic changes. Possibly, the liver function in a hyperbaric environment should be taken into account, especially when anesthetic pharmacologic agents are used at the same time for treatment.

REFERENCES


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