Göteborg 2022

Diving and the brain

Akademisk avhandling
som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin,
Göteborgs universitet kommer att offentligen försvaras i Aulan,
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Anders Rosén

Fakultetsopponent

Michael Haney

Institutionen för kirurgisk och perioperativ vetenskap

Umeå universitet, Sverige

Avhandlingen baseras på följande delarbeten:

I. **Serum tau concentration after diving – an observational pilot study.** Rosén A, Oscarsson N, Kvarnström A, Gennser M, Sandström G, Blennow K, Seeman-Lodding H, Zetterberg H
Diving and Hyperbaric Medicine 2019;49(2):88‑95.

II. **Biomarkers of neuronal damage in saturation diving – a controlled observational study.** Rosén A, Gennser M, Oscarsson N, Kvarnström A, Sandström G, Blennow K, Seeman-Lodding H, Zetterberg H
European Journal of Applied Physiology 2020;120(12):2773‑2784

III. **Protein tau concentration in blood increases after SCUBA diving: an observational study.** Rosén A, Gennser M, Oscarsson N, Kvarnström A, Sandström G, Seeman-Lodding H, Simrén J, Zetterberg H
European Journal of Applied Physiology 2022;122(4):993‑1005.

IV. **Venous gas bubble load after immediate or delayed normobaric oxygen breathing post-decompression.** Gennser M, Blogg S L, Rosén A
Manuscript submitted to Diving and Hyperbaric Medicine spring 2022

SAHLGRENSKA AKADEMIN
INSTITUTIONEN FÖR KLINISKA VETENSKAPER

GÖTEBORGS UNIVERSITET

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Diving and the brain

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Abstract
There are reports that long-term diving is associated with cognitive impairments. This raises the question if diving itself is harmful to the brain in the absence of decompression sickness or hypoxia. Protein tau (tau), glial fibrillary acid protein (GFAp) and neurofilament light (NfL) are biomarkers whose concentrations in blood increase after traumatic brain injuries, cerebral hypoxia, and stroke, though both tau and GFAp are alleged also to change in response to cellular stress without overt damage. Inert gas bubbles are common in the blood after diving and the amount of bubbles present correlates to the risk of developing decompression sickness.

The present dissertation investigates if exposure to increased ambient pressure causes tau, GFAp, or NfL concentrations in blood to increase, and if breathing oxygen after diving decreases the amount of nitrogen bubbles in blood. It includes three studies, which resulted in four papers.

Ten professional divers dived in the open sea over four days in the first study. Maximum dive depths ranged from 52–90 metres of seawater. Concentrations of tau, GFAp and NfL, and the amount of nitrogen bubbles in the blood was measured using Doppler ultrasound (Paper I). In the second study, 14 submariners were pressurised in a dry hyperbaric chamber to an equivalent of 30 metres of seawater and remained at that pressure for 36 hours. Thereafter, pressure was slowly decreased over 70 hours. Concentrations of tau, GFAp and NfL were measured before, during and after exposure (Paper II). In the third study, 48 professional divers were pressurised twice, 48 hours apart, to an equivalent of 42 metres of sea water for 10 minutes in a water-filled hyperbaric chamber. After one dive, oxygen was breathed for 30 minutes, with air breathed after the other. Concentrations of tau, GFAp and NfL (Paper III), and the amount of nitrogen bubbles in blood (Paper IV) after diving were analysed.

Protein tau increased by 98.8% after four days of deep open water diving (Paper I) and by 31.5% after exposure to a pressure equivalent of 42 metres of seawater (Paper III). GFAp and NfL did not increase, and there were no associations between the amount of gas bubbles in blood and changes in protein tau (Paper I and III). Tau, GFAp or NfL concentrations did not change in response to 36 hours of exposure to a pressure equivalent of 30 metres of seawater, followed by slow decompression (Paper II). The amount of nitrogen gas bubbles in blood were significantly lower among subjects that had breathed oxygen after being pressurised in a water-filled hyperbaric chamber to an equivalent of 42 metres of depth compared to those that breathed air (Paper IV).

Protein tau increases after diving, presumably due to neuronal stress. Unchanged NfL and GFAp concentrations suggest that neither frank neuronal injury nor astrocytic injury are involved. Oxygen breathing after diving effectively reduces the amount of nitrogen gas bubbles in blood, which decreases the risk of decompression sickness.

Keywords
biomarkers, brain, central nervous system, decompression sickness, dive research, diving, neuronal damage, saturation diving, tau protein, venous gas embolism

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