Co-ordinated investigation into the possible long term health effects of diving at work. Examination of the long term health impact of diving: The ELTHI diving study [Abstract]


Departments of Radiology and Environmental and Occupational Medicine, University of Aberdeen, and Departments of Medicine and Therapeutics and Psychology, University of St Andrews, Highland & Island Health Research Institute and Arnold School of Public Health, University of South Carolina

Abstract
We explored self-reported health and health related quality of life in a large group of divers (n = 1540; 56% response) compared to a non-diving group of offshore industrial workers (n = 1035; 51% response) with a questionnaire survey. We then validated the questionnaire responses by a detailed clinic assessment of a 10% random sample from each group. This included a range of objective tests and measurements. Finally, we studied reported ‘forgetfulness or loss of concentration’ in a case-control study, to determine the significance of this symptom and its relationship with diving practice. Health related quality of life (HRQOL) was similar in each group and within normative values. The major work related factor affecting HRQOL was industrial accident and this effect was most marked for offshore workers. A significant group of divers (18%) complained of ‘forgetfulness or loss of concentration’ and this was related to their diving experience. This complaint was associated with a significant moderate reduction in group mean HRQOL. A random sample of this group had a lower group mean performance on objective tests of cognitive function most particularly of memory and structural differences from control on cerebral MRI. The practice of welding had an unexpected amplifying effect in terms of the symptoms experienced by divers. There was a very high prevalence (50%) of objectively determined hearing disorder in both divers and offshore workers. This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.


Key words
Occupational diving, health surveillance, questionnaire, diving industry, morbidity, epidemiology

Commentary
David Elliott

Background
What follows is not a book review because the report is not a book. Nor is this an article reprinted from another journal. The publication to be reviewed is a research report that is available as a free download on the website of a government department. Though much of this rather lengthy report has been referred to as a whole or in part in various EUBS and UHMS abstracts, this encompassing project may be at risk of being overlooked because the original is invisible to Medline. Indeed the UK HSE website has a number of decompression-related and other research reports, each in full, just waiting to be opened by a visitor. Not all of them have been cited in the spotlight of traditional publications. No doubt web-crawlers are filling this gap but at present, though the ‘advanced search’ of one search engine reaches some out-of-date pages of the HSE, they highlight much that is not peer-reviewed or that is just not relevant.

Our editor invited this particular review for the purpose of bringing this study, The Examination of the Long Term Health Impact of Diving, to wider attention and doing so concisely because the document’s own abstract is too lengthy for direct reproduction in this journal (although the condensed version is presented above). The following synopsis is drawn from the writings of its ten authors and any misinterpretation is the error of this reviewer. Because the content surely has relevance to all in this field, the principal recommendation is that you download the article from the site detailed at the foot of this article, and read it in whole or in part. But first you need to know why.
**Introduction**

Recovery from decompression and other diving illnesses depends on the nature of the diving and severity of the condition. In many cases recovery is complete. Less certain are the possible long-term health effects of diving, particularly in the absence of a history of an injury or decompression illness (DCI).

Dysbaric osteonecrosis is an example that is associated with work in hyperbaric environments. The first cases, presenting as a painful shoulder or hip, were found to be due to subchondral collapse and not related to a recent decompression. The natural history of this condition is now thought to be quite different from that of other avascular necrosis such as idiopathic femoral head necrosis and, if not static, progress is measured in years rather than months. The assessment of this pre-clinical condition among an apparently healthy workforce led to the introduction of control measures, such as modification of the decompression procedures, and the subsequent monitoring of the population at risk by routine health surveillance. It is now a notifiable industrial disease.

In contrast, some papers on other aspects of diver health have not followed that basic sequence in occupational medicine of recognise, assess, control and monitor. This research has raised public concern even though few significant findings have been associated conclusively with a career in diving. The illnesses concerned include neurological abnormalities, inner-ear deficits and changes of lung function. Other findings have yet to be associated with any known disease state and some are incidental findings that seem to have little impact on the diver’s quality of life.

**The synopsis**

In this project, professional divers and a comparison group of age-matched workers from the offshore oil and gas industry who had never dived were selected for review. They were required to have been working in their respective industry for at least 10 years prior to the study. This timing was set to allow medical conditions related to their career to become apparent. The study was in two parts, a postal survey and, for two sub-samples of responders, a clinic investigation.

**QUESTIONNAIRE SURVEY**

A postal questionnaire was sent to 2,958 divers and 2,708 offshore workers. It was designed to assess occupational history, general health complaints, diagnosed medical conditions and health-related quality of life (HRQOL). From a response rate of more than 50%, there were 1,540 divers and 1,035 offshore workers who met the inclusion criteria for the study.

From the broad range of other results presented in the report, the questionnaire survey identified three complaints that were more common in divers than offshore workers:
- ‘forgetfulness or loss of concentration’
- ‘joint pain or muscle stiffness’
- ‘impaired hearing’.

Divers were three times more likely to report symptoms of ‘forgetfulness or loss of concentration’ than an age-matched group of offshore workers. The complaint of ‘forgetfulness and loss of concentration’ was found to be the most significant long-term health effect and was not explained by factors such as welding, three-day accidents, head injury, DCI and lifestyle (age, alcohol consumption, smoking). Divers reporting ‘forgetfulness or loss of concentration’ tended to have had longer diving careers. Also, specific diving techniques such as mixed-gas bounce, saturation and surface decompression diving appeared to have had dose-response effects for this subjective complaint, and those reporting it were more likely to have suffered DCI. Adjusting for this factor reduced the relationship between ‘forgetfulness or loss of concentration’ and surface decompression diving, but not its relationship with mixed-gas bounce and saturation diving. This suggested that this complaint was explained by DCI in surface decompression diving but not in mixed-gas diving.

Complaints of ‘forgetfulness or loss of concentration’ and ‘joint pain or muscle stiffness’ were associated with a significantly lower HRQOL (health-related quality of life) score. Despite divers reporting more factors that were associated with lower HRQOL (symptoms, accidents, head injuries), as a group their reported HRQOL did not significantly differ from that of offshore workers. Further investigation of this paradox demonstrated that these factors have less of an influence on the HRQOL of divers than that of offshore workers.

**CLINIC STUDY OF RELIABILITY**

In the first phase of the clinic study a 10% age-stratified random sample was made of those divers and offshore workers who had completed the questionnaire (n = 151 and n = 103 respectively). The purpose of this was to check the reliability of the postal questionnaire and to identify asymptomatic hearing or neuropsychological deficits that would not have been detected in the postal questionnaire.

Consistency of reported symptoms indicated a moderate strength of agreement between enquiries and that the diving history reported in the questionnaire survey was consistent with the data recalled in the occupational interview. Subjects complaining of ‘forgetfulness or loss of concentration’ in the questionnaire, as a group, performed less well on objective tests of memory and concentration. Subjects complaining of ‘impaired hearing’ were more likely to have a detectable abnormality in the audiograms than subjects not reporting this complaint.
CASE-CONTROL STUDY

The second phase of the clinic study was a case-control study that comprised ‘forgetful’ divers (F divers: n = 102) while the controls were ‘non-forgetful’ divers (NF divers: n = 100) and ‘non-forgetful’ offshore workers (NF OSW: n = 100). Subjects completed the following tests: subjective and objective measures of neuropsychological function, lung function, hearing, balance, a medical examination and detailed occupational history (including diving experience and accidents). In addition to these tests, subjects in the case-control study had MRI of the brain, including voxel-based morphometry (VBM) to characterise regional cerebral volume.

F divers were found to perform more poorly on objective neuropsychological tests of memory and concentration. Diving experience continued to be significantly associated with what the authors refer to as ‘caseness’, with F divers having done significantly more dives than NF divers. However, among divers in the case-control study, there was no substantive relationship between objective cognitive performance and the amount of diving performed. Consistent with the questionnaire survey, a higher proportion of F divers had done mixed-gas bounce, surface-oxygen decompression and saturation diving than NF divers. Taking into account confounding factors, ‘forgetfulness or loss of concentration’ was found to be associated with an increased incidence of periventricular hyperintensities on MRI. Periventricular hyperintensities have been related in previous studies to lower cognitive performance. Divers were found to have an increased likelihood of subcortical or deep white matter hyperintensities compared with offshore workers, but this was not related to forgetfulness.

An interesting finding of the study was that divers, as a group, did not rate their HRQOL differently, despite a greater proportion of divers having symptoms that are usually associated with lower HRQOL. It appeared that symptoms such as joint pain, hearing loss and forgetfulness had less of an impact on divers than offshore workers. However, the case-control study found significant deficits in HRQOL of F divers, compared with NF divers and NF offshore workers. This suggests that the HRQOL impact of forgetfulness could have been disguised in the screening survey when only the minority of the population reported the complaint of ‘forgetfulness or loss of concentration’.

Conclusions

The ELTHI diving study did not identify any long-term health effects associated with professional diving amounting to a clinical abnormality. The extent of the neuropsychological effect observed in forgetful divers was at a level indicative of mild sub-clinical deficit. ‘Forgetfulness or loss of concentration’ was associated with significant impairment of HRQOL and MRI changes. The authors expressed the need for further study. Their concerns include whether their observation represents one point on a progressive decline of function or is merely the result of some form of diving-related insult with stable consequences. They also wish to establish whether any form of recovery occurs after cessation of diving.

In the opinion of this reviewer the main obstacle for the ELTHI team and other researchers will not be academic in nature but related to funding. I believe that this was a cross-sectional study because most government-funded departments do not have the authority to fund research in the longer term and I am aware that the HSE rejected several proposals for longitudinal studies (that included osteonecrosis with MRI). I hope they will relent.

Thus this report represents a substantial study that defies reduction to an adequate and accurate synopsis. One must also thank the UK HSE (diving and medical divisions) for their record of funding this and many other studies in the past thirty years. The recommendation of this reviewer is that each reader of this now downloads the original, reads it (in whole or in part), and then keeps it filed under ‘Milestones’.

Professor David H Elliott, DPhil(Oxon), FRCP, FFOM, OBE, is a Life Member of SPUMS. He claims to have retired.

Address for correspondence:
40 Petworth Road, Haslemere
Surrey GU27 2HX, UK
Phone: +44-(0)1428-644212
Fax: +44-(0)1428-658678
E-mail: <davidelliott001@aol.com>

Readers can download the full report reviewed here from the HSE website at:
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