

## **Intellectual deterioration with excessive diving (punch drunk divers)**

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Edmonds C, Boughton J. Intellectual deterioration with excessive diving (punch drunk divers). *Undersea Biomed Res* 1985; 12(3):321-326.—A survey was performed on a specific occupational group of compressed air divers—the professional abalone divers of New South Wales. One aspect of this survey included the use of psychometric screening tests to elicit evidence of impaired intellectual capacity, which may be related to the compressed air diving. Results of the survey indicate that there is suggestion of intellectual impairment in almost half of this diving population. The fact that this diving group exposed themselves to much greater decompression stress than the more conventional professional diving groups suggests that these results should not be extrapolated to other diving populations. The results are supportive of the anecdotal beliefs that exist regarding this highly selective diving group, i.e., that a syndrome of reduced intellectual capacity (dementia or "punch drunkenness") may be present.

compressed air divers  
reduced intellectual capacity

psychometric screening  
professional abalone divers

There is an anecdotal or folklore belief among many occupational diving groups, that a dementia syndrome, or "punch drunk" effect, is produced by prolonged compressed air diving. The Diving Medical Centre in Sydney, Australia, was requested to advise on this subject and to make recommendations that could allow preventive action to be taken by newer divers. Unfortunately, there was inadequate data for such a hypothesis, and therefore more information was sought regarding this problem.

During recent years interest has been mainly on the effects of deep diving and its neuropsychological sequelae (1). Workshops and symposium in Luxembourg (1978), Bethesda, Maryland (1981), and Stavanger, Norway (1983) highlighted this problem without producing a consensus. Nevertheless, during the investigations of deep diving effects there has been an apparent acceptance of neuropsychological complications of diving with compressed air at shallower depths. This disorder seemed to be presumed, without a great deal of objective or clinical evidence.

The belief that prolonged compressed air exposure resulted in intellectual impairment, with a variety of neurological and psychological disorders, was promoted by

Rozsahegyi (2) in Hungary, with clinical observations on caisson workers who had neurological decompression sickness. Peters et al. (3) in the United States, with Værnes and Eidsvik (4) from Norway, supported this association in compressed air divers who had decompression sickness. Autopsies on divers by Calder (in ref. 1) suggested a diffuse cerebral pathology to explain these observations. In each of the above reports the brain damage, with the neuropsychological clinical sequelae, was specifically correlated to the existence of decompression sickness. The incidence, or even the presence, of the "punch drunk" syndrome among compressed air divers who had not been subject to gross neurological decompression sickness was not elucidated.

A report on abalone diving in Australia (5) states that 30% of the divers suffered chronic ear damage, 20% had dysbaric osteonecrosis, and 10% had brain damage—but detailed analysis and assessments were not presented and so the observation, whether accurate or not, must be classified as conjecture.

An opportunity became available to carry out a basic clinical screening examination on a very special group of divers who could clarify the association of extreme diving exposure and the development of dementia. It was conjectured that such a group would be likely to show a much greater degree of morbidity than their more regimented colleagues. The hypothesis was that if this group of divers showed no degree of dementia, then it would be an unlikely or uncommon complication of compressed air diving *per se*.

#### POPULATION STUDIED

The professional abalone divers of New South Wales, Australia, had performed a great deal of compressed air diving and competed for a very limited catch. In this state of Australia, they formed a closed community. They were obliged to register for licenses in 1980, and a prerequisite was to have had at least 3 yr full-time professional abalone diving before the application. Thus, all the divers had more than 6 yr full-time experience at the time the study was performed. No formal diving training was required. They tended to be ex-fishermen from fishing families who had moved from their previously profitable and traditional occupation to the more lucrative abalone industry—taking with them their maritime skills but little else.

The diving was strenuous, with the divers carrying bags of abalone and enduring the tidal drag on their long, compressed-air supply hoses, collecting bags of abalone that were then transferred to the boat when filled. Each diver would average approximately 100 d diving per year and on each diving day he would be under water for a total of 4 h, which was unrelated in any way to depth. There would usually be three or four brief surface intervals, usually only of 10 min or so, but could be up to an hour—the time necessary to move his boat to an adjacent nonfished area. Most dives were between 15 and 20 m, shallow depths only being possible in very good weather and with low seas (uncommon in that area). No decompression staging was performed.

Despite the hazardous nature of the diving the financial rewards were not great, and there was a considerable depletion of the accessible abalone beds. Because of this and other reasons, the licenses were not able to be transferred or sold, but were waived when the diver decided not to continue his occupation. Thus the divers had

to persevere with their diving to finance their heavy capital expenditures on boats and equipment without opportunity to "sell out" (despite considerations of age or health) and with little opportunity to be redeployed to other occupations. Detailed records were not kept of the daily diving profile, and often neither watch nor depth gauge was worn. Most of the depths were known from the accurate maritime charts and the reported depth of the anchorages. Rarely was it possible to dive according to any plan or principle. Diving first in deeper water and then shallow water would only be possible if the wind and sea abated during the day, the opposite of its customary activity.

### METHOD

The object was to employ psychometric screening tests, standardized and extensively used on the Australian population (6), to indicate the existence or otherwise of brain damage. Tests in common clinical practice were selected, and it was not intended to apply sophisticated test batteries to demonstrate highly specific cognitive dysfunctions or conceptual abnormalities at this stage.

The screening program required the divers to complete two separate psychometric assessments. The first was the ACER Higher Test WL, standardized on Australian populations, and designed to measure general ability as revealed by performance on material of a verbal nature. As the abilities tapped by the test are among those that are hypothesized to not decline significantly with age and to be least affected by the deteriorative process, the final result provided an indication of premorbid intellectual endowment.

The second test was the Revised Visual Retention Test (Benton) which is a clinical and research instrument designed to assess visual perception, visual memory, and visuoconstructive abilities (7). Research findings have demonstrated significant relationship between Revised Visual Retention Test performance and general intelligence level, and between test performance and chronological age. The tests' normative data provide the basis for clinical interpretation within the framework of knowledge of age and estimate of premorbid intellectual endowment of the subject.

Given the subject's age and the estimate of premorbid intellectual functioning from the ACER Higher Test WL, an "expected score" appropriate to these factors can be deduced for the Benton. Interpretation of any subject's performance is then made by comparing this "expected score" with the obtained score of the test itself. The degree of discrepancy between the scores allowed the results to be classified as either "no indication" of acquired impairment of cognitive function, "raise the question" of such impairment, "suggest" such impairment, or show "strong suggestion" of such impairment. This is analogous to the approach in assessment of dementia in the clinical setting.

As well as the psychometric assessments, a record was made of the diver's age, number of years diving, number of days involved in professional abalone diving, number of times decompression sickness had been diagnosed, and alcohol intake.

### RESULTS

The population studied was as follows:

There were 30 professional abalone divers with a mean age of 37.5 yr (SD = 7.70). They averaged 13.0 yr diving (SD = 3.80), and the number of days diving per diver

was 1523.5 (SD = 1270.50). Two thirds of the divers admitted to alcohol ingestion, but only 2 of the 30 claimed to drink more than two bottles of beer per day, i.e. 1.5 liters. No divers admitted to the ingestion of spirits, and the observations of the investigators, who were staying with the divers in the same isolated residential hotel, were consistent with their claims.

In assessing the results of the psychometric screening test there were six exclusions necessary for technical reasons. One refused to do any psychological testing; one did not have his reading glasses and was therefore unable to perform the tests; one did not give his age; one missed out a whole page of one test but was otherwise assessed to have "strongly suggestive" indications of impairment; one did not attempt the ACER Higher Test WL and the Benton was poorly completed and indicative of impairment; one performed below the norms on one test and with questionable performance on the other, generating hypotheses of reading ability, visual difficulty, problems in attention span, and comprehension instructions. Thus, of the subjects excluded from formal analysis, approximately half demonstrated results or behavior suggestive of deteriorated performance.

Of the remaining 24 divers there was no evidence of intellectual impairment in 12 and 1 had results that required allocation to the "questionable" category. The results indicated impairment of acquired intellectual capacity in the remaining 11, 4 suggestive and 7 strongly suggestive. As a quick screening device it appears that at least with this population, definitive allocation to categories can be made with few equivocal cases.

Fifteen of the 28 divers reported decompression sickness but this was not significantly correlated with the impairment of intellectual capacity. The total number of episodes of decompression sickness was 41.

## DISCUSSION

These divers were selected for investigation because of their known extreme exposure to dysbaric conditions and their very productive diving procedures. It was presumed that had this group not shown any evidence of intellectual impairment, it would be unlikely to be of a significant degree in the more conventional air diving groups.

The range of environmental hazards which have been conjectured as possible etiological agents producing dementia in divers include such factors as: decompression sickness; air emboli; carbon monoxide toxicity; hypoxia; high oxygen or nitrogen pressures, etc. No attempt was made to differentiate these factors during this survey as we intended only to ascertain whether there was reason to proceed further. Had results shown no indication of dementia, further investigation would not have been warranted.

The psychometric tests performed in this survey were of a screening type, able to detect only the more gross psychopathology indicative of intellectual deterioration of a clinically relevant level (7). They would not have adequately delineated the nature of the specific neuropsychological pathology in any individual case. This would require far more extensive test batteries on each individual. The results were, however, strongly suggestive of a general impairment of intellectual capacity (dementia) in at least 7 of the subjects tested, out of a total of 24, with 4 showing some evidence

of this disorder. Demonstration of such impairment would not be expected in normal subjects and thus this finding in 11 out of 24 subjects is a cause for concern.

These divers have no gross or obvious neurological manifestations (they are all required to pass medical examinations each year), and no obvious nondiving environmental factor explains the results.

Extrapolation from the psychometric testing on other groups of more conventional divers would not have led us to suspect the results obtained during this survey. Previous work (8) suggested that intelligence is positively correlated with diving success, at least in the navy diver training courses, and the psychometric investigations performed on professional divers in the Australian Navy showed no evidence of intellectual impairment.

Because the results achieved indicate that there could be valid support for the hypothesis that compressed air diving can lead to impaired intellectual capacity (dementia), further studies are being performed on this and analogous groups throughout Australia. This particular group of divers comply less with formal decompression procedures than most other groups, although only about half the divers reported this disorder.

It is known that this incidence of decompression sickness is grossly under reported because there is very little that can be offered to the divers in the way of recompression facilities in that area. Moreover, the training and awareness of these divers in identifying decompression sickness is much below any acceptable standard. The only time they reported the disorder was when it was very obvious.

It is appreciated that much of the information obtained did not have the accuracy that one would wish. Specific details regarding the extent of the diving exposure, either for individual divers or in total, must be considered mere approximations. So also would be the degree of alcohol consumption and the incidence of decompression sickness. Nevertheless, whether these figures are underestimates or overestimates, the implications of the psychometric testing still require explanation.

Edmonds C, Boughton J. Détérioration intellectuelle reliée aux plongées excessives ('cranio-encéphalite des plongeurs'). *Undersea Biomed Res* 1985; 12(3): 321-326.—Une enquête fut entreprise auprès d'un groupe professionnel particulier de plongeurs à l'air comprimé—les plongeurs professionnels d'ormeaux de la Nouvelle—Galles du Sud. Un aspect de cette enquête inclua l'usage d'examens psychométriques de sélection afin de dévoiler une évidence d'affection de la capacité intellectuelle, laquelle peut être reliée à la plongée à l'air comprimé. Les résultats de l'étude indiquent qu'il y a des évidences de détérioration intellectuelle chez presque la moitié de cette population de plongeurs. Le fait que ce groupe de plongeurs s'exposent, eux-mêmes, au stress de la décompression de façon beaucoup plus grande que les groupes de plongeurs professionnels plus conventionnels suggèrera que ces résultats ne devraient pas être extrapolés à d'autres populations de plongeurs. Les résultats supportent les croyances anecdotiques qui existent auprès de ce groupe de plongeurs très sélectif, i.e., la présence d'un syndrome de capacité intellectuelle réduite (démence ou cranio-encéphalite des boxeurs).

plongeurs d'ormeaux  
cranio-encéphalite des boxeurs

démence  
capacité intellectuelle

#### REFERENCES

1. Symposium proceedings. Longterm neurological consequences of deep diving. EUBS and NPD Workshop. Stavanger, Norway: A.s Verbum, 1983.

2. Rozsahegyi I. Late consequences of the neurological forms of decompression sickness. *Br J Ind Med* 1959; 16:311-317.
3. Peters BH, Levin HS, Kelly PJ. Neurologic and psychologic manifestations of decompression illness in divers. *Neurology* 1976; 26:381-382.
4. Værnes RJ, Eidsvik S. Central nervous dysfunction after near miss accidents in diving. *Aviat Space Environ Med* 1982; 53:803-807.
5. Australian Fisheries. Aust Govt Publ Office. Jan. 1976:21.
6. Psychological Catalogue, 1983-1984, Australian Council for Educational Research. Hawthorne, Victoria, Australia.
7. Anastasi A. *Psychological Testing*. 5th ed. New York: Collier Macmillan, 1982.
8. Edmonds C. The diver. Royal Australian Navy S.U.M. Res Rep 1972.