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Hearing acuity in professional divers

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Molvær OI, Lehmann EH. Hearing acuity in professional divers. Undersea Biomed Res 1985; 12(3):333–349.—Pure tone audiograms and relevant history were recorded in 164 professional divers aged 19 to 66 yr, mean 30.9. A close correlation exists between hearing impairment and increasing age, increasing diving experience, and acoustic trauma. A statistically significant elevation ($P = 0.01$) of the high-frequency hearing threshold is demonstrated in smokers as compared to those who had never smoked. The divers' hearing threshold was elevated in the high frequencies in all age groups as compared to ISO normality curves. It was, however, lower than that of a Norwegian standard population at a young age, but in their fourth decade of life, the divers' high frequency hearing was at the same level as that of the standard population. We conclude that professional diving may cause a more rapid deterioration of high-frequency hearing than seen in a standard population and that smoking may be an additional hazard to high-frequency hearing.

hearing loss
diving
smoking

"Divers have always been deaf, so the story goes" (1). As far back as written accounts about diving can be traced, ear problems have been emphasized. Thus, Aristotle described tympanic membrane rupture in divers more than 300 yr before Christ (2).

Acute injuries to all parts of the ear may occur during diving, and permanent damage to the inner ear in all phases of diving is well documented (3–10). Further, ubiquitous noise is a problem in dive helmets (11) and pressure chambers (12–15) and has even penetrated the depths of Costeau's "Monde du silence," especially originating from divers' tools (16, 17).

Due to the quoted facts, combined with our own impression of hearing impairment being frequent in the diving community, we decided to investigate whether or not the hearing acuity in professional divers deviated from that in a standard population of nondivers.

MATERIALS AND METHODS

The present sample of male professional divers is heterogeneous concerning age, diving experience, and main type of diving. The Norwegian Government Diver Training School was founded in 1979. Before that a diver's education had been on-the-job training, Navy hard-hat diving courses, or courses in sports diving supplemented by short courses on different underwater work procedures. Some of our divers are deep divers working mainly offshore in the saturation mode, while others are standard hard-hat divers working inshore, mainly performing shallow construction work. Some are inspection divers and some Navy divers. The latter group comprises several categories, like shallow-water ship divers, mine clearance divers, and demolition team divers. The picture is even more complicated by the fact that some had many years of experience as sports divers before their professional diving careers, and have also been Navy divers. Some divers fluctuate between the different categories described above. Some had worked in noisy work sites onshore, like shipyards, before their diving careers, and others take construction work onshore whenever underwater work is unavailable.

The age distribution in the present sample of 164 divers is shown in Fig. 1. The median age was 30 yr, mean 30.9 (SD 8.4), the span was 19 to 66 yr and the most commonly occurring age was 28 yr (in 16 divers).

Some students from the Norwegian Government Diver Training School's classes for deep divers were included. One year of professional diving is a minimum requirement of applicants for this type of training, but some of them had more extensive diving experience. A representative group of standard hard-hat divers was obtained by traveling to a major underwater construction work site. By preference, their hearing was measured when they returned from a weekend off to minimize possible effects of temporary threshold shifts (TTS) from the dive activity. Deep divers and inspection divers were included when they came to the Norwegien Underwater Technology Center (NUTEC) to have their annual medical examination or to participate in experimental dives. Navy divers were recruited mainly from the Haakonsvern Navy base. In addition, divers of different categories were admitted by other physicians or arrived by other routes. The majority of the divers were Norwegian, but some came from other Scandinavian and Nordic countries and a few from other European countries and overseas.

The distribution of diving experience, defined as total number of years of diving, is shown in Fig. 2. The span is 1 to 43 yr, the most commonly occurring is 5 yr, the median is 8 yr, the mean 10.2 yr, and the standard deviation 7.8.

One of the authors, an ear, nose, and throat specialist, personally filled in a questionnaire for each diver and performed an otological examination on all of them. He also performed the audiometric measurements on the majority of the divers. A few had their hearing tested by experienced technicians in the County Hospital of Haugesund, Audiology Department.

The following items were included in the questionnaire: hearing loss in close relatives; previous ear disease or injury and head injury with inner ear symptoms/signs; noise exposure; diving experience; inner ear barotrauma; inner ear decompression sickness; other diving-related ear injury; vertigo in diving; use of tobacco; kind of diving equipment used.

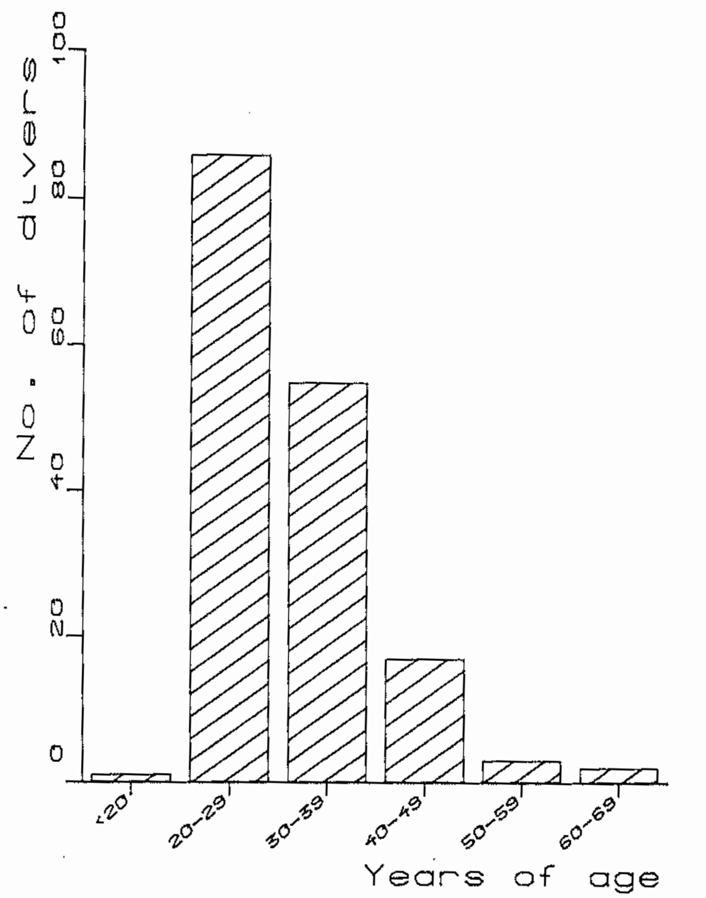

Fig. 1. Age distribution of the 164 divers.

The hearing was tested in soundproof rooms or booths (Tegner, Stockholm). The background noise level was examined by means of a Brüel and Kjær sound lever meter type 2204 with an octave band filter type 1613 and found to meet the requirements for audiometric test rooms according to Flottorp and Sundby (18) and the Norwegian Labour Inspectorate's Guidelines (19). The audiometers used (Madsen OB 70 Clinical Audiometer, Oscilla KD 277, Oscilla Battery and Danplex AS62) were calibrated according to ISO 389 (20). Telephonics TDH 39 earphones mounted in MX 41/AR cushions were used for the air conduction tests; and whenever a bone conduction threshold was recorded a Radioear B 71 telephone was used. In this report only the air conduction thresholds will be discussed.

The test procedures generally followed the guidelines given by the Norwegian Labour Inspectorate (19), and the frequencies tested for the air conduction thresholds were: 0.125, 0.25, 0.5, 1, 2, 3, 4, 6, and 8 kHz. In a minority the 0.125 and 3 kHz frequencies were not included in the test.

Previous investigations of different groups of people have indicated a possible relationship between smoking and hearing impairment, and animal experiments have demonstrated a connection between exposure to tobacco and ear damage (21–37).

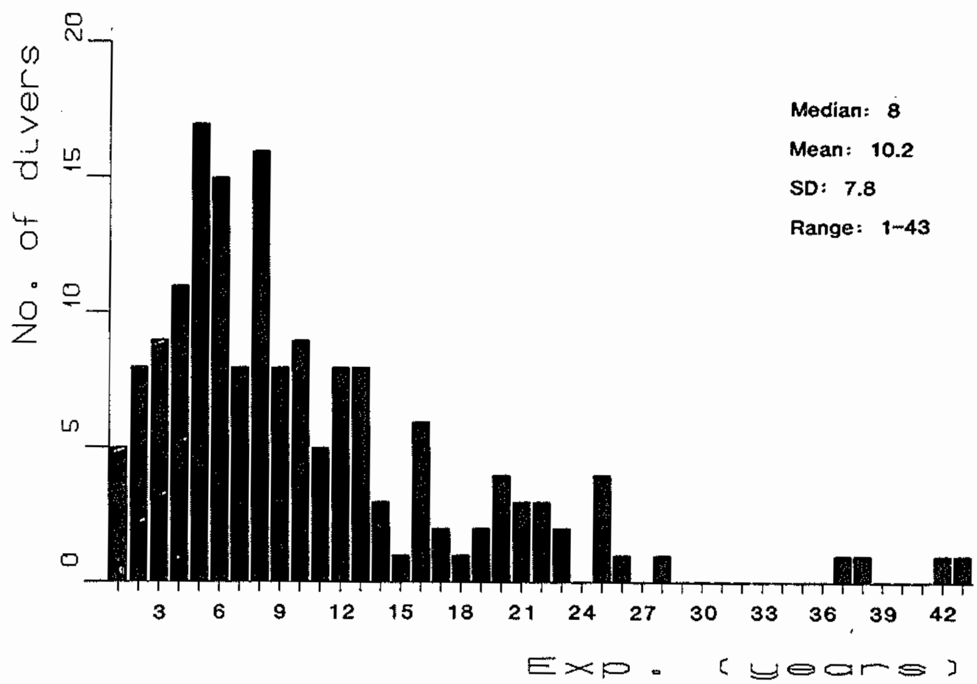

Fig. 2. Distribution of diving experience.

In the age groups below 20 yr and above 49 yr there were too few subjects for statistical analysis of the results. Consequently, the audiograms will be given only for the age groups 20 to 29, 30 to 39, and 40 to 49 yr.

RESULTS

The mean hearing levels in decibel for each ear separately in the different age groups are given in Table 1 with the standard deviations in parentheses.

The mean hearing levels in decibel for both ears combined in the different age groups are given in Table 2, and the corresponding audiograms for the age groups 20 to 29, 30 to 39, and 40 to 49 yr are shown in Fig. 3. As expected, the hearing deteriorated with increasing age.

The mean hearing level in decibel according to diving experience is given for each ear separately in Table 3, for both ears combined in Table 4, and illustrated as audiograms in Fig. 4. Not surprisingly, the hearing is shown to deteriorate with increasing diving experience.

The audiograms suggested that a reduction in hearing acuity was more often present in the left ear than in the right, and that hearing impairment, when present bilaterally, was more pronounced in the left ear than in the right. Since this impression was consistent with the observations of Rózsahegyi and Láng (38), we evaluated the differences in mean hearing levels between the right and the left ears in the different age groups by means of Wilcoxon's matched pairs signed ranks test. The results are given in Table 5 demonstrating that significant side difference was present only at 2,

TABLE 1

MEAN HEARING LEVEL IN DECIBEL ACCORDING TO AGE, EACH EAR SEPARATELY

Frequency, kHz	Age, yr <20 $n = 1$		20–29 $n = 86$		30–39 $n = 55$		40–49 $n = 17$		50–59 $n = 3$		60–69 $n = 2$	
	R	L	R	L	R	L	R	L	R	L	R	L
0.125	—	—	7.5[a]	8.9[a]	5.0[d]	4.4[d]	7.5[f]	10.5[f]	10[g]	15[g]	20[g]	20[g]
			(4.6)	(8.0)	(4.1)	(4.0)	(4.2)	(6.0)				
0.25	0	0	1.2	1.5	1.0	1.5	3.8	5.3	8.3	8.3	7.5	10.0
			(4.6)	(6.3)	(9.0)	(7.8)	(6.3)	(6.7)	(2.9)	(7.6)	(10.6)	(7.0)
0.5	0	−5	1.3	1.7	1.8	2.2	4.1	4.7	11.7	11.7	2.5	5.0
			(5.6)	(6.8)	(8.4)	(8.8)	(6.7)	(8.6)	(11.5)	(7.6)	(3.5)	(0.0)
1	0	−5	0.6	1.8	0.1	1.0	6.8	6.2	11.7	16.7	0.0	2.5
			(5.7)	(10.8)	(8.0)	(8.2)	(7.8)	(9.6)	(17.6)	(16.1)	(0.0)	(3.5)
2	−5	−5	−0.5	3.1	2.0	2.5	11.8	15.3	20.0	25.0	7.5	22.5
			(6.5)	(12.9)	(8.7)	(10.5)	(18.0)	(16.1)	(21.8)	(20.0)	(3.5)	(3.5)
3	0	10	4.4[b]	8.5[c]	9.8[e]	9.5[e]	18.2	25.3	32.5[h]	30.0[h]	30.0	42.5
			(7.2)	(12.3)	(13.0)	(9.4)	(15.6)	(14.8)	(17.7)	(21.2)	(7.1)	(17.7)
4	−10	−5	3.3	9.0	13.2	16.2	30.9	32.1	30.0	33.3	37.5	50.0
			(10.9)	(16.0)	(18.3)	(17.6)	(14.5)	(15.8)	(5.0)	(16.1)	(3.5)	(14.1)
6	−10	−10	6.1	8.7	13.5	16.3	32.6	33.5	38.3	30.0	40.0	65.0
			(13.9)	(15.1)	(18.8)	(17.9)	(19.8)	(19.2)	(25.7)	(26.0)	(7.1)	(14.1)
8	−5	−15	5.1	6.2	10.4	12.0	29.7	30.9	38.3	30.0	55.0	62.5
			(13.7)	(13.2)	(18.8)	(14.2)	(22.9)	(21.8)	(30.6)	(27.8)	(7.1)	(24.7)

Standard deviations in parentheses; n = number of divers. Where n is different from the number quoted in the column heading the correct number is given in the footnote. [a]$n = 18$; [b]$n = 83$; [c]$n = 81$; [d]$n = 16$; [e]$n = 53$; [f]$n = 10$; [g]$n = 1$; [h]$n = 2$.

3, and 4 kHz in the 20 to 29 yr group and at 3 kHz in the 40 to 49 yr group. In all four instances the threshold was highest in the left ear.

The tobacco habits of our sample are shown in Table 6, demonstrating that 29% had never smoked, 52% did not smoke at the time of the investigation, 47% smoked, and 70% either smoked or had smoked previously.

To evaluate the effects of smoking on hearing, we first compared the mean hearing level for 4, 6, and 8 kHz for both ears combined in each group (smokers, previous smokers, never smoked) to the total sample mean (hearing level 1 = HL_1) in Table 7. The "never" group's threshold was 5.1 dB lower than the mean, the "previous" group's threshold was close to the mean, and the "smoker" group's threshold 3 dB higher than the mean. The contrast between "smokers" and "never smoked" was thus 8.1 dB. Then we adjusted the HL_1 values for the effects of age, diving experience, and a "yes" or "no" answer to the question about previous noise damage. This was done by an analysis of covariance, a correlation and regression analysis using the ANOVA program from the Statistical Package for the Social Sciences (SPSS). The adjusted hearing levels, HL_2, and their contrast are also given in Table 7. Even though

TABLE 2
MEAN HEARING LEVEL IN DECIBEL IN DIFFERENT AGE GROUPS, BOTH EARS COMBINED

Frequency, kHz	Age, yr					
	>20	20–29	30–39	40–49	50–59	60–69
0.125	—	8.2	4.7	9.0	12.5	20.0
0.25	0.0	1.4	1.3	4.6	8.3	8.8
0.5	−2.5	1.5	2.0	4.4	11.7	3.8
1	−2.5	1.2	0.5	6.5	14.2	1.3
2	−5.0	1.3	2.3	13.5	22.5	15.0
3	5.0	6.5	9.7	21.8	31.3	36.3
4	−7.5	6.1	14.7	31.5	31.7	43.8
6	−10.0	7.4	14.9	33.1	34.2	52.5
8	−10.0	5.6	11.2	30.3	34.2	58.8

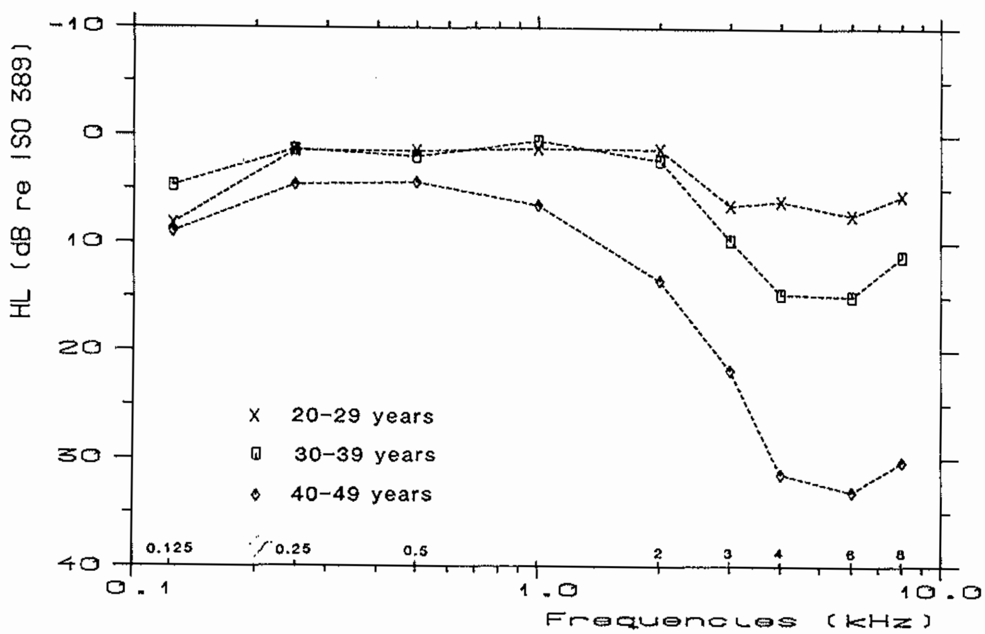

Fig. 3. Hearing thresholds in the three main age groups (based on Table 2).

the contrast after adjustment is only 5.5 dB, this is statistically significant at the 1% level according to an F test, as shown in Table 8.

For comparison, the contrast between the "yes" and "no" answer regarding previous noise damage was 16.2 dB before adjustment and 10.5 dB after correction for the other variables. Thus, the effect of smoking on hearing seems to be roughly half that of noise according to the criteria defined above. No interaction was seen between noise exposure and smoking ($P = 0.59$); i.e. the combined effect on hearing may be additive.

TABLE 3
MEAN HEARING LEVEL IN DECIBEL ACCORDING TO DIVING EXPERIENCE, EACH EAR SEPARATELY

Frequency kHz	Diving Experience, yr: 0–4 $n = 33$ R	0–4 L	5–9 $n = 64$ R	5–9 L	10–14 $n = 34$ R	10–14 L	15–19 $n = 13$ R	15–19 L	>20 $n = 23$ R	>20 L
0.125	7.5[a]	7.5[a]	6.1[b]	8.2[b]	3.5[c]	3.5[c]	8.0[d]	6.0[d]	9.2[e]	11.9[e]
	(2.9)	(2.9)	(4.5)	(9.3)	(4.1)	(3.4)	(2.7)	(2.2)	(4.9)	(6.0)
0.25	1.5	1.2	0.5	0.9	0.3	1.0	4.2	5.0	4.3	5.7
	(4.4)	(5.7)	(5.2)	(7.0)	(5.1)	(4.9)	(15.3)	(10.4)	(6.8)	(7.3)
0.5	1.4	1.5	1.3	2.0	0.4	0.9	4.6	4.2	4.9	5.4
	(6.9)	(6.6)	(5.0)	(8.1)	(5.0)	(5.8)	(14.1)	(11.0)	(7.9)	(8.2)
1	0.6	−0.2	0.1	2.0	0.3	0.9	2.3	4.2	5.9	7.2
	(6.5)	(6.8)	(5.2)	(11.3)	(4.4)	(8.0)	(14.1)	(12.0)	(9.6)	(10.5)
2	−1.7	1.7	0.5	4.3	1.0	0.9	5.4	5.4	11.3	15.7
	(5.8)	(8.1)	(6.5)	(13.8)	(6.6)	(9.2)	(14.1)	(16.4)	(17.8)	(16.7)
3	4.5	5.3	5.5	9.8	8.4	9.2	13.7	14.2	20.2	25.2
	(7.9)	(8.4)	(8.0)	(11.7)	(13.6)	(10.7)	(14.6)	(15.3)	(15.1)	(16.6)
4	3.5	3.8	4.5	10.8	12.6	17.2	18.1	17.3	30.0	32.4
	(15.1)	(11.5)	(11.0)	(17.4)	(18.6)	(16.6)	(23.0)	(17.6)	(14.0)	(18.3)
6	4.7	5.6	8.8	10.4	10.6	16.2	16.9	17.7	33.3	33.3
	(12.2)	(12.0)	(17.4)	(17.1)	(18.6)	(16.1)	(16.7)	(22.2)	(19.4)	(22.4)
8	5.2	3.6	8.4	7.7	6.8	10.4	9.2	16.2	32.6	31.5
	(12.0)	(10.6)	(18.0)	(14.8)	(18.1)	(14.1)	(15.7)	(16.6)	(23.1)	(23.6)

Standard deviations in parenthesis; n = number of divers. Where n is different from the number given in the column heading the correct number is given in a footnote. [a]$n = 4$; [b]$n = 14$; [c]$n = 10$; [d]$n = 5$; [e]$n = 13$.

The covariates of age and diving experience were so closely associated that either could be used alone without changing the results.

DISCUSSION

We usually consider divers as a highly selected group as far as ear physiology is concerned, but there are still a few left of the old school who, without any medical screening or formal training, took over their father's hard-hat diving business. Today, all holders of commercial diving certificates have a medical examination annually. At present we have two different medical screening procedures for applicants for commercial diver training in Norway. One is applicable only to standard hard-hat divers and dates back to 1959 (39). The requirements for the ear and hearing are as follows:

"The hearing ought to be normal in both ears (whispering understood at a distance of at least 5 m). Signs of acute or chronic ear diseases must not be present." Work

TABLE 4
MEAN HEARING LEVEL IN DECIBEL ACCORDING TO DIVING EXPERIENCE, BOTH EARS COMBINED

Frequency, kHz	Diving Experience, yr				
	0–4	5–9	10–14	15–19	>20
0.125	7.5	7.1	3.5	7.0	10.6
0.25	1.4	0.7	0.7	4.6	5.0
0.5	1.4	1.6	0.7	4.4	5.1
1.0	0.2	1.0	0.6	3.3	6.5
2.0	0.0	2.4	1.0	5.4	13.5
3	4.9	7.7	8.8	14.0	22.7
4	3.6	7.7	14.9	17.7	31.2
6	5.2	9.6	13.4	17.3	33.3
8	4.4	8.1	8.6	12.7	32.1

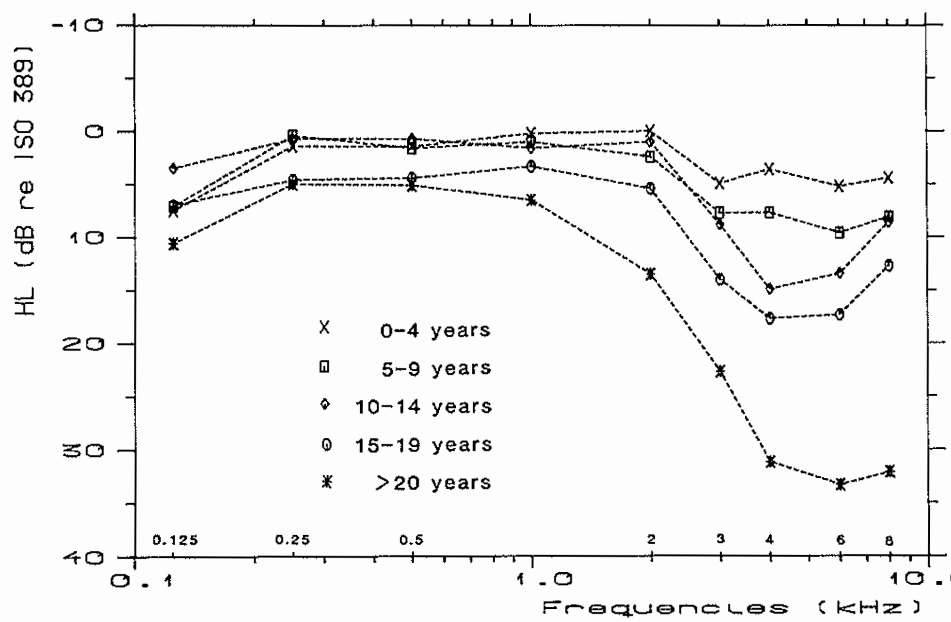

Fig. 4. Hearing thresholds according to diving experience (based on Table 3).

is in progress to have these directions replaced by the other of the two medical standards (40) in which the requirements for the ears and hearing are as follows.

Both tympanic membranes must be intact and mobile. The Eustachian tubes must function normally when a Valsalva test is carried out. Chronic otorrhea shall be cause for rejection. Active Ménière's disease shall always be cause for rejection. Any history of ear surgery necessitates a specialist opinion, preferably from the surgeon who operated, otherwise from another ear, nose and throat specialist. Hearing must be tested annually with a pure tone audiometer. The following frequencies must be tested: 500,

TABLE 5

DIFFERENCE IN HEARING LEVEL BETWEEN RIGHT (R) AND LEFT (L) EAR IN DIFFERENT AGE GROUPS EVALUATED BY MEANS OF WILCOXON'S MATCHED PAIRS SIGNED RANKS TEST

Frequency, kHz	Age, yr 20–29		30–39		40–49		50–59		60–69	
	R–L	*P*	R–L	*P*	R–L	*P*	R–L	*P*	R–L	*P*
0.125	−1.4	0.625	0.6	0.575	−3.0	0.249	−5.0	0.317	0.0	1.000
0.25	−0.3	0.876	−0.5	0.504	−1.5	0.214	0.0	1.000	−2.5	0.317
0.5	−0.5	0.738	−0.4	0.829	−0.6	0.610	0.0	1.000	−2.5	0.317
1	−1.2	0.699	−0.9	0.249	0.6	0.646	−0.5	0.180	−2.5	0.317
2	−3.6	0.005*	−0.5	0.640	−3.5	0.136	−5.0	0.655	−15.0	0.180
3	−4.0	0.000*	0.3	0.708	−7.1	0.006*	2.5	0.317	−12.5	0.180
4	−5.7	0.000*	−3.0	0.085	−1.2	0.932	−3.3	0.593	−12.5	0.317
6	−2.6	0.165	−2.7	0.115	−0.9	0.816	8.3	1.000	−25.0	0.180
8	−1.0	0.328	−1.6	0.134	−1.2	0.753	8.3	0.655	−7.5	0.655

*Statistically significant.

TABLE 6

THE DISTRIBUTION OF TOBACCO HABITS IN PROFESSIONAL DIVERS

Tobacco habits	%
Never used	29
Previously	23
Not presently	52
Presently using	47
Previously or presently	70
Missing data	1

TABLE 7

THE EFFECT OF SMOKING ON THE HEARING. HL_1 IS THE DIFFERENCE IN HEARING LEVEL BETWEEN EACH SUBGROUP AND THE TOTAL GROUP MEAN FOR THE FREQUENCIES 4, 6, AND 8 KHZ (ARITHMETIC MEAN). IN HL_2 THE FIGURES ARE CORRECTED FOR THE EFFECTS OF AGE, DIVING EXPERIENCE, AND NOISE EXPOSURE

Tobacco Habits	HL_1, dB	HL_2 dB
Never	−5.1	−2.9
Previously	0.9	−1.3
Presently	3.0	2.6
Contrast	8.1	5.5

TABLE 8

THE RESULTS OF AN *F*-TEST TO INVESTIGATE THE CORRELATION BETWEEN EACH INDEPENDENT VARIABLE AND THE RECORDED HEARING LOSS

Covariates	*P*
Age/diving experience	<0.0005
Noise exposure	<0.0005
Tobacco	$=0.01$

1000, 2000, 3000, 4000 and 6000 Hz. Each ear shall be examined separately. A hearing loss in one ear of 35 dB or more at frequencies up to 3000 Hz or of 50 dB or more at frequencies of 3000 Hz or higher shall always constitute grounds for examination by a specialist. A hearing loss of this order in both ears will as a general rule be cause for rejection. Where there is any indication of incipient or progressive injury caused by noise, the diver's hearing should be checked in accordance with the Labour Inspectorate's regulations on noise in the working environment.

With the described selection procedures in mind, one may compare the divers' hearing with normal hearing in the different age groups (41) as well as with the hearing in a standard population of nondivers (42). The youngest age group is also compared to U.S. Navy divers with a mean age of 28.3 yr (43) in Fig. 5. In this figure we can see that our divers in the youngest age group, 20 to 29 yr, have normal hearing in the low and middle frequencies but have slightly higher thresholds than the ISO curve in the high frequencies. On the other hand, our divers have better hearing at all measured frequencies than the standard population. The reason may be that the standard population was a random sample from a general population and thus contained people with ear diseases, noise injuries, sequelae from head injuries, and general diseases affecting the hearing, like meningitis, whereas the divers are highly selected regarding their ear state and hearing. Even though the mean age of the U.S. Navy divers is within the same span as our group, they are not readily comparable because the Navy sample is averaged over a range from 20 to 42 yr. In addition, they are military personnel who may have been subjected to more gunfire noise than the other groups, as in Coles and Knight's sample from the Royal Navy (44). Our sample also covers Royal Norwegian Navy divers, but they are not a majority and they are in the correct age span.

As shown in Fig. 6, the tendency is the same in the next age group, 30 to 39 yr. The high-frequency hearing of the divers falls between that of the ISO norm and the standard population.

Our oldest group of divers (40 to 49 yr), however, seem to have caught up with the standard population as far as high-tone hearing loss is concerned, as illustrated in Fig. 7. Since this is a cross-sectional investigation, one cannot claim that the divers lose their high-frequency hearing faster than the standard population and thus end at the same level as that group after a couple of decades. Even though the steeper slope of the deterioration curves for 4 and 6 kHz with advancing age for the divers may seem convincing when compared to the standard population (Fig. 8), we cannot

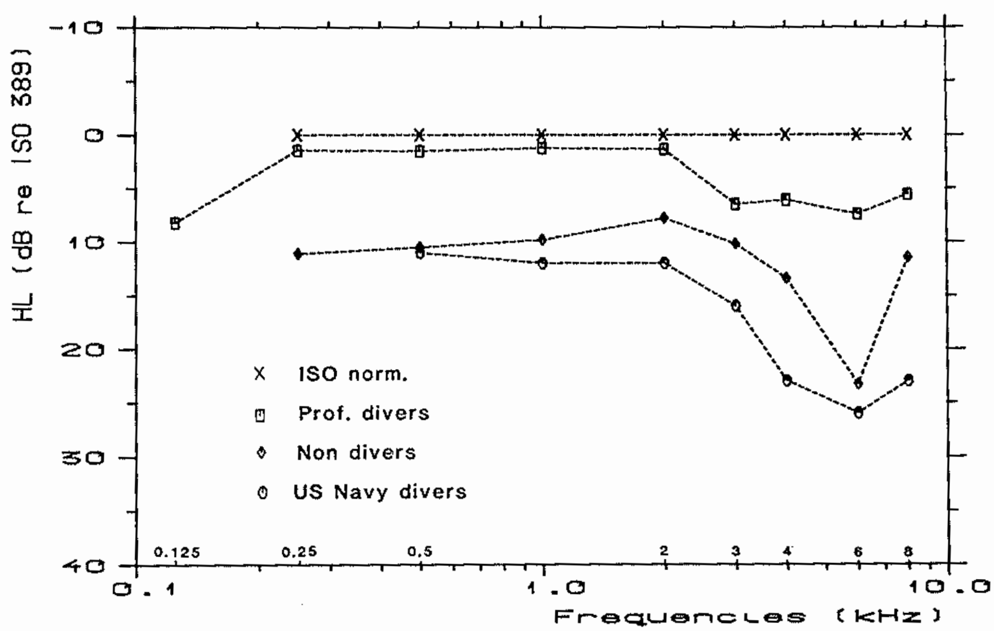

Fig. 5. The hearing threshold in our sample of professional divers aged 20 to 29 yr compared to normal hearing, the hearing in nondivers, and the hearing in navy divers.

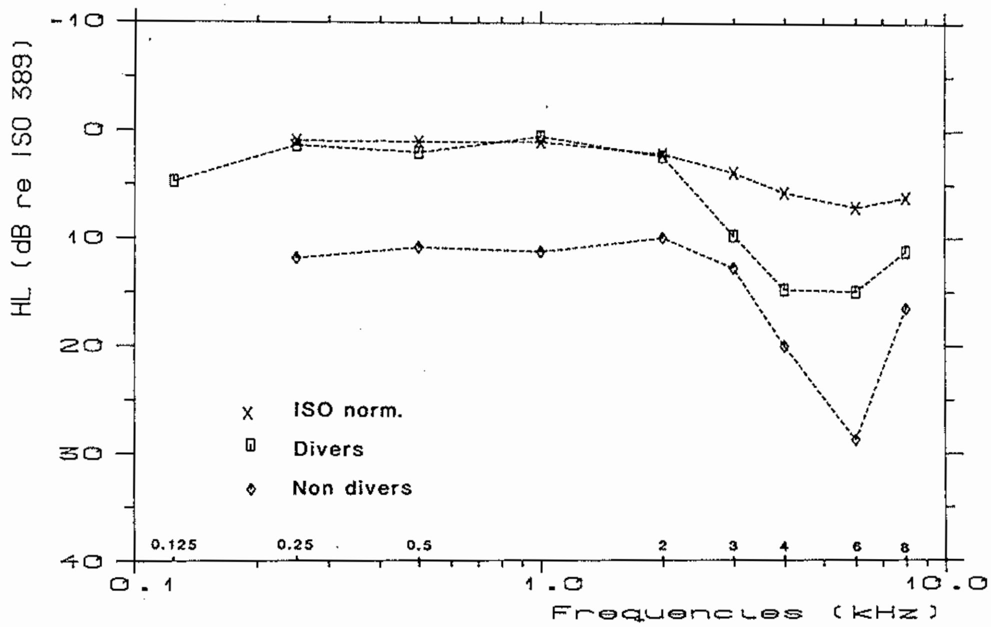

Fig. 6. The hearing level in our sample of 30 to 39 yr old divers compared to normal hearing and the hearing in nondivers.

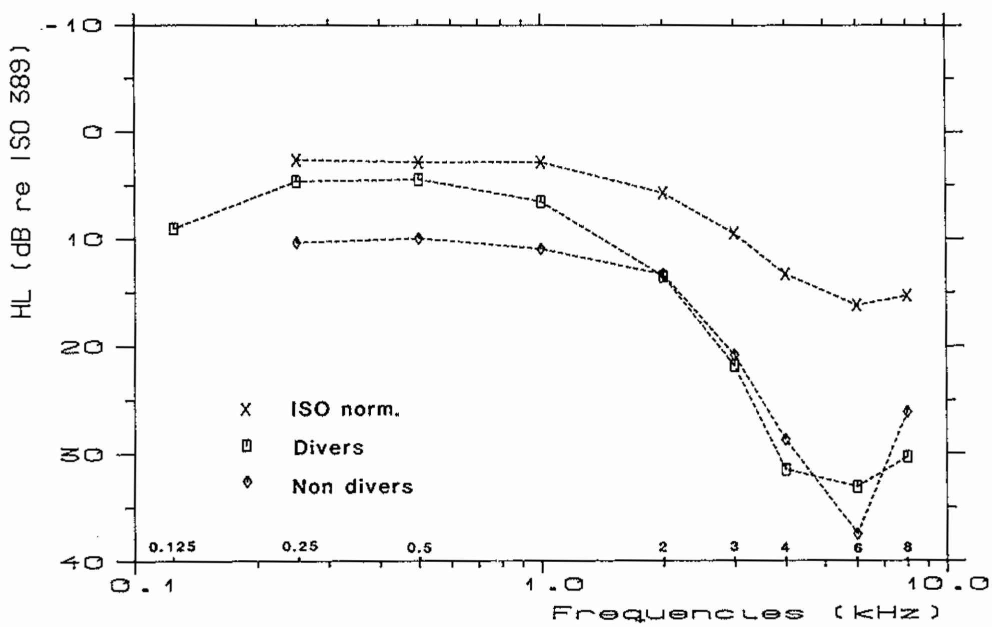

Fig. 7. The hearing level in our sample of 40 to 49-yr-old divers compared to normal hearing and the hearing in nondivers.

exclude cohort effects. We do not know what the hearing was in the 40 to 49 yr group when they were younger, nor can we predict what the hearing will be in our young divers when they grow older. To decide this, a prospective investigation is necessary, which we plan to do, using the present material as a base. By extrapolating the curves

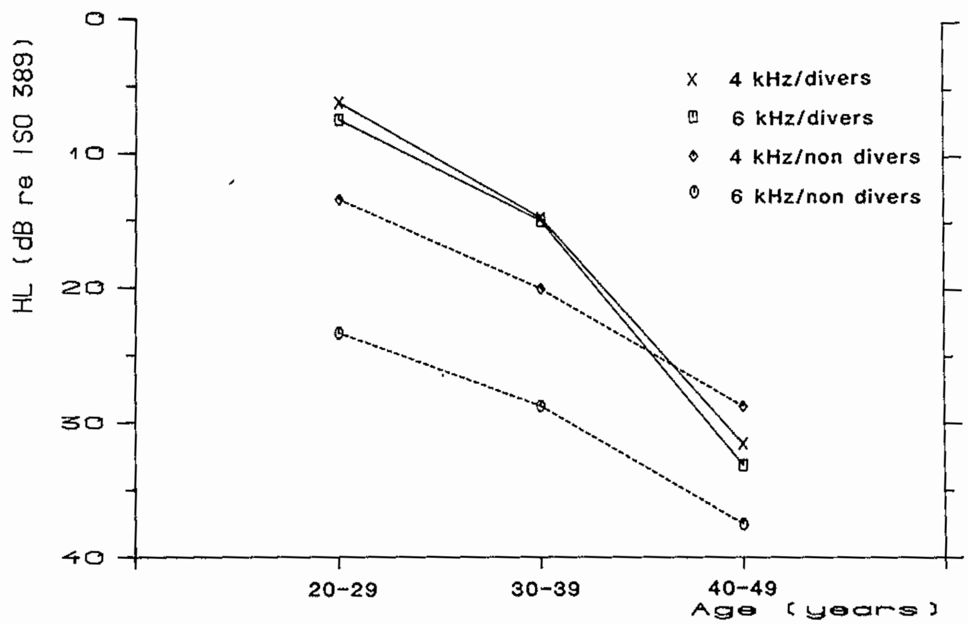

Fig. 8. The deterioration of high frequency hearing with increasing age in divers and nondivers.

in Fig. 8 we would find that in the next higher age group the divers would pass the standard population in high-tone loss, but since our material of divers in the 50 to 59 yr age group still is too small for statistical calculations, the said development of hearing loss is mere conjecture. We are, however, in the process of collecting relevant data.

One has to consider the possibility that what the diver does under water may be more decisive for his long-term hearing ability than whether he dives or not. Further, what the diver did before his diving career and what he does in his spare time can heavily influence his hearing acuity. Thus it is not easy to determine how much repetitive compressions and decompressions contribute to hearing deterioration in divers.

We do know that hyperbaric diving involves a variety of stress factors which can inflict permanent injury to the inner ear, as referred to in the introduction. But mechanical trauma, diseases, high intensity impulsive noise, and long-term, high-level noise exposure also affect the ears of nondivers. Thus, when comparing the hearing ability in divers with that of nondivers, one has to select a control group the same age as the divers and preferably with a similar professional noise exposure. Rogberg and Löwing (45) found comparable high-tone losses in standard hard-hat divers and surface construction workers, while the divers had significantly greater hearing loss in the low frequencies. Coles and Knight (44) found high frequency hearing losses in 51 of 62 (82.3%) navy divers, but attributed that to gunfire and concluded that they could not find any progressive middle or inner ear injury from diving. But later, Coles (46) maintains that an insidious development of high-tone sensorineural hearing loss may be associated with diving. Zannini et al. (47) found significantly higher incidence of hearing loss in 160 professional divers than in comparable nondivers, but later Zannini and Marroni (48) found only slight and transient hearing impairment in 47 of 100 professional divers aged 20 to 50 yr. Brady et al. (49)

found no significant difference in hearing between 97 navy divers aged 20 to 43 yr and a normal population of nondivers. Similar observations were made by Brink (50) when comparing the hearing in 135 navy divers with that of 103 nondiving navy crew members. Edmonds and Blackwood (51) found no difference in hearing between full-time divers and nondivers. Borasi and Sperati (52) found hearing impairment in 56% of 108 professional divers. The hearing loss was predominantly conductive in divers with less than 5 yr experience, perceptive in divers with more than 8 yr experience, and mixed in the middle group. The authors interpreted the hearing impairment as a professional injury. Also, Zannini et al. (47) observed a change from conductive through mixed to perceptive losses with increasing diving experience. Cross and Mayo (53) found high-frequency hearing impairment, most pronounced at 6 kHz, much more frequently in North Sea divers than in nondivers, regardless of the diver's experience. They also observed a low-frequency conductive loss increasing with diving experience. Although Taniewski and Kwiatkowski (54) are cautious, they conclude from their investigation of 70 professional divers aged 25 to 53 yr that diving has a possible harmful effect on the auditory function. Poulton and Poulton (55) found a hearing loss exceeding 20 dB in 76.9% of 160 commercial divers. Even in sports divers, Wilke and Šteffl (56) found hearing impairment of the cochlear type, mostly in the high frequencies, in 40.4% of their sample of 47 divers with a mean age of 23 yr. In professional breath-hold divers, Harashima and Iwasaki (57) and Hong (58) found ear pathology and hearing loss more frequently than in controls. These female Ama and Hae-Nyo divers of Japan and Korea, operating in silent surroundings, predominantly displayed the low frequency component of the hearing losses reported by several of the authors quoted above, whereas the high frequency impairment typical for noise injury was rare.

Caisson and compressed air workers in tunnels are exposed to changes in ambient pressure comparable to some categories of divers, and the noise levels in their work sites are generally high. Early in this century, Boot (59) reported high-tone hearing impairment in caisson workers exposed to high noise levels, many of whom were elderly. Simultaneously, Bassoe (60) found permanent hearing impairment in 40.4% (65 of 161) compressed air workers who had experienced decompression sickness. Palmgren (61) demonstrated high-tone hearing deterioration in 17 of 49 (34.7%) caisson workers after a mean exposure time of 725 d. They had been exposed regularly to noise levels of 100 dB (at 1 kHz), so even though glass wool had been used for ear protection, the author found it impossible to evaluate a possible effect of the changes in ambient pressure in this connection. Láng et al. (62), on the other hand, concluded from their neurootological investigations on 432 caisson workers that nerve deafness occurred more often, appeared earlier, and was more pronounced than from similar noise exposure at surface pressure. Rózsahegyi and Láng (38) arrived at the same conclusion from their audiological examination of 330 caisson workers. Using as a criterion for hearing loss that the arithmetic mean at the eight tested frequencies exceeds 20 dB for both ears combined, Rózsahegyi and Gömöri (63) found hearing impairment in 40.4% of the caisson workers. When using the mean loss at 4 kHz for both ears combined, the percentage of hearing impairment rose to 71.2, even when subjects with a history of previous noise exposure and ear diseases and subjects with tympanic membrane changes were excluded. In his followup of 100 cases of decompression sickness from caisson work, Rózsahegyi (64) found hearing impairment in only 11 and tinnitus in 8 subjects.

CONCLUSION

From the literature it is difficult to conclude whether the hearing threshold is higher in divers than in nondivers. Our investigation suggests that hearing at a young age is better in divers than in a standard population, probably due to the selection procedures for the diving profession. In the fourth decade of life, however, the high frequency hearing in divers is at the same level as in the standard population, suggesting a faster deterioration in divers. This investigation also indicates that, besides noise exposure, smoking may contribute to the observed hearing impairment.

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Molvær OI, Lehmann EH. Acuité auditive chez des plongeurs professionnels. Undersea Biomed Res 1985; 12(3):333–349.—Des audiogrammes de tons purs et les antécédants pertinents furent documentés chez 164 plongeurs professionnels âgés de 19 à 66 ans, moyenne de 30.9 ans. Une corrélation étroite existe entre les troubles auditifs et le vieillissement, le gain de l'expérience en plongée et les dommages acoustiques. Une élévation statistiquement significative (P<0.01) du seuil auditif des hautes fréquences est démontrée chez les fumeurs en comparaison avec ceux qui n'ont jamais fumé. Les seuils auditifs des plongeurs étaient élevés pour les hautes fréquences dans tous les groupes d'âges en comparaison avec les courbes iso-normales. Cependant, ils étaient plus bas que ceux d'une population norvégienne typique de jeune âge, mais dans la quatrième décade de vie, l'audition des plongeurs pour les hautes fréquences était au même niveau que celle de la population typique. Il est conclu que la plongée professionnelle peut produire une détérioration plus rapide de l'audition des hautes fréquences que celle observée dans une population typique, et que le fumâge peut ête un risque supplémentaire à l'audition des hautes fréquences.

fumâge
plongée
perte auditive

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