Does cold water truly promote diver's ear?

M. ITO and M. IKEDA

First Department of Anatomy, National Defense Medical College, Namiki Tokorozawa; and Japan Maritime Self-Defense Force Undersea Medical Center, Nagase, Yokosuka, Japan.

Ito M, Ikeda M. Does cold water truly promote diver's ear? Undersea Hyper Med 1998; 25(1):59–62.—Ninety-seven Japanese military divers from two districts, Mutsu (Northern Japan) and Yokosuka (Central Japan), were examined for the incidence of diver's ear (exostosis of the external auditory canal). The average temperature of sea water of the two districts is different because of their latitude, but the two groups had no significant difference in diving career. The incidence of exostosis in the Mutsu (cold area) group showed a significant increase as the diving career progressed. This tendency was not seen in the Yokosuka (warm area) group. The severity of exostosis increased in divers in both districts. The incidence of exostosis in Mutsu was significantly higher than in Yokosuka. The Mutsu group also showed a higher ratio of exostosis grade 2 than the Yokosuka group. These results may support the hypothesis that cold water facilitates formation of external auditory canal exostosis.

exostosis, external auditory canal, diver's ear, diver, navy

Exostosis of the external auditory canal, "surfer's ear", which is also often called "diver's ear" among Japanese Navy divers, is an acquired sessile mass arising from the bony portion of the external auditory canal; it is often seen in active aquatic sport athletes and workers, such as surfers, swimmers, and divers (1,2). In previous studies (3,4), the relationship between the activity of the aquatic sports and the incidence of exostosis has been pointed out, but no reports compare career-matched populations of aquatic sports athletes with regard to the incidence of exostosis.

In this study we were able to examine two populations whose diving careers were well matched, with the exception of the climate where divers usually did their missions. The targets of our research were as follows: a) Does the diving career (the duration of contact with water) truly have a relationship with the incidence of exostosis? b) What is the relationship between the diving career and the severity of exostosis? c) What is the relationship of water temperature to the incidence and severity of exostosis? We considered that these two populations would be suitable subjects to examine these queries.

METHODS

Subjects

Ninety-seven healthy male Navy divers (194 ears), ranging in age from 20 to 53 yr, were from two districts in Japan, Mutsu and Yokosuka, latitudes of 41° N and 36° N, respectively. The average ages and average diving careers of Mutsu (27 divers) were 34.9 ± 8.1 and 33.1 ± 8.6 yr old (mean ± SD) and for Yokosuka (70 divers) 12.3 ± 6.9 and 10.7 ± 8.7 yr (mean ± SD). The location of each district is depicted in Fig. 1. All divers were qualified for deep diving. Most used open scuba apparatus and commonly dived for training and for operations around the districts. They usually did not dive in other district areas except for combined training exercises once or twice a year. No diver had a medical history of ear disease that would affect the morphology of the ear canal, and there were no significant differences in age and length of diving career between the two groups. Their scheduled total diving time over a year was the same (Table 1). Because no significant difference existed between the monthly diving hours for the two groups, Table 1 shows the average for the combined groups. However, marine meteorologic difference between the two districts is significant; it is windy and the sea is rough throughout the year in Mutsu.

Climate data of Mutsu and Yokosuka

Temperatures of the sea surface and atmosphere at each diving area are shown in Table 2.

Diagnosis and grading

After inquiring about medical history of otologic disorders, both ear canals were examined with a rigid otoscope (MACHIDA type EN-SL-A, Tokyo, Japan). The degree of obstruction was classified into five grades based on the otoscopic findings as follows:

- Grade 0: no evidence of exostosis
- Grade 1: less than 30% obstruction
- Grade 2: 30–60% obstruction
- Grade 3: 60–90% obstruction
- Grade 4: over 90% obstruction

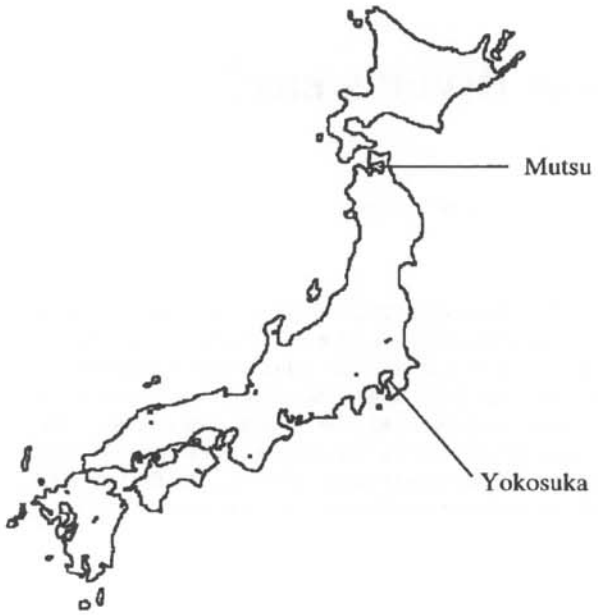

FIG. 1—Location of Mutsu and Yokosuka. Mutsu is located 41° N, 140° E; Yokosuka is 36° N, 140° E.

Statistics

Statistical analysis was performed for the following four points:

1. Test for the population proportion using the normal distribution as an approximation of the binomial distribution was performed to examine the incidence of exostosis between Mutsu and Yokosuka, the relationship between the incidence of exostosis and diving career, and the proportional difference of laterality in those subjects who have exostosis in either canal.
2. Spearman rank correlation was used for examining the relationship between the severity of exostosis and diving career.
3 Mann-Whitney's U test was used to determine which group had the most higher grades.

RESULTS

The incidence of exostosis grade 1 or higher was 57.4% (31 out of 54 ears) in Mutsu and 35.7% (50 out of 140 ears) in Yokosuka (Table 3). As shown in Table 4, the incidence of bilateral exostosis was 44.4% (12 out of 27 divers) in Mutsu and 24.3% (17 out of 70 divers) in Yokosuka. All unilateral cases were grade 1, with the exception of a Mutsu diver who had grade 2 exostosis of the left ear.

No severe exostosis of grade 3 or higher and no cases with active external otitis were observed. Figure 2 shows the typical otoscopic findings of grade 2 diver's ear:

1. The incidence of exostosis of Mutsu divers having careers of 0–9 yr, 10–19 yr, and over 20 yr was 41.7, 56.3, and 85.7%, respectively; for corresponding Yokosuka groups the incidence was 34.2, 28.1, and 46.9%, respectively. The incidence of exostosis in the Mutsu group showed an increase as the diving career progressed (test for population proportion, $P = 0.0022$). This tendency was not seen in the Yokosuka group ($P = 0.18$).
2. The severity of exostosis increased as the diving career progressed. This finding was seen in both districts (Spearman rank correlation, Mutsu: $r = 0.474$ and $P = 0.0006$, Yokosuka: $r = 0.36$ and $P < 0.0001$).
3. The incidence of exostosis in Mutsu was significantly higher than in Yokosuka (test for population proportion, $P = 0.0005$).
4. The Mutsu group showed a higher ratio of grade 2 than the Yokosuka group (Mann-Whitney's U test $P = 0.01$).
5. No significant difference in the laterality of exostosis was found in either group (test for population proportion, Mutsu $P = 0.5$, Yokosuka $P = 0.39$).

DISCUSSION

According to anthropologic studies, exostosis of the external auditory canals is rarely seen in some races such as Africans and Egyptians (5), and the incidence varies among tribes of Australian Aborigines (6) or Indians of South and North Dakota (7). A racial variation in the presence of exostosis is suspected from these reports. As the subjects in the present study were all Japanese (Asian) males, these results are not affected by a racial variation.

The incidence of exostosis of the Mutsu group was higher than the Yokosuka group. This result supports the hypothesis that the long-term chronic stimulation on the

Table 1: Standard Diving Times of a Japanese Naval Diver

	Spring March-May	Summer June-August	Fall Sept - Nov	Winter Dec - Feb	Total
Diving time per month, h	47, 40, 47	40, 51, 20	42, 32, 53	23, 28, 34	457

Table 2: Average Temperature of Sea (Surface) Water and Atmosphere of the Districts[a]

	Spring	Summer	Fall	Winter	Average
Water temperature at sea surface, °C:					
Mutsu	12.1	22.1	12.4	2.0	13.3
Yokosuka	17.0	25.4	15.9	8.5	16.3
Temperature of atmosphers, °C:					
Mutsu	7.6	19.9	12.8	−1.1	9.9
Yokosuka	14.1	24.7	17.9	6.1	15.8

[a]Numerals are shown in degrees Celsius.

external ear canal by cold water exposure promotes the growth of exostosis.

Fowler and Osmum (8) reported new bone formation in the external ears of guinea pigs by the stimulation of cold water, but the precise mechanism of the new bone formation in human external auditory canals stimulated by cold ocean water remains unknown.

In the present study, we investigated two groups that had the same seasonal diving hours with the exception of the marine meteorologic differences. The incidence of exostosis in the Mutsu group showed an increase as the diving career progressed. This tendency was not seen in the Yokosuka group. The severity of exostosis increased in divers in both districts as the diving career progressed. The incidence of exostosis in the Mutsu group was significantly higher than in the Yokosuka group. Moreover, the Mutsu group showed a higher ratio of grade 2 than the Yokosuka group. Cold water exposure was definitely one of the factors promoting exostosis.

There might be a trigger temperature of promoting exostosis. The total of each season's diving time divided by the mean water temperature was 68.8 and 30.3 in the Mutsu and Yokosuka groups, respectively. We tried to represent the risk of exostosis by using this number. It is difficult, however, to represent the risk by this number alone because it does not explain the presence of severe exostosis in young divers and no exostosis in veteran divers.

Table 3: Relationship Between the Severity of Exostosis and Diving Career: Mutsu and Yokosuka[a]

	Diving Career			
Grade	0–9 yr	10–19 yr	Over 20 yr	Total
Mutsu				
0	14	7	2	23
1	8	9	7	24
2	2	0	5	7
Total	24	16	14	54
Yokosuka				
0	50	23	17	90
1	23	7	14	44
2	3	2	1	6
Total	76	32	32	140

[a]Numerals show the number of ears affected.

We observed no significant difference in the appearance of exostosis between the right and left ear canal, but it is unknown whether the exostosis occurs unilaterally or bilaterally. As all of the unilateral cases were grade 1, with the exception of a Mutsu diver who had grade 2 left canal exostosis, the exostosis of some bilateral cases might start unilaterally at first and then grow bilaterally as the diving career progressed. However, we cannot explain a grade 2 unilateral exostosis observed in the Mutsu diver. Other factors will be needed to predict diver's ear. One other factor is air temperature. The annual average water temperature difference between Mutsu and Yokosuka is 3°C but in winter it widens to 6.5°C (Table 2). The difference in air temperature is much greater. Divers have to spend a long time with their ears wet and unprotected when not diving. The cold air may also be a contributing factor of exostosis formation.

Umeda et al. (2) reported that exostosis in surfers was more severe in the right canal than in the left. They postulated that it is caused by the difference of position resulting from the pivoting foot (mostly right) of surfers and the effect of splash and wind of a wave. Their postulation seems to be consistent with the present study because there are no pivoting feet in diving.

The cleansing of the wet external auditory canals with a

Table 4: Laterality of Exostosis[a]

	Mutsu	Yokosuka
Bilateral	44.4%(12/27)	24.3%(17/70)
Unilateral		
right	11.1%(3/27)	10.0%(7/70)
left	14.8%(4/27)	12.9%(9/70)

[a]Numerals in parentheses indicate the number of divers.

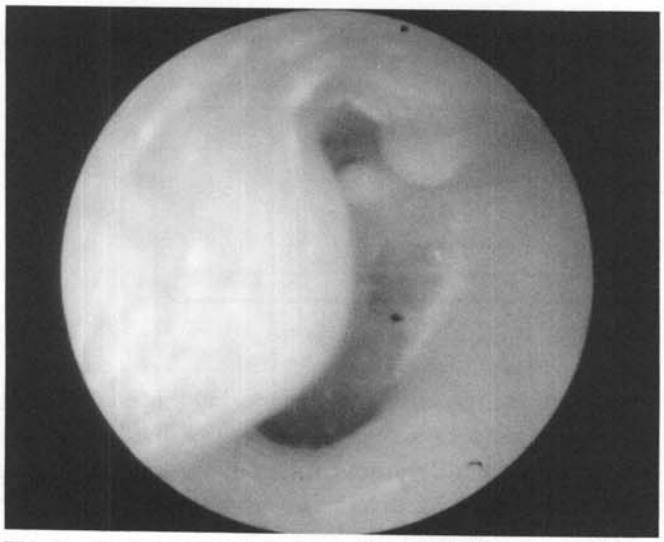

FIG. 2—Typical otoscopic findings of exostosis of external auditory canal, "diver's ear", at grade 2 in 46-yr-old Japanese Navy diver with a 24-yr diving experience.

dry swab after diving and the use of an ear protector to prevent getting cold from the cold air may help to avoid the growth of exostosis.

We are indebted to Dr. Atsushi Ito, commanding officer of JMSDF Undersea Medical Center. We also thank Dr. Akio Hashimoto, JMSDF Undersea Medical Center, and Dr. Mamoru Tsukuda, professor, Department of Otolaryngology, School of Medicine, Yokohama-city University for their skillful review of this article.—*Manuscript received May 1997; accepted November 1997.*

REFERENCES

1. Fabiani M, Barbara R, Filipo R. External ear canal exostosis and aquatic sports. J Oto Rhino Laryngol 1984; 46:159–164.
2. Umeda Y, Nakajima M, Yoshida H. Surfer's ear in Japan. Laryngoscope 1989; 99:639–641.
3. Seftel DM. Ear canal hyperostosis—surfer's ear. Arch Otolaryngol 1977; 103:58–60.
4. DiBartolomeo JR. Exostoses of the external auditory canal. Ann Otol Rhinol Laryngol suppl 1979; 61:1–20.
5. Hidlicka A. Ear exostosis. Smithsonian Misc Coll 1935; 93:91–100.
6. Roche AF. Aural exostoses in Austrian aboriginal skulls. Ann Otol Rhinol Laryngol 1964; 73: 82–91.
7. Gregg JB, Bass WM. Exostoses in the external auditory canals. Ann Otol Rhinol Laryngol 1970; 79:834–839.
8. Fowler EP Jr, Osmun PM. New bone growth due to cold water in the ears. Arch Otolaryngol 1942; 36:455–466.