

Safety and Health at Non-saturated Diving : The Actual Situation of Japanese Sport Divers

Yoshihiro MANO

Abstract

To draw a profile of Japanese sport divers, we have conducted personal interviews at 3 diving spots situated in the Izu Peninsula, during the summer vacation periods of 1991 and 1992. The results of 235 interviews are presented. The male v.s. female ratio was of 2.8 v.s. 1, the average of age being of 28.4 years. The average diving experience was of 230.1 tanks (27.3 tanks per year, 2 tanks per day). Recorded in 40 (17%) cases, nitrogen narcosis (NN) was the most frequent dysbaric disorder, followed by barotrauma at paranasal sinus (SB) and ear (EB), dental barotrauma (DB), and decompression sickness (DCS). NN has manifested at the average depth of 35.0 meters, and almost half of the divers with more than 5 years of experience have already had experienced such kind of narcosis. Occurrence of EB (12%) was associated to non-traditional ear-clearing methods, as the so-called 'natural' (spontaneous) equalization. Positive answers to questions concerning SB (12%) have pointed to some predisposing factors, such as cold, sleeplessness and hangover. Decompression sickness (DCS), reported by 3%, affected exclusively divers with 5 or more years of experience.



Fig. 1 Localization of the three diving spots in the Izu Peninsula

Introduction

Recently, sport diving has been in fashion, boosting an increasing number of young people to the diving schools throughout Japan. On the other hand, the more unaware divers are of the real risks involved by evolving in underwater environment, the larger the incidence of dysbaric accidents. According to the questionnaire conducted by Kakibana, et al. (1984), out of 135 divers from Okinawa Prefecture, 64.4% of them had never heard of decompression tables and, on the onset of symptoms, about a half (47.7%) had been recompressed at underwater and 22.9% did not search medical assistance. In Kyushu, a questionnaire survey conducted by Hayashi, et al. (1981) revealed that 33.5% of 391 local divers had past instances of decompression sickness (DCS).

To gather subsidiary information on this issue and to draw a profile of the Japanese sport divers, hitherto not reported, we have elaborated a questionnaire focusing mainly on dysbaric disorders.

Material and Methods

We have conducted personal interviews at three of the most popular diving spots, situated in the Izu Peninsula (Ohsezaki, Izu-kaiyo-koen and Shobuzawa), southwest of Tokyo (Table 1), during the August summer vacation periods of 1991 and 1992. The interviewees were all sport divers. Before answering, the divers have been assured that all information provided would be strictly confidential. The sequence of questions (below) was not previously made known to the interviewees.

Results

We have interviewed 360 divers but, the interviews taken to beginners (at their first diving experience, without the Certificated-card), the interviews taken to divers with bizarre records and the interviews not adequately filled in were excluded from the statistical analysis, which resumes 235 interviews: 85 to divers from Ohsezaki, 100 to divers from Izu-kaiyo-koen, and 50 divers from Shobuzawa. The male v.s. female ratio was of 173 v.s. 62 (2.8 v.s. 1), the respective average ages being of 30.2 and 26.6 years (overall average: 28.4 years). The oldest diver was 57 years old (male) and the oldest female diver was 44 years old; the youngest male diver was 15 years old and the youngest female diver was 18 years old. The most experienced diver was a male who had performed 27 years of diving and the most experienced female diver had a record of 11 years of diving. The earliest to become a diver was a female who began diving when 10 years old and the youngest male to become a diver was 11 years old; the oldest to began diving were a 55 years old male and a 43 years old female. Table 2 shows diving records along with data concerning the usage of tanks. The average experience was of 230.1 tanks (27.3 tanks per year, 2 tanks per day); 6 divers had records ranging from 1,000 to 1,800 tanks, 4 referred the use of 2,000 tanks, 2 of 3,000, 1 of 4,000, and the highest record was of 4,800 tanks. As to the maximum depth experienced, answers ranged from 5 to 75 meters, which shows an average of 25.7 meters. Out of the total, 80 divers (34%) described past instances of barotrauma and/or DCS, the more experienced the divers, the more frequent being such instances. Recorded in 40 (17%) cases, nitrogen narcosis (NN) was the most frequent dysbaric disorder, followed by sinus barotrauma (SB) with 12.3%, ear barotrauma (EB) with 12.0%, dental barotrauma (DB) and DCS (Table 3). NN has

QUESTIONNAIRE	
Name _____	Age _____ Sex: M / F
Diving spot _____	
1. DIVING EXPERIENCE	
Total years of experience: _____	
Total of tanks used until now: _____	
Number of tanks used per year: _____	
Maximum diving depth: _____ meters	
2. TODAY'S SCHEDULE	
Number of tanks to be used (or already used): _____	
Time of each dive: _____ minutes	
Diving depth (s): _____ meters	
Rest time: _____ minutes	
3. DIVER'S QUALIFICATION	
Do you possess the C-card? Yes / No	
If yes, which diving school did you get it from?	
PADI/NAUI/JP/JUDE/Other: _____	
4. [In cases of past instance (s) of DYSBARIC DISORDER]	
4.1. How do you clear the ears?	
() swallowing saliva	
() blowing against the clamped nose	
() clamping the nose and swallowing	
() other: _____	
4.2. EAR BAROTRAUMA (EB)	
What was the part of ear affected?	
() Ear drum	
() Middle ear	
() Internal ear	
Did you search any medical assistance? Yes / No	
If yes, what was the physician's diagnosis?	
() Internal ear disorder	
() Otitis media	
() Ear drum perforation	
() Other: _____	
When the EB occurred, the ear-clearing during descent had been: efficient / inefficient	
If inefficient, the pressure equilibration had been difficult	
() on the right ear	
() on the left ear	
() both	
4.3. SINUS BAROTRAUMA (SB)	
What sinus was affected?	
() Frontal sinus	
() Maxillary sinus	
() Other	
The local pain was: intense / mild	
How was you physical condition before diving?	
() You had a cold	
() You hadn't slept well the previous day	
() You had a hangover	
() Other: _____	
4.4. DENTAL BAROTRAUMA (DB)	
Had you tooth-filling (s) on that occasion?	
Yes / No	
4.5. DECOMPRESSION SICKNESS (DCS)	
The symptoms of DCS:	
() broke out in a rush	
() consisted on myalgia and/or arthralgia	
() were related to the respiratory/circulatory systems	
() accused spinal cord injury	
4.6. NITROGEN NARCOSIS (NN)	
Depth when it occurred: _____ meters	
4.7. OTHER DISORDERS:	

Table 1

Diving spot	A	B	C	Over. ave.
Total of tanks	140.0	207.2	397.4	230.1
No. of tanks/yr.	19.6	27.6	41.0	27.3
No. of tanks 'today'	2.2	2.0	2.0	2.0
Max. depth 'today'	11.8	17.1	17.3	15.7
Dive time/dive (min)	23.9	24.8	22.8	23.1
Max. depth (m)	21.8	27.1	27.3	25.7
Rest time 'today'	113.5	102.1	119.4	110.8

Table 2. Diving experience based on individual diving records and data concerning usage of tanks.
A—Ohsezaki, B—Izu-kaiyo-koen, C—Shobuzawa
Over. ave.—Overall average

Dysbaric disorder	No.	%
Nitrogen narcosis	40	17.0
Sinus barotrauma	29	12.3
Ear barotrauma	28	12.0
Dental barotrauma	17	7.2
DCS	7	3.0

Table 3. Frequency of dysbaric disorders.

DE (yrs.)	NN	SB	EB	DS	DCS
<1	0	5.8	7.7	3.8	0
1≤ x <3	8.5	8.5	9.8	7.3	0
3≤ x <5	11.9	16.7	11.9	11.7	2.4
≥5	47.5	20.3	15.3	6.8	10.2

Table 4. Percentage of divers (%) with past history of dysbaric disorder.
DE—diving experience

manifested at depth ranging from 18 to 75 meters, the average being of 35.0 meters. According to Table 4, almost half (47.5%) of the divers with more than 5 years of experience have already had experienced such kind of narcosis, this percentage decreasing proportionally with diver's experience.

Accordingly, divers aged more than 35 years old accounted for 24 (60%) of the cases, which means that about 35% of this group reported NN, a percentage much higher than that of the group aged below 35, counting 16 cases of NN (about 9% of this group) (Table 5). Table 6 shows the connection between ear-clearing method used and the record of EB (26 subjects). Valsalva (60.2%) and swallowing (25.4%) maneuvers, although utilized by the majority, are not associated to high occurrence of EB; but the group of 'other' methods like no specific maneuver during descent (12 divers), head rotation (1), jaw contraction (1) and

Age (yrs.)	NN	SB	EB	DS	DCS
<20	9.1	0	9.1	9.1	0
20 ≤ x < 25	10.0	11.3	13.8	5.0	1.3
25 ≤ x < 30	9.1	10.4	7.8	10.5	2.6
30 ≤ x < 35	36.1	19.4	8.3	2.8	2.8
35 ≤ x < 40	38.9	11.1	16.7	0	11.1
≥40	30.8	23.1	15.4	23.1	7.7

Table 5. Percentage of divers (%) with past history of dysbaric disorder, within age-groups.

Method	No.	EB cases	EB/No. (%)
Valsalva m.	159 (60.2%)	18	11.3
Swallowing	67 (25.4%)	8	11.9
Toynbee m.	23 (8.7%)	3	13.0
Other	15 (5.7%)	3	20.0

Table 6. Ear-clearing method and occurrence of EB (The plural answers were considered).

m – maneuver

Sinus	No.	%
Frontal s.	15	50.0
Maxillary s.	6	20.0
Other	7	23.3
Unknown	2	6.7
Total	30	100.0

Table 7. Sites os SB.

Pleural answers were considered

	No.	%
Cold	11	31.4
Sleeplessness	8	22.9
Hangover	3	8.6
Other	9	25.7
No answer	4	11.4
Total	35	100.0

Table 8. Physical condition and outbreak of SB.

Pleural answers were considered

air aspiration via nasal followed by apnea (1), presented EB in 20.0%. The ear drum was the most commonly affected (48.3%), followed by the middle ear (27.6%), inner ear (6.9%), and other sites (17.2%).

All subjects reported having consulted a physician on the onset of symptoms; ear drum perforation was diagnosed in 8 cases (30.8%), otitis media in 7 (26.9%), other affections in 6 (23.1%) and 5 (19.2%) were unaware of the diagnosis. EB was registered in 11.1% of the divers and it seems not to have differed with age and diving experience distribution. As it is shown in Table 6, 30 (12.8%) divers referred past instances of SB. Frontal sinus was affected in half of the cases (15 divers), maxillary sinus in 20.0% (6 divers), other sinus in 23.3% (7 divers), and 2 could not answer (Table 7). Predisposing factors to the occurrence of SB (35 cases), such as cold, sleeplessness, hangover and others, were referred by 31 divers or 88.6%

TFT	No.	DB	DB/No. (%)
(+)	37	12	32.4
(-)	198	4	2.0
Total	235	16	6.8

Table 9. Tooth-filling treatment (TFT) and outbreak of DB.

of the cases (Table 8).

According to age distribution, divers aged over 35 referred proportionally more instances of SD; accordingly, divers with more than 3 years of experience accounted for 65.5% of the cases. Out of the total, 16 (6.8%) described past instances of DB, 12 of whom had tooth-fillings (Table 9). The group aged over 40 was relatively the most affected (23.1% of the group) and there was no significant difference between groups of diving experience. DCS has been reported by 7 interviewees, all with 5 or more years of diving experience, and proportionally more referred by the group aged over 40 years (Table 3, 4).

Discussion

Bove (1989) states that ear squeeze is the most common medical problem in diving; he adds that aural barotrauma occurs for all divers and can only be avoided by paying great attention to ear clearing during descent and the maintenance of open-air passages in the ears and throat. Shibayama, et al. (1991) have studied the functioning of the auditory tube during scuba diving, concluding that diving posture affected the opening and closing of the auditory tube. On a questionnaire survey conducted by Lundgren (1965), answered by 550 Swedish divers, it was observed that, in a few cases, the maneuver of blowing out air with the nose clamped and thus forcing air into the ears produced vertigo combined with horizontal nystagmus, nausea and loss of balance immediately upon application of pressure. In another survey, Lundgren and Malm (1966) have observed that the use of the Valsalva maneuver to clear the ears was more frequent in the vertigo group which could indicate greater difficulties in pressure equalization than in the non-vertigo group in which methods as swallowing and yawning had dominated. On the other hand, frequent dry swallowing, particularly in the head-down position, seems to introduce considerable amounts of gas in the GI of some individuals; thus, it appears prudent to recommend other earclearing methods than swallowing (Brattstrom et al, 1975). In what regards outbreak of EB, our survey has observed no association with traditional equalization techniques, but with the so-called 'natural' (spontaneous) equalization (no maneuver at all), referred by 12 divers, one of them with unilateral hearing loss. Although generally accepted that conditions like the above, or a perforated ear drum should make a subject unfit to dive, it seems that Japanese divers overlook them, or are unaware of the risks involved. This is also showed by the fact that 15% of the divers, at least, were normally diving without ideal physical condition. Moreover, a few divers described routinely pain in the frontal area and 2 described regular epistaxis.

NN is known to manifest by changes in the mood and behavior of a divers, at depths over 30 meters. In our survey, 40 divers (17.0%) have experienced that sensation, frequency unexpectedly high, partially due to misjudgement and even because a few veterans dive at greater depths just to feel the sensation NN causes. Marked individual variation had been

observed: the less experienced the diver the lower the depth at which NN manifested.

Before the boom in the number of leisure divers in the early 1980s in Japan, the C-card holders counted only 10,000 (1981). In 1987, this number boosted to 300,000; and it is estimated a raise to 630,000 by 1993. Accordingly, the average age has been continuously decreasing, which is also showed in our survey: 29.8 years in 1991 and 27.1 years in 1992. At the same time, older people have also begun diving recently; for example, we have found out that the first experience of 4 males and 2 females occurred in their forties and of one male at the age of 55. Another interesting observation of our survey refers to a kind of gap existent between the records of the veterans and the so-called new generation of divers.

Along with the increase in the number of leisure divers, there were also recorded diving accidents: in 1985, 16 sport divers were reported dead by such a cause. While the increase in the number of divers was of 1.3 times in 2 years, the record of fatal accidents had doubled in the same period. In 1987, 27 maritime accidents were related to diving and, of these, 16 were fatal or missing cases. In 1989, the missing or fatal cases counted 30 in a total of 55 diving accidents; 64 were victimized in 1990, year when 27 were reported dead or missing (JMSA = the Japan Maritime Safety Agency, 1990). In cases of fatal accidents, the real cause and the circumstances involved has usually been difficult to determine, especially in solo dives. Solo dives are not recommended, but, in a survey conducted by us (Mano and Shibayama, 1987), from 1975 to 1987, out of a total of 113 non-missing cases, 26 (23.0%) were found to have been diving solo and 36 (31.9%), because of dispersion during the dive, had finished it solo. Curiously, according to the same survey, the main cause of fatal accidents was drowning; one third of the victims were at their first dive, and the accidents occurred below 5 meters of depth in almost half of the cases. Thus, in 1989, with the goal of giving immediate aid to this kind of victims, the Civil Alert Network (CAN) was established in Japan. Later on, in 1992, the Divers Alert Network - Japan (DAN-JAPAN) was inaugurated, replacing CAN and integrating this country to the international DAN organization for rescue, transport and medical care of diving accidents victims.

References

- Bove, A. A., 1989. Health and fitness of sport divers. *Marine Technology Society J.*, 23: 4-7.
- Brattstrom, B., et al., 1975. Influence of body posture and ear clearing on body buoyance during diving. *Undersea Biomed Res.*, 2: 161-166.
- Hayashi, K., et al., 1981. Medical survey on divers from Kyushu District: a questionnaire (in Japanese). *Jpn. J. Hyperbaric Med.*, 16: 1-3.
- JCSA (Japanese Coast Safety Agency), 1990. Leisure diving. Annual report. Underwater Research Center Press, Tokyo (in Japanese).
- Kakibana, O., et al., 1984. Questionnaire survey on fishing divers from Okinawa Prefecture (in Japanese). *Jpn. J. Hyperbaric Med.*, 19: 42-44.
- Lundgren, C. E. C., 1965. Alternobaric vertigo - a diving hazard. *Br. Med. J.* 2: 511-513.
- Lundgren, C. E. C., and Malm, L. M., 1966. Alternobaric vertigo among pilots. *Aerospace Med.*, 32: 179-180.
- Mano, Y. and Shibayama, M., 1987. Prevention of diving accidents (in Japanese) in *Diver's Handbook* (edited by Mano, Y. and Shibayama, M.) 13-16, JUDF Press, Tokyo.
- Shibayama, M., Mano, Y., et al., 1991. The auditory tube function and scuba-diving (in Japanese). *Jpn. J. Hyperbaric Med.* 26: 57-63.