

CHAPTER

16

THE AMA DIVERS

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The *Ama* divers have been in existence for more than 5,000 years, as documented in 3rd Century Chinese classic texts. These women harvest the ocean floor by gathering seaweed, abalone, and sea urchins daily.

Today, there are still around 30,000 professional breath-hold divers along the coast and islands of Japan and Korea. These divers, called *Hae-Nyo* (sea women) or *Jam-Soo* (diving women) in Korea,^{1,2} and *Ama* (sea men and woman) in Japan, are scientifically and collectively called *Ama* since their diving work was first published by a Japanese scientist in 1932.³ On the basis of this first observation, physiologists have been studying the capacities and physiological capabilities of these *Ama* divers. This information is frequently used as the starting point for studies of women divers in other countries.

INTRODUCTION

The origin of the *Ama* diving practice is not well known, although about one third of all the *Ama* divers dwell on a small island called Cheju-Do located between Korea and Japan. One theory contends that this diving tradition originated from male Polynesian pearl divers.⁴ The breath-hold diving profession was essentially for men in warm areas and it was introduced to Japan and Korea where the ocean floor is rich in shellfish. Women in these areas may have started to engage in diving activities because their physiques are better suited to overcome cold stress. Female *Ama* divers are distributed along the northern part of Japan and the southern coast of Korea. In contrast, male divers mainly work in the southern part of Japan. Female *Ama* divers in both Japan and Korea congregate where mean surface seawater temperature is 25°C in August,⁵ as the distribution of female *Ama* divers is mainly affected by the sea-water temperature. Female *Ama* divers prefer to dive in groups and the operation might have made a special community in villages. Each community has different union rules, which restrict harvesting areas, seasons, diving time of the day, and garments for the divers.

The Korean *Ama* divers included men as well as women up to the 17th century; however, nowadays all the divers are female.¹ Unlike Korea, where only women are engaged in breath-hold diving, both men and women are involved in the diving in Japan. According to 1977 statistics by the Ministry of Forestry and Fishers of the Japanese government, there were approximately 13,000 full-time *Ama* divers in Japan, of whom 8,500 (65%) were male; the number of male divers remained the same whereas that of females decreased by 20% since 1965. The number of *Ama* divers increased to 16,500 in 1986 including a greater population of male divers because of the advent of wetsuits for thermal protection.⁶ Recently, the relative role of male *Ama* divers has become popular in Japan, because of the high market price of their marine invertebrate harvest.

The *Ama* divers usually start their profession in shallow water at an early age (approximately 15 years old) and continue until they are over 60 years old.^{1,7} However, modern-day Japanese women are reluctant to go into the diving profession; consequently, the average age of female *Ama* divers has been high. It is rare to see female divers less than 30 years of age in Japan, whereas young or middle-aged male divers are common.

DIVING PATTERNS

Traditionally, both Korean and Japanese *Ama* divers were not equipped with any diving devices, except for their facemasks. They wore traditional working clothing such as cotton bathing suits and loincloths. Japanese divers made their dives in the warm seasons, while Korean divers worked using only light cotton suits even in wintertime. Since the 1960s, wetsuits have become popular among the fishery divers in both countries, and this modern gear made the long-term deep diving possible in winter. Local Japanese union rules do not allow the use of wetsuits in some areas, in order to protect their natural resources from over-harvesting; moreover, the divers are only allowed to work during the harvesting seasons.^{4,8} *Ama* divers use small cabins in their boats for frequent warming using propane stoves. After arriving at the diving locations, they stay in the cabin until they are warm enough to perspire. Another group of *Ama* divers who dive at shallow depths make fires to warm their bodies before and after each shift of dives, either on the beach or in their cabins on the seashore.

There are two types of diving methods for these professional breath-hold divers. The first is a simple diving system without any aids, non-assisted *Ama* divers called *Cachido* in Japanese. The other technique is an assisted and more sophisticated method known as *Funado* using weights for descending.

The *Cachido* divers walk into the sea from the shore and swim to the diving grounds holding a wooden tub in Japan (Fig. 1) or a floating ball with a collection net in Korea. They descend on their own from a drifting tub or ball to 2-10 meters of seawater (msw). The divers take a couple of deep breaths, dive to the desired depth and stay 15 seconds at the bottom for harvesting. They purse their

lips and emit a loud whistle with each breath of expiration. These whistles of female *Ama* divers in Japan and Korea, which can be heard for long distances, have become their trademark. The purpose of the whistles is unknown, although it may help in controlling their respirations and informing their locations to other divers. After 30-60 seconds of each diving session, *Ama* divers make their next dive after another 30 seconds of rest. Korean *Ama* divers hyperventilate for 5-10 seconds before each dive; in contrast, Japanese female *Ama* divers do not.

The *Funado* divers leave the shore by motorboats, traveling 5-10 minutes to reach the diving grounds. In general, female and male *Funado* divers are assisted and partially assisted divers, respectively. Female *Funado* divers descend to 10-20 msw holding a 4-5 kg weight belt and keeping a rope, while male divers dive to 10-30 msw carrying a 15-20-kg iron weight bar. After collecting harvests at the bottom, they are pulled to the surface by an assistant or swim up on their own. Female *Funado* divers holding a weight belt cannot ascend by themselves and need to be pulled up by assistants, mostly their husbands or brothers (Fig. 2); in contrast, male *Funado* divers wear fins and swim up without assistance.

The whole *Funado* diving session lasts for 1-2 minutes and the divers stay for 30-60 seconds on the bottom for harvesting. Although almost all of *Funado* divers are currently male, 10 female *Ama* divers exist as *Funado* divers on Hegura Island located northwest of Tokyo in the Sea of Japan.⁹ Their previous diving weights similar to those for men have become lighter, and they use 1.5 kg extra weights attached to their 5-7 kg weight belts. Additionally, it is rare to see female *Funado* divers in other districts of Japan. Male and female *Funado* divers do not whistle after their each dive.

Diving shifts and durations depend on environmental conditions, and the most important factor is the seawater temperature. Nowadays, *Ama* divers work 4-6 hours a day, with the resting intervals of about an hour or so away from the water. The working shifts of the *Funado* divers tend to be longer than that of the *Cachido* divers, whereas the total diving time in *Funado* divers is shorter.⁹ Male *Cachido* and *Funado* divers make deeper and longer dives than female divers. Since they begin to work as *Cachido* divers in shallow water, then they go on to become *Funado* divers, *Funado* divers are older than *Cachido*. However, the diving patterns and methods in *Cachido* divers have not changed at all through the history. While pregnant *Ama* divers may be allowed to work up to the day of delivery, they either dive close to the shore, or do not engage in diving work at all.

THERMAL STATE

The *Ama* divers have to overcome various physiological stresses in their working environment, and the body heat loss in the water is the most important factor restricting their diving activities. The seawater temperature ranges from 10°C in winter to 25°C in summer. Female *Ama* divers in Korea



Figure 1. A female unassisted Ama diver (Cachido), wearing traditional diving gear, dives from a floating tub. After collecting seaweed, abalone, snails or sea urchins, she puts them into the tub and repeats her dives. (Reprinted from Wikipedia's photo and 'Ama' edited by Nakamura, with permission from Marine Planning Co., Ltd., photographed in 1950s)



Figure 2. A female assisted Ama diver (Funado). After descending with holding a 4-5 kg extra-weight belt, she is pulled to the surface using a rope by an assistant, her husband or brother. Just before stifling her breath-holding, she makes a sign to the assistant by pulling a rope on the bottom. This rope is her lifeline. (Reprinted from 'Ama' edited by Nakamura, with permission from Marine Planning Co., Ltd., photographed in 1950s)

used to dive throughout the year wearing only a cotton bathing suit until late 1970s, subjecting them to severe cold-water stress.^{10,11} Regardless of the seawater temperature, when the core body temperature declined to 35°C, the divers would voluntarily terminate their work and return to the shore until the body temperature returned to the pre-dive level.^{10,11} The duration of their diving work shift is mainly determined by the deep-body cooling. Before using wetsuits, Korean *Ama* divers wearing cotton suits took only one brief diving work shift lasting 15-30 min in winter.¹¹ In the summer, the duration of the work shift became longer in Japan and Korea;⁸ Japanese *Ama* divers used to work three 1.5-2 hour shifts.

To protect themselves from cold stresses, the *Ama* divers need to increase body heat production and reduce the body heat loss. Interestingly, female *Ama* divers are known to have developed special adaptations and physiological defenses against cold.^{1,4} The adaptation to cold may be accomplished by raising basal metabolic rates in the winter season,¹ when several hormones are evoked in response to extreme cold stresses. However, the heat production mainly developed by shivering is lower in female *Ama* divers compared with male divers.¹² Another aspect of physiological defenses is the body's fatty insulation for retaining heat, which is supplemented by some type of vascular adaptation that restricts the heat loss from the blood vessels to the skin. For example, female *Ama* divers can tolerate lower water temperatures than non-diving women without shivering.^{1,4} It is believed that these defensive mechanisms and their additional insulation allow them to dive longer than males. (Editor note: see Chapter 8 for a complete discussion of gender and thermal issues.)

The introduction of wetsuits provided adequate thermal protection, as indicated by the remarkable increase in the duration of the work shift up to 3-6 hours per day in Japan and Korea. Using the modern diving gear has enabled male *Ama* divers to improve their thermal economy^{11,12} and increased the number of male divers in Japan. Today, it is rare to see women wearing traditional cotton suits for their diving work in Japan and Korea.

PRESSURE EFFECTS

Nitrogen (N₂) accumulation in the tissues can occur as a result of breath-hold diving. Compression of air in the lungs during dives increases N₂ pressure in the alveoli, inducing N₂ to be taken up by the blood. Because of a smaller gradient in N₂ tension from tissues to blood during ascent, N₂ is not released into the alveoli as rapidly as it was taken up by the blood and the tissues during descent. N₂ accumulation in venous blood has been described in female *Cachido* divers, hence repetitive deep breath-hold dives with short intervals can theoretically cause decompression illness (DCI). Based on some reports of breath-hold divers with diving accidents from different areas, DCI following breath-hold diving indeed appear to exist as a clinical entity.¹³

Characteristically, DCI in *Ama* divers is limited to the brain involvement, while sparing the spinal cord injury. In addition, most

Ama divers exhibited transient neurological deficits lasting only several hours.¹⁴ Common risk factors include: deep dives in excess of 20 msw, conducted over a longer than three hour period with surface intervals shorter than breath-hold times.¹³ These diving accidents in male *Ama* divers are similar or identical to the “Taravana” diving syndrome observed in Polynesian pearl divers.¹⁵

Unlike male *Ama* divers, DCI is very rare in women. A field study on the Hegura Island described no report of DCI among female *Ama* divers from medical records or by hearsay.⁹ However, a report of the specific neurological deficit on the same island showed a female diver with a transient left-sided hemiplegia and dysarthria after her dives.¹⁶ DCI in *Ama* divers, especially female divers, was not well recognized by Japanese physicians and scientists. One reason is the transient nature of this disorder, while the *Ama* divers may visit medical facilities infrequently, due to the inherent secrecy of Japanese diving communities.¹⁴

The brain MRI findings in the *Ama* divers with DCI showed multiple cerebral infarcts in areas corresponding to the symptoms and elicited signs. The brain lesions are localized in the basal ganglia, internal capsule, and deep and subcortical white matter.¹⁷ The type of brain lesions in the *Ama* divers are identical to those caused by compressed air diving. The ischemic lesions in the basal ganglia were situated in the terminal zone, and the lesions involving deep or superficial white matter corresponded to border zone or watershed regions. They are the so-called “low-flow” cerebral infarctions as the result of the low perfusion pressure in the terminal supply areas, and these lesions are considered to be cerebral arterial gas embolism (CAGE).

Various mechanisms of DCI following breath-hold diving may be caused by the formation of venous bubbles. After deep, repetitive dives, bubbles are formed in the venous side and travel through the heart to the lungs. Micro-bubbles, a part of venous bubbles passing through the pulmonary capillaries, are generally harmless to some tissues. Initially, the proposed mechanism to explain DCI in *Ama* divers purported that micro-bubbles impair the blood brain barrier transiently, based on experimental data.¹⁸ This hypothesis, however, is inconsistent with MRI findings in *Ama* divers with neurological DCI. Large or small venous bubbles after repetitive deep breath-hold dives are retained or trapped at the small pulmonary arteries. When *Ama* divers descend, the “trapped” bubbles are compressed and liable to pass through the pulmonary capillaries.¹⁹ The arterialized bubbles expand during each ascent and gather in the terminal supply areas of the brain, border zones, and watershed regions. However, the mechanism of DCI in *Ama* divers is still not clear.

MENTAL CONDITIONS

Neuro-psychiatric problems have not yet been detected in male and female sport breath-hold divers who had continued repetitive 30-64 msw dives for several years.²⁰ Additionally, male *Ama* divers have reported no mental diseases following diving, although they may occasionally complain of anxiety during deep and long-term dives. On the other hand, female *Ama* divers have suffered specific psychiatric disorders in relation to their dives on the island. A survey of 44 female divers noted that nine of them had mental disturbances based on the episodes of anxiety attacks during diving.¹⁶ This study was characterized by anticipatory anxieties, about the panic attacks, and reduced the activity of diving work for the divers. Female *Ama* divers reported distinct and realistic fears of death by drowning, which prevented them from diving. The clinical features of the psychiatric diseases closely resemble those of some types of panic disorders with agoraphobia. However, depersonalization or de-realization observed in panic disorders did not occur for female divers. The clinical symptoms included palpitation, dizziness or unsteady feelings, dyspnea, nausea, and/or hot flushes; palpitation being the most frequent among them. Several *Ama* divers who had experienced the illness could not dive and had to stop their diving work. The age of onset was usually in the 30s, and the illness continued for 20-30 years. While female *Ama* divers may have recovered from the illness, they were unable to dive at great depths and always had to take anti-anxiety medicine prior to diving.

On the island where some female *Ama* divers had psychiatric or psychological complaints, they made 90-120 dives/day to the depths of 13-22 msw, each dive lasting 60 seconds, considerably longer and deeper than those observed in other areas.^{9,17} These diving patterns and depths are similar to those of male *Ama* divers with a high incidence of DCI.¹⁴ However, the reported psychiatric disorders among women performing deep, long, breath-hold diving were not related to DCI. These psychiatric problems in female *Ama* divers are not reported widely in the field of diving medicine even in Japan. A possible explanation may be the tendency to keeping mental disorders secret in the Japanese *Ama* communities. It is not known whether these problems are related to decompression physiology per se, or the unique stress of breath-hold diving. (See a discussion of the effects of diving on psychological health in Chapter 11 by Leach.)

CONCLUSION

For more than 5,000 years both males and females have worked the sea as divers in Asia, and distinct diving cultures have evolved which control their techniques. Modern technology has changed some diving habits. Fewer Japanese women are becoming *Ama* divers with serious implications for the future of these indigenous divers. Decompression illness can occur with breath hold diving and is usually neurological (cerebral). Women are not perceived as being at greater risk of DCI. Some women have developed psychological or psychiatric symptoms (e.g. anxiety disorder) after years of deep, long breath hold diving, but this has not been properly studied. Female *Ama* divers continue working throughout pregnancy although they alter their dive profile as gestation progresses. Women *Ama* divers are revered in the diving culture of Asia and are perceived to have advantages over men in the area of cold tolerance.

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