Chapter 8

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THE FEMALE DIVER

Up to the 1960's, diving was almost exclusively a male domain with a certain associated macho image. Since then, an increasing proportion of female divers have come to enjoy this sport and have proven themselves equal to male divers in every regard.

Despite this, women are not the same as men and there are important consequences of this dissimilarity in diving activities. Unfortunately, much of the following information is based on very inadequate data.

History of Women in Diving

Probably the most famous of female diver groups are the **Ama** shell divers of Japan and Korea. These divers were originally men but the work was taken over by women, possibly because of their better tolerance to cold – the men only dived in summer while women were able to dive all year round. Another theory is that the men believed that diving impaired their virility.

The Ama underwent some remarkable physiological adaptations. During the winter months they increased their metabolic rate by 30%, which allowed them to generate more internal heat. Also, they reduced their skin blood flow by 30%. The fat content beneath their skin was increased. Both these changes improved their insulation.

There have been numerous famous women diving personalities. In the 1940's, Simone Cousteau dived alongside her husband Jacques Cousteau. In Australia, Valerie Taylor and Eva Cropp became well known because of their diving exploits. In America, Eugenie Clark was known as the 'shark lady' because of her brilliant work in this field. In 1969, Sylvia Earle led the first all woman team of aquanauts in the Tektite II habitat experiment.

Until recent years **diving instruction** was almost exclusively a male occupation. Many of these instructors basked in a 'superman' role and possessed more experience than knowledge.

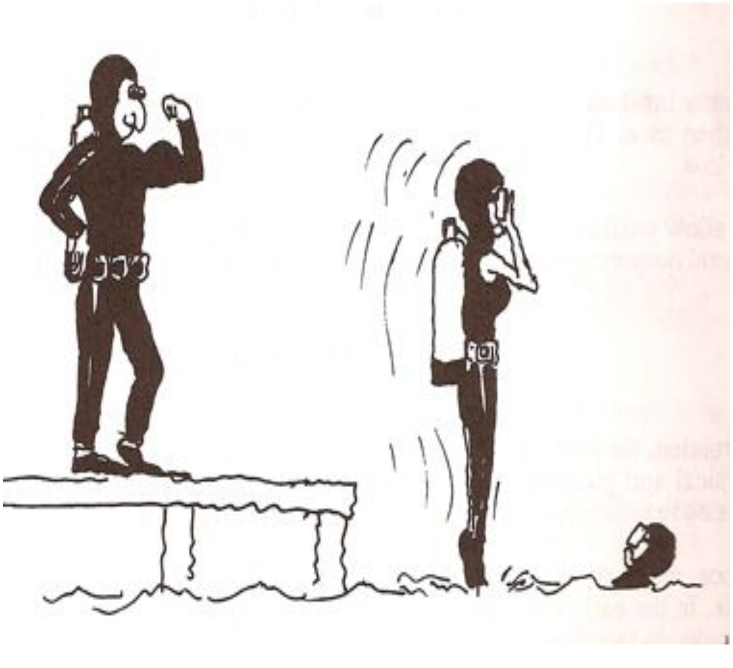
In recent years women have become recreational diving instructors and have proven to be diligent and highly competent. In general they have been more keen to impress their students by knowledge and skills, rather than strength and bravado.

Women divers must be doing something right. Diving statistics show that females comprise 34% of trainees, but account for only 10-20% of fatalities (depending on the survey).

Scuba Training

In Western society, women are generally regarded as being less mechanically and mathematically adept than men. This prejudice is reflected in attitudes to diver training. In many cases, women are patronised by well-meaning male instructors and male companions.

Until recently, culturally acquired lack of assertiveness on the part of many women led them to refrain from asking what appeared to them to be naive questions of their instructors. On the other hand, prejudices by instructors led them to assume women would not be interested in, or understand, the intricacies of equipment functioning or decompression planning. This information tended to be directed towards the males in a training group. Women would often turn to a male friend or buddy rather than the instructor for answers to questions which arose during training. The information that they received was not always accurate.



A woman who has her equipment assembled and checked by a male companion, who has the equipment carried to the water and who is assisted into and out of the water, is overall less likely to become a competent and self sufficient diver.

The old stereotype of the woman in a dependent role can lead to problems in diving practice. Thus having men and women buddied together for basic training may be inappropriate. The concept, introduced by PADI some years ago, of an all-women class has much to commend it.

Fig. 8.1

Anatomical Differences

Womankind has been described as the "weaker sex." While it is generally true that on average women are less physically strong than men, there is not a vast difference in their performance in aquatic sports. For example, in the 1988 Olympics there was only a 10–12% difference in times between women and men for swimming events.

For the same physical size, men on average have greater physical strength than women. This is because men have a greater muscle mass per unit body weight. This minor difference in strength is much less significant in the weightless aquatic environment.

Being physically smaller, the woman has a lower requirement for oxygen at a given level of physical activity and will produce less carbon dioxide. With smaller lungs, women also take smaller breaths. Thus, women can often manage with less air than a male diving companion and so can use a smaller, lighter scuba cylinder. This can offset the apparent disadvantage of diminished body size and strength.

Because of differences in body shape, women have different equipment design requirements. There can be difficulty in obtaining appropriate sized or shaped wet suits, fins, boots, and gloves, in less developed countries.

Particular problems arise with male sized equipment, especially face masks which may not fit well, and large scuba cylinders which are unnecessarily bulky or heavy. Backpacks can be too long and so cover the weight belt, making the release of the belt in an emergency difficult. Over sized buoyancy compensators designed for males may give excessive buoyancy and drag with females.

Diving Activity

It is anecdotally believed that males tend to dive deeper, longer, more frequently and engage in more rapid ascents. Whether this is true, is unknown, but they certainly do engage in more risk-taking activities than females in all general epidemiological surveys, and so perhaps it is correct. They also suffer many more accidents and traumatic deaths than females – at all ages.

In one study, females dived mostly between 19-40m (61-68% of the activity) and much less between 41-60m (16-26%) or greater than 60m (1-2%). Young females dived at a more varied depth but also deeper than older females.

Thermal Variations

Women are better insulated than their male counterparts. They have a fat layer beneath the skin some 25% greater then men. They also have a better ability to constrict the blood flow to their limbs, reducing heat loss. These factors allow women to conserve their heat more effectively in a cold water environment while producing natural buoyancy, which improves their swimming and floating ability.

Unfortunately women tend to expose themselves less to demanding environmental temperatures, and so may not become as well adapted to cold exposure, and initially react more to this situation.

Menstruation

Some women perceive their ability to dive safely during the menstrual cycle may be impaired, and that the activity of scuba diving may alter the menstrual cycle. Statistically there is some justification for believing that diving related incidents are more frequent around the time of menstruation.

During menstruation, the average woman is likely to lose 50–150cc blood and cellular debris. There are some physical and physiological consequences of menstruation which will be discussed, but usually there is no reason why women should not dive during menstruation. For convenience, most women today prefer to wear internal protection such as tampons rather then menstrual pads. In the early days, there was some concern that menstrual blood-loss may act as an attractant to sharks. In fact, females have a much lower incidence of shark attacks than males. This may be related to their different diving behaviour, or that haemolysed blood is a shark repellant.

Menstrual pads and protection

There is little reason to avoid diving during the menstrual period. If the woman develops significant psychological problems at this time, then of course this must be considered on its merits, but this is not common.

The main difficulty with menstruation during diving or swimming is the physical and social complication of a bloody discharge, and the attempts to limit its distribution and appearance.

Menstrual pads can cause problems. A pad, especially some of the older styles, can leak, disintegrate and move (more so in a dry suit). They are also too obvious in a Bikini style bathing costume. Infinity pads may be acceptable in a dry suit.

Tampons are effective and cause few or no problems. The Diva cup, Mooncup or the disposable Instead cup are effective and convenient.

Hormonal changes before and during menstruation tend to cause fluid retention and swelling. There is a theoretical possibility that this might encourage the development of DCS, and one study of altitude DCS suggested that DCS was more likely earlier in the menstrual cycle. This has not been validated for divers. There is minimal experimental data to support this association, but it may be wise for women, at least during this time, to add a safety margin to their decompression requirements.

Some women have significant psychological and physical problems around the time of menstruation, with abdominal pain, muscle cramps, headaches, nausea and vomiting. These may impair their diving ability. Women who suffer from severe problems of this nature, are advised to avoid diving at this time. The psychological disturbances associated with pre-menstrual tension and anxiety, may sometimes warrant the avoidance of diving during this time.

Some female migraine sufferers, have an increased likelihood of migraines around the time of menstruation. The problems associated with migraine are discussed further in Chapter 32 and the recommendations there should be followed.

Repeated exposure to high pressure environments seems to have no significant effect on hormone regulation, ovulation or menstruation.

Oral Contraceptives
(the "Pill")

The physiological and psychological consequences of these hormonal tablets may have similar implications to those described above, under "menstruation". In theory, the increased coagulation effects from the pill could initiate or aggravate DCS. In practice this has not been observed. There is no relationship between the development of DCS and the taking of oral contraceptive tablets *per se*. It was considered prudent to cease oral contraceptives in the female team who undertook a long saturation dive during the Tektite No. 2 project. However, the absence of males probably made this decision an uncomplicated one.

Decompression Sickness (DCS)

Several studies have shown an increased incidence of DCS in women. Some studies of women divers showed a more than 3 times increased incidence of DCS compared with men who were exposed to the same dive profiles. Other studies have not shown this and perhaps the different observations are due to different cohorts with different dive profiles. For example, females in the space program seemed to be more susceptible to altitude DCS, and develop more serious DCS, than men.

Studies on female divers indicated that those who did “reverse profile” dives had more DCS symptoms than those who did their deeper dives first. In a large series of DCS cases it was shown that the men so affected dived deeper than the women (almost 3 metres) and it is possible that their diving exposures and ascent rates were greater.

The weight of evidence does tend to suggest that there might be an increased incidence of DCS among women**.** There are several possible explanations for this.

Women are frequently less physically fit than men and physical fitness is negatively related to DCS. Women usually have a higher proportion of subcutaneous body fat (+ 10%) for a given weight than men, and the body fat has a 4-5 times higher capacity for absorbing nitrogen. Fat tissue is slower to absorb and to eliminate the nitrogen. Logically, because of the different fat distribution between the sexes, studies that dealt with certain dive profiles (longer dives) could have more nitrogen absorbed and a greater incidence of DCS in females. Both reduced physical fitness and higher fat content probably increase the incidence of DCS .

Navy decompression tables were designed for and tested on physically fit, healthy young male divers. Strictly speaking, the tables should only apply to this population.

Because of this increased risk, it is wise for women divers to apply extra safety factors when using the dive tables: e.g. by reducing the allowable bottom time for any depth or by decompressing for a greater duration. Decompression computer programs should be on the more conservative settings.

A modern decompression problem has emerged with **breast implants**. Fortunately, gas filled implants are no longer used, as the barotrauma consequences of diving with these would be disturbing. However, even silicone filled implants do absorb nitrogen during a dive and a 4% expansion in the size of these implants has been recorded after dive profiles commonly used by women sports divers. This is not likely to cause a problem with the implants. However, if these women were involved in saturation diving there is the potential for significant volume changes which could lead to damage or rupture of the implant during or after ascent.

Other Diving Diseases

In a number of reports on **scuba divers pulmonary oedema**, a preponderance of females has been noted. Others have suggested an increased susceptibility to **dysbaric osteonecrosis**.

The relative risk of **oxygen toxicity** for women compared to men was 1.6 times for pulmonary toxicity and 2.9 times for neurological toxicity.

Panic is a common and potentially serious problem even amongst experienced divers. Although females reported this more frequently than males, the latter waited longer to react and so it was more likely to progress to a life threatening situation in them.

A study of dive masters and instructors found that female instructors and dive masters reported more diving-related **ear and sinus** symptoms than males. This relation was consistent even when controlling for potential confounders.

PREGNANCY

There has been considerable controversy over whether pregnant women should dive. This question arises because most women divers are in the child-bearing age group. The controversy hinges on the conflict between restricting the freedom of an individual and the risks (which have not been fully evaluated) to the unborn child. The potential problems of diving during pregnancy are as follows:

Maternal Effects

❑ Vomiting.

In the second and third months of pregnancy, many women are prone to vomiting – often manifest as "morning sickness". They are more prone to seasickness and to nausea and vomiting underwater during certain conditions. This predisposes to serious diving accidents.

❑ Barotrauma.

From the fourth month onwards, fluid retention and swelling of the lining of the respiratory tract, makes sinus and ear equalisation more difficult and predisposes to barotrauma.

❑ Respiratory function.

There is a decline in respiratory function as pregnancy progresses. There is an increase in resistance to air flow in the lungs. Later, the enlarging baby presses up into the chest, limiting breathing capacity. This combination impairs the pregnant woman's ability to cope with strenuous activity which may be required in an emergency, and may predispose to hypoxia or pulmonary barotrauma.

❑ Decompression sickness.

There are major alterations in blood volume and circulation during pregnancy. This may increase the uptake and distribution of nitrogen and may make the woman more prone to DCS.

❑ Infection.

It has been claimed that there is an increased risk of vaginal infection in pregnant women who dive. In the later stages of pregnancy some women develop minor leaks of the amniotic sac, which surrounds the baby with fluid. There is a possibility of infection of this fluid from organisms entering from the water before birth or directly into the womb after birth.

Effects on the Baby

The developing foetus is uniquely at risk from some of the physiological hazards associated with diving. The potential risk primarily consists of DCS, but hyperoxia, hypoxia, hypercapnia and increased nitrogen pressure may also be involved.

❑ Development of the foetus.

The foetus begins as a single cell organism and up until after the fourth month it is smaller than a mouse. A small bubble, such as develops during DCS, could have catastrophic effects.

The **circulation in the foetus** is unique and critical. In an adult diver, venous blood returning from the body passes through the lung capillaries, which filter out the bubbles frequently formed during or after ascent. In the foetus, the blood by-passes the lungs (since the foetus does not need to breathe) and passes directly to the left heart without passing first through this filtering network. Even one bubble forming in the tissues then veins of a foetus will be transported directly to the arterial circulation and will embolise to somewhere in its body.

In one study it was shown that diving >30 metres in the first trimester was associated with a 16% risk of foetal abnormality, but the numbers were small. Other studies have produced conflicting data.

❑ Hypoxia.

The outcome of many non-fatal diving incidents is hypoxia, most likely to be caused by salt water aspiration or near drowning. The pregnant diver will not only expose herself to hypoxia in this situation but will also expose the much more susceptible foetus to this.

❑ Hyperbaric oxygen.

Divers are likely to be exposed to hyperbaric oxygen in two situations. By simply breathing compressed air at depth they are inhaling elevated partial pressures of oxygen. In addition, if divers develop DCS or air embolism they will be given hyperbaric oxygen therapy for treatment of the condition.

Some foetal tissues are very sensitive to high partial pressures of oxygen. Great care is taken with newborn premature babies to avoid administration of high concentrations of oxygen because of the danger of retrolental fibroplasia, which causes blindness. The eye of the unborn baby is probably even more sensitive to high partial pressures of oxygen.

The circulation of the foetus contains a channel (the ductus arteriosus) which allows blood to by-pass the lungs. This channel closes after birth under the influence of a raised partial pressure of oxygen in the blood. There is a danger of premature closing of this and other shunts if the foetus is exposed to hyperbaric oxygen because of treatment given to the mother.

❑ Decompression sickness.

As mentioned earlier, women may have increased susceptibility to DCS and there are theoretical reasons to believe that pregnant women are even more susceptible. It is known from Doppler studies that showers of bubbles are regularly formed in the veins of divers ascending from many routine non-decompression dives. These bubbles do not usually cause any symptoms.

Some experiments in pregnant animals suggest that the foetus is more resistant to bubble formation than the mother but that bubbles do form after some dives, especially those deeper than 20 metres. Because of the unique circulation of the foetus even a few bubbles in the foetal circulation can have disastrous consequences.

Experiments with pregnant animals have produced conflicting results. One study on pregnant sheep (which have a placenta similar to a human) showed that the foetus developed bubbles in its circulation even after dives of less than 30 metres (100 ft.) and within the US Navy no-decompression limits. These results are disturbing when considering the vulnerability of the foetus to any bubble.

Other studies have shown an increased incidence of abortion, birth defects and still-births in pregnant animals after decompression.

Exposure to hyperbaric oxygen has also been shown in some studies to cause birth abnormalities and death.

Human Data

Japanese female divers, the Ama, often dived until late pregnancy, and had a 44% incidence of premature delivery with a high incidence of small babies when compared with non-diving women from the same area. Another survey on modern day Ama, who were not exposed to the same stresses, did not reflect this association.

Margaret Bolton from the University of Florida carried out a survey on 208 women who dived during pregnancy. She found an increased incidence of abortion, still-birth, low birth weight and death of the infant within the first month. Of the 24 women who reported diving to 30 metres (100 ft) or more, three had children with congenital defects. This contrasts with an incidence of 1 in 50 in the general population. One of the infants had an absent hand, a very rare abnormality.

An Australian case report, showing multiple grotesque abnormalities after diving, suggested that the effects and vulnerable time frame may be similar to taking congenital-abnormality producing drug, Thalidomide, during pregnancy.

It is difficult to draw firm conclusions from these studies, or others that have been conducted, because the numbers are too low for statistical validation, or are retrospective. They are however consistent with many of the animal studies.

The Bottom Line ---

There is considerable evidence suggesting that diving during pregnancy is harmful to the foetus. It is generally accepted that unnecessary drugs, alcohol and smoking should be avoided during pregnancy because of the risk to the foetus and we recommend a similar conservative approach to diving. The sacrifice of not diving during pregnancy may be easier to cope with than the guilt, valid or not, associated with abortion or giving birth to a malformed child.

Evidence in western societies suggest that female divers have accepted the above restriction and now do avoid diving when pregnant, or when attempting to become pregnant, making the collection of more data difficult, but good for the kids.

One interesting issue to consider by women who contemplate diving during pregnancy is that the foetus, who will have to live with any birth defect which may result, cannot be consulted when the decision to dive is made.

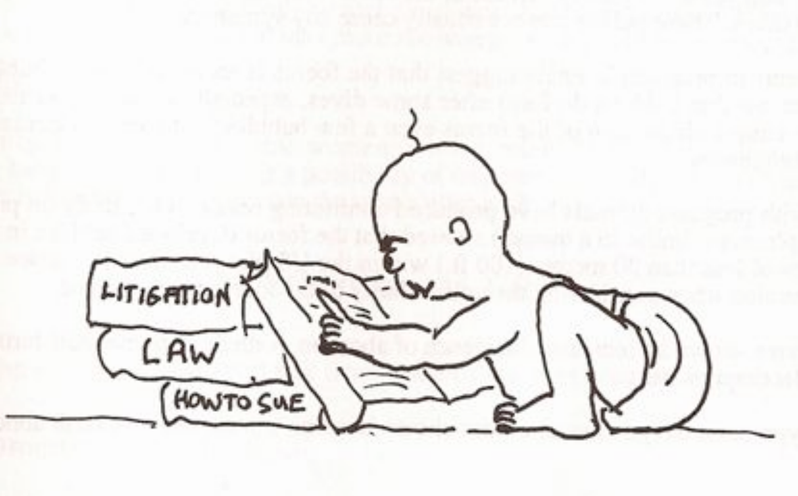


Fig. 8.2