

Young Divers

DAN Offers an Assessment of Medical Issues Associated with Children and Diving

By DAN Medical Staff

Families should consider carefully the decision to allow their pre-teens to dive. Do they have the physical stamina? Do they have the coping skills in a dive emergency? Will they be safe dive buddies?

These are just a few of the considerations responsible divers want answers to before they make the decision to let their kids learn to dive.

This statement has been developed in consultation with the DAN staff physicians and other medical specialists at Duke University Medical Centre.



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A search of the Medline database (a part of the U.S. National Library of Medicine that contains references and abstracts from 4,600 biomedical journals) since 1966 revealed no papers dealing with the issue of how the physiological differences between adults and otherwise healthy children would alter the child's capability and risks associated with diving. Therefore, any recommendations made would be based on theoretical considerations taking into account what is known about normal growth and development, and the empirical evidence that exists where children younger than age 12 have scuba dived.

In addressing the question of children and diving, we have considered what we feel are the main issues that must be addressed in considering children and scuba diving. These are:

- Since a patent foramen ovale is a risk factor in developing decompression illness, we looked for evidence that there is an increased incidence of patent foramen ovale (PFO) in children.
- Because of differences in central nervous system (CNS) development, is there evidence that children are more susceptible to oxygen toxicity?
- Are growing bones in pre-pubertal children more susceptible to injury from decompression illness or silent bubbles?

• Is there any difference in the lung tissue or chest wall of children compared to adults, which might make children more susceptible to pulmonary barotrauma?

• Given that young children have an increased incidence of asthma compared to adults, is diving more likely to trigger an asthmatic attack?

• Do children have an increased propensity for ear barotrauma?

• Are there special considerations needed to determine whether a child's thermal protection is adequate?

• Because large amounts of venous gas emboli (VGE) are thought to be associated with the development of decompression illness, is there

evidence that children have a higher propensity to form VGE than adults?

- Are children, whose CNS is still developing, more susceptible in general to decompression illness than adults?
- If children do get decompression illness, will an immature CNS result in an increased severity compared to adults?
- Do children have the strength and endurance to cope with emergencies?

The above are felt to be the most important medical and physiological considerations in assessing the medical issues associated with children and diving. They do not, however, address behavioral or psychological issues, which may be equally, if not more important than any medical and physiological considerations and should be addressed when considering the involvement of children in scuba diving.

Is there any evidence for increased incidence of patent foramen ovale (PFO) in children?

One paper has looked at the age distribution of PFO.¹ This paper looked at the incidence of PFO in cadavers down to age 10. They found an increased incidence of PFO in the 10- to 20-year-old group compared to other groups. They did not specify the actual ages of the cases. However, this incidence was based only on six cases (three with a patent PFO) out of a total of 705, and the true binomial incidence could be between 11 percent and 88 percent. Thus, there is a suggestion of an increased incidence of PFO as age decreases below 20.

Are children more susceptible to oxygen toxicity?

Clinical experience here at Duke University shows no particular difference in susceptibility of children down to age 8 to either pulmonary or CNS oxygen toxicity. Only a single paper was found which attempted to address the subject.² They were only able to cite animal data that showed that the effect of age on susceptibility to pulmonary oxygen toxicity was species-specific. In some instances immaturity was protective, in others it was not.

Are growing bones more susceptible to injury from decompression sickness or silent bubbles?

In growing children up to the age of 18, bones continue to grow from a region called the physis, which in long bones (arms and legs) is near each end. This area consists of mostly cartilage and has no blood supply, it depends on diffusion of substances to and from adjacent tissue which has a blood supply.

If this area is injured, then abnormal bone growth will result, such as one leg being longer than the other. The main causes of injury to this region are weight-bearing sports activities such as skiing, rollerblading, ice skating, football, etc. Accidental fractures are also common causes of injury to the physis.

Joints are affected in musculoskeletal decompression sickness, and osteonecrosis has been associated with divers who have done many near-saturation dives, such as tunnel workers. We do not know the exact anatomical site of joint involvement, and there is no published evidence suggesting that the physis is more susceptible to decompression sickness in children compared to adults.

Children are unlikely to be exposed to the conditions most often associated with osteonecrosis in adults, but sports divers do occasionally develop osteonecrosis. Thus, we support time and depth restrictions for children. Restrictions have been imposed by certification organisations such as SSI, PADI and CMAS for children in confined and open-water environments.

Is there any difference in the lung tissue or chest wall that might make children more susceptible to pulmonary barotrauma?

Up to about age 8, the pulmonary alveoli are still multiplying, pulmonary elasticity is decreased, and chest wall compliance increased. This puts children 8 and younger at a theoretical increased risk of pulmonary barotrauma, although we have found nothing published in the literature addressing this possibility.

Based on this consideration, CMAS, PADI, SDI and SSI have recommended that children younger than age 8 not scuba dive, and we concur. Given the variation in rates of growth and maturity, it would even seem prudent to raise the minimum age to closer to puberty (not less than 10 years old) to exclude any chance of children with immature lungs from diving. Organisations including SSI, SDI and PADI have all agreed.

Are children more likely to have an asthma episode while diving?

Risk factors that might provoke an asthma attack, such as cold or exercise, are present in the dry environment as well as underwater. However, the possibility of salt-



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water aspiration adds an additional risk factor. In addition, a child's reaction to an asthma attack underwater may involve a higher panic component than in an adult, putting them at increased risk of injury. Unfortunately, there is no controlled study data to accept or refute these hypotheses.

Do children have an increased propensity for ear barotrauma?

Up to age 8, the Eustachian tube, which is responsible for equalizing the middle ear, is more tortuous, compared to adults. This is why ear infections are more common in children than adults. Dr. Guy Vandenhoven reported on his experience with 234 children, ages 6-12, in a Belgian diving club from 1985-1992 and found barotrauma and ear infections to be the most common medical sequelae to diving.

Are there special considerations needed to determine whether thermal protection is adequate?

Children have a higher surface area /volume ratio and smaller body mass, which means under similar

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conditions with similar thermal protection they will cool faster. Special attention must be paid to ensure that children do not become hypothermic during diving. Exposure protection designed for children's sizes is recommended where warranted.

Do children have a higher propensity to form venous gas emboli (VGE) than adults?

No studies have been done comparing post-dive VGE incidence in children compared to adults.

Are children more susceptible to decompression sickness than adults?

There are no published data which could be used to answer this question. However, organisations including PADI, SSI and TDI have all imposed depth and time restrictions to address this.

If children do get decompression sickness, is it likely to be of increased severity compared to adults?

There are no published data which could be used to answer this question.

Do children have the strength and endurance to cope with emergencies?

Children have less strength and endurance than adults. Whether it is sufficient to cope with emergencies, swim against currents, or board a boat under less than ideal conditions is unknown, since the appropriate human factor studies have not been carried out.

SUMMARY

Based on the above considerations, the only data available that could be used to establish a minimum age for diving are based on pulmonary development. This suggests the possibility of and increased susceptibility to pulmonary barotrauma for pre-pubertal children, especially those younger than 10 years old. There is no other data available that would assist in making this determination.

It should also be noted that the empirical data and collective experience with children scuba diving seems to be based on shallow-water, protected diving. There is insufficient information available to make any evidence-based medical judgment for or against involving children in scuba diving.

As more children under the age of 12 dive, additional empirical data will gradually accumulate. However, in order for this data to be useful in making medically based decisions regarding children in diving, it will have to be carefully collected, vetted and analysed.

While the above represents the fruit of DAN's best effort at looking at the problem, we realise there may be quality data available that has not yet been published. For as wide a perspective as possible, we invite anyone with substantive comments either on DAN's assessment or the issues pertinent to children in diving in general to forward them the DAN. We realise that this issue will generate a lot of personal opinion, and while these are useful, conclusions backed up by actual data or records are the most useful. □