

Children and diving: the recreational-diving training perspective

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Abstract

(Richardson D. Children and diving: the recreational-diving training perspective. *SPUMS J* 2003; 33: 83-89)

The provision of scuba experiences for children is drawing increased interest from many who look to scuba diving as a family activity. Dive industry professionals may independently decide if they wish to train families with children under 12 years old. The Professional Association of Diving Instructors (PADI) has made concerted efforts to provide information to assist affiliated instructors in making that decision, and prescribes standards and post-certification limitations based on minimum age requirements. This position statement overviews and identifies the issues involved in teaching children to scuba dive, including the risks in doing so from PADI's perspective and what to do to responsibly address these risks.

Introduction – the history of scuba diving in children

Training children to dive has a substantial history outside North America, particularly in Europe. For many years now, the Confédération Mondiale des Activités Subaquatiques (CMAS) has had a formal programme and training guidelines, as well as well-defined standards for teaching

children as young as eight.¹⁻⁵ Prior to 1987, the Professional Association of Diving Instructors (PADI) and other certification organisations had no minimum age for certifying young divers. Teaching children younger than 12 was sanctioned on a performance-based approach throughout the 1960s, 1970s and 1980s for thousands of children.⁶ Nearly 40 years ago children were diving into

Junior Frogman Programmes. The decades-old Jacques Cousteau film, *The Silent World*, shows young sons Phillippe and Jean-Michel diving with their father. There is indeed a developed base of empirical data and experience for children younger than age 12 getting a start in scuba diving.

Six reasons PADI introduced scuba programmes for children

There are six reasons PADI chose to add junior diver programmes for children aged 10 years:

SASY

Supplied Air Snorkelling for Youth (SASY) introduced new equipment and an unprecedented approach to offering safe, surface-based experiences to children as young as five.

BUBBLEMAKER

PADI introduced Bubblemaker to offer children as young as eight a safe and enjoyable scuba pool experience to a maximum depth of two metres. This was possible due to the development of child-specific diving equipment.

AN EMPIRICAL HISTORY OF SCUBA DIVING IN CHILDREN

Many PADI members asked PADI to change its minimum age requirement from 12 to 10 years. We did so only after evaluating the good safety record generated from the empirical data we reviewed from our own experiences in the 1960s, 1970s and 1980s training children younger than 12, as well as the data from other organisations during the same time period. In particular, CMAS has accumulated 20 years' experience of safely offering scuba training to children.¹ CMAS training programmes include compressed-air breathing in pool environments for children as young as four, and open-water scuba training and certification for children with a recommended, though not required, minimum age of eight. The Club Med resort system has similar programmes in many locations in the world, and has long been an advocate of children's dive programmes. With these data, we then developed a sequence of programming based on age and equipment, and we added strict pre- and post-certification limitations to courses like Junior Scuba Diver and Junior Open Water Diver based on minimum age requirements in terms of depth, supervision, ratios and control, along with other relevant safety factors.

RETURN TO PERFORMANCE-BASED TRAINING BY RECREATIONAL SCUBA TRAINING COUNCIL (RSTC)

When the dive industry settled on a minimum age of 12 for certification, PADI adopted this standard. The most recent PADI change came after the RSTC's vote to eliminate a minimum age in favour of performance-based training, and return the industry standard to its original wording.

SNUBA

Over the past ten years, SNUBA operations have allowed children as young as seven to participate in open-water experiences. SNUBA is a scuba/snorkelling adaptation where two divers can swim freely to a depth of six metres without a buoyancy control device or other equipment and breathe from a specially adapted regulator attached to a scuba cylinder floating at the surface. SNUBA operators report 3.5 million open-water exposures without incident (<<http://www.scuba.com/questions.asp>>).

FAMILY DIVING

We wished to provide families with an opportunity for a shared, non-contact adventure activity.

Special new restrictions and limitations

PADI has clear standards in place for teaching children to scuba dive, as well as limitations on dive certifications. Since the inception of the junior diver certification, divers under the age of 15 have always been required to dive under the direct supervision of a certified adult. Furthermore, this age group is restricted to a depth of no more than 18 metres, or 21 metres for Junior Advanced Open Water Divers.

Children under 12 have even greater restrictions placed on their certification. First, they are limited to a maximum depth of 12 metres. This ensures that junior divers are subjected to only minimal decompression stress, thereby addressing concerns raised over the unknown, and possibly increased, risk of decompression illness (DCI).

Another restriction of equal importance deals with the issue of supervision. While any certified adult diver might accompany Junior Open Water Divers aged between 12 and 15 after certification, that is not the case with those under the age of 12. These younger Junior Open Water Divers are required to dive with either a certified dive professional, Divemaster or higher, or a scuba-certified parent or guardian. No others, regardless of dive experience and training, qualify as supervisors.

Supervising children and instructor readiness

Teaching children to snorkel and scuba dive can be fun and rewarding, but places a new responsibility on instructors. It requires an adjustment to instructional techniques and supervisory procedures. After all, children are not little adults.

It is important to be comfortable teaching children before one does it. Teaching children is a choice. If an instructor has a personal interest in teaching children, but is not a parent and has had few opportunities to interact with them, it is recommended they team teach with someone skilled in teaching young people. Children often need more

recognition, reassurance, praise and positive reinforcement than adults to remain focused and motivated. By being supportive and nurturing, an instructor can create a non-threatening environment conducive to learning and fun. Letting children know the instructor recognises and appreciates their efforts encourages them to keep trying. This takes personal commitment and a lot of energy. Some instructors may not feel comfortable with, nor want to take on, the added responsibility of dealing with younger students; that is fine in PADI's view.

Ten- and 11-year-old dive students

Without a doubt, there are 10-year-olds who do not qualify for dive training, and will not until they mature physically, emotionally and cognitively. Some children tend to be more physical and visual, while others may be less so. Because of their different rates of cognitive development, learning styles for children differ from those for adults. Scuba instructors need to be aware of these factors and may need to break a complex concept or task into simpler segments so children can grasp it more readily.

In the case of 10- and 11-year-olds, dive operators must be more attentive to the learning process than with adults. Likewise, when presented with the opportunity to train a physically challenged person, more personal attention, a review of dive-site selection and possibly special equipment configurations may be in order. These days, there are lots of choices out there for children in terms of smaller-sized dive equipment. Manufacturers like Aqualung, Scubapro and Oceanic are developing full-product lines for children, including child-sized wet suits and buoyancy compensators, as well as smaller tanks, masks, fins and mouthpieces for snorkels and regulators.

Medical issues regarding scuba diving in children

Speculation and controversy surround the discussion of the medical implications of allowing children to dive. After a thorough review of the medical literature on children and diving, the Diver Alert Network (DAN) concluded that insufficient clinical or scientific medical documentation exists to make any evidence-based judgment on the medical implications of allowing children to dive (unpublished data).

Under PADI standards, children are pre-screened for dive fitness under parental supervision via a dive-specific medical screen, and are required to be evaluated by a physician should anything on the screening form be answered in the affirmative.

The following commentary was prepared in consultation with the DAN staff physicians and other medical specialists at Duke University Medical Center. DAN conducted a Medline search from 1966, which revealed no papers dealing with how the physiological differences between adults and 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 participated in scuba diving.

The following are the main issues that we consider must be addressed in considering children and scuba diving:

- Since a patent foramen ovale (PFO) is a risk factor in DCI, is there evidence of an increased incidence of PFO in children?
- Because of differences in neurological development, is there evidence that children are more susceptible to oxygen toxicity?
- Are growing bones in pre-pubertal children more susceptible to injury from DCI or silent bubbles?
- Are there any differences in the lung tissue or chest wall of children compared with adults that might make children more susceptible to pulmonary barotrauma?
- Given that young children have an increased incidence of asthma compared with 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 DCI, is there evidence that children have a higher propensity to form VGE than adults?
- Are children whose central nervous system (CNS) is still developing more susceptible in general to DCI than adults?
- If children do get DCI, will it be of increased severity compared with adults as a result of an immature CNS?
- Do children have the strength and endurance to cope with emergencies?

The above are felt to be the most important medical and physiological considerations associated with children and diving. They do not, however, address behavioural 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 an increased incidence of PFO in children?

DAN: One paper has looked at the incidence and age distribution of PFO in cadavers down to age 10.⁷ An increased incidence of PFO in the 10–20 year group compared with other groups was noted. However, this incidence was based on only six cases, three with a patent PFO, out of a total of 705 (95% confidence intervals 11–88%). Thus, there is a suggestion of an increased incidence of PFO as age decreases below 20.

PADI: PFO is thought to be a risk factor in developing DCI. To avoid DCI concerns, PADI limited the depth for 10- and 11-year-olds to a maximum of 12 metres. According to the metric version of the Recreational Dive Planner the no-decompression limit for 12 metres is 147 minutes. Even in warm waters, recreational dives longer than one hour are unusual. This is a very generous safety margin and effectively precludes concerns about DCI.

Are children more susceptible to oxygen toxicity?

DAN: Clinical experience at Duke University showed no particular difference in susceptibility of children down to age eight to either pulmonary or CNS oxygen toxicity. Only a single paper was found that attempted to address the subject.⁸ Bland showed that the effect of age on susceptibility to pulmonary oxygen toxicity was species specific; in some immaturity was protective, in others it was not.

PADI: The recreational dive community regards a maximum ppO_2 of 1.4 bar (142 kPa) as a conservative figure when discussing the possible onset of acute oxygen toxicity. PADI has not approved 10- and 11-year-old children for enriched air Nitrox, technical or deep diving courses. So, given that children will breathe compressed air only, they would need to dive to 60 metres before reaching a ppO_2 of 1.4 bar, well beyond the 12 metre limit. Pulmonary oxygen toxicity is not considered relevant to this discussion.

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

DAN: In children up to age 18, long bones continue to grow from the epiphyseal region near each end. The epiphysis consists of mostly cartilage and has no blood supply, depending on diffusion of substances to and from adjacent vascularised tissue. If this area is injured then abnormal bone growth will result, such as one leg becoming shorter 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 epiphysis.

Joints are affected in musculoskeletal DCI, and avascular osteonecrosis has been associated with saturation diving and tunnel workers. The exact anatomical site of joint involvement is not known, and there is no published evidence suggesting that the epiphysis is more susceptible to DCI in children compared with adults. Children are unlikely to be exposed to the conditions most often associated with osteonecrosis in adults, but sport divers do occasionally develop osteonecrosis. Thus, we support time and depth restrictions for children. Restrictions have been imposed by organisations such as SSI, PADI and CMAS for children in confined and open-water environments.

PADI: There are no relevant experimental or clinical data, while data from clinical reports in cases of DCI in those

aged 15–20 have not shown damage to the epiphysis. It is likely that exposures would have to be extreme, such as in caisson workers or saturation commercial divers, a scenario well outside the scope of recreational diving. The depth limits and limited decompression stress for junior divers add a considerable measure of safety. If this were an issue, it would apply to any diver younger than 20 years old.

Given its poor blood supply, the epiphysis is likely to behave as a 'slow' tissue (it 'on gasses' and 'off gasses' slowly). Slow tissues are more of a factor on long dives when there is plenty of time for tissues with poor blood supply to absorb nitrogen. Hence the enhanced osteonecrosis concerns for caisson workers and saturation divers. Given the depth restrictions and the short bottom times imposed on 10- and 11-year-olds, and the fact that scuba diving is a non-impact activity, risks to the epiphysis can be considered minimal.

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

DAN: Up to about age eight the pulmonary alveoli are still multiplying, pulmonary elasticity is decreased, and chest-wall compliance increased. This puts children eight years and younger at a theoretical increased risk of pulmonary barotrauma, although nothing was found in the published literature addressing this possibility. Based on this consideration, CMAS, PADI, SDI and SSI have recommended that children younger than age eight not scuba dive, with which DAN concurs. Given the variation in rates of growth and maturity it would even seem prudent to raise the minimum age 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.

PADI: This is the primary reason for the 10-year age limit.

Are children more likely to have an asthmatic attack while diving?

DAN: Risk factors that might provoke an asthmatic attack such as cold or exercise are present in the dry environment as well as underwater. However, the possibility of salt-water aspiration adds an additional risk factor. In addition, a child's reaction to an asthmatic attack underwater may involve a higher panic component than in an adult, putting them at increased risk of injury. There are no data to accept or refute these hypotheses.

PADI: Active asthma is a contraindication to diving, both for adults and children. This is a determination made by doctors and parents for 10- and 11-year-olds. If a 10- or 11-year-old child has active asthma, or if there is any doubt at all, the only possible recommendation is to avoid diving completely. This also applies to older children and adults.

Do children have an increased propensity for ear barotrauma?

DAN: Up to age eight, the Eustachian tube, which is responsible for equalizing the middle ear, is more tortuous than in adults. Hence, ear infections are more common in children. In a group of 234 Belgian children, aged six to 12 years, it was found that barotrauma and ear infections were the most common medical sequelae to diving.⁹

PADI: This is another reason for PADI's 10-year age limit and a very good reason to ensure that everyone in dive training programmes can equalize properly. It is worth pointing out that equalization of ears and mask is one of the first and most important skills any diver needs to master. Eustachian tube dysfunction is common in early childhood, so susceptibility to ear barotrauma is greater for children under age 12, when most children have achieved adult-level Eustachian tubes. It is important to make certain children can equalize properly in confined water before taking them on open-water dives.

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

DAN: Children have a higher body surface area to volume ratio and smaller body mass than adults, which means under similar 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 is recommended where warranted.

PADI: Make sure children have adequate thermal protection and monitor them closely for signs of chilling.

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

DAN: No studies have been carried out comparing post-dive VGE incidence in children compared with adults.

Are children more susceptible to DCI than adults?

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

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

DAN: We have no published data to answer this question.

PADI: For this and the previous two questions, PADI refers back to the discussion regarding PFO relating to DCI. Given the restrictions placed on 10- and 11-year-old divers, this risk, from a practical standpoint, can be considered minimal.

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

DAN: 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.

PADI: This question is not unique to 10- and 11-year-old children, PADI professionals have helped divers deal with this issue for years. Specific to this age group, however, is the requirement that they dive with a parent, guardian or PADI professional. PADI is defining the diving envelope within which these children may dive. An instructor must further define it based on local conditions. Philosophically, the very premise of the PADI Rescue Diver course reflects this issue in that there is never only one way to deal with an emergency or stressful situation.

Addressing this concern from a practical perspective begins with dive-site selection, ensuring the site is appropriate for the divers' age and experience levels. It is not reasonable nor prudent to expect children to simply tag along on dive trips designed for experienced adults. Dive professionals are encouraged to emphasise the importance of dive planning and sticking to that plan, and of supervision. That said, there are numerous instances of children younger than 10 making emergency assistance calls and helping adults in distress in other ways.

Summary of research evidence

Based on the above considerations, DAN considered 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 less than 10 years old. There are no other data available that would assist in making this determination. It should also be noted that the empirical data and collective experience with scuba diving in children seem to be based on shallow-water, protected diving.

There is insufficient information 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 these 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 DAN's best effort at looking at the problem, we realise there may be quality data available that have not yet been published. For as wide a perspective as possible, DAN invites anyone with substantive comments on DAN's assessment of the issues pertinent to children in diving to forward them to DAN (<www.danseap.org>). This

issue will generate a wide range of opinions and, while these are useful, conclusions backed up by actual data or records are the most constructive.

Dive risks in perspective

Every day, thousands of parents enroll their children in sports such as soccer, rugby, American football, basketball, field hockey, skiing, gymnastics, skateboarding, bicycling, snowboarding, volleyball, wrestling, baseball, martial arts and other contact adventure sports and recreations. The incidence of morbidity and mortality in these activities is significant. For example, in the United States alone, emergency rooms treat more than 775,000 children under the age of 15 for contact-sports injuries each year. Trauma involving cervical and other spinal injuries, long-bone fractures and the like are regular occurrences in these sports. The risks and severity of the consequences of such activities are clear.

In comparison, scuba diving is a non-contact, non-impact soft activity experienced under closely controlled conditions requiring strict supervision, limited depth and careful instruction. Clearly, scuba is a reasonably safe activity with manageable risks, but is definitely not risk free. The major, potentially catastrophic dive-related risks for children include drowning, lung overexpansion injuries including arterial gas embolism, water aspiration and ear injury. These need to be managed through proper supervision and other precautions, such as reducing ratios and increased adult supervision. Both of these are vital requirements in PADI's junior diver programmes.

Ten- and 11-year-old dive buddies

A 10-year-old may not be able to assist a larger buddy such as a parent, for example, should an incident arise. However, some adult buddy teams may find themselves in similar situations, particularly when one diver is significantly smaller in stature and ability. When a physically challenged diver is teamed with an able-bodied one, or even when a neophyte diver is teamed with an experienced one, there are limitations on the team based on the weakest member. Yet, it works out in reality. This is because people tend to accept relevant limitations and accommodate them. These limitations are factored into the dive plan in terms of selecting an appropriate site based on depth and environmental conditions. Dive operators must be attentive to the limitations of their customers and select dive sites accordingly. Although Junior Scuba Divers and Junior Open Water Divers must fulfil the same certification requirements as an adult, the expectations faced by adult divers do not apply to divers with these certifications.

The implication of the differences between adult and junior divers has an important bearing on supervision. When an adult dives with a child, that adult may not have a buddy in the same sense as when diving with another adult, for example. On the other hand, there are anecdotes of children

offering assistance to adults, children who call emergency services or even offer CPR in a medical emergency. The child mature enough to handle a dive certification course has demonstrated the ability to be responsible and to follow rules. It may follow that the same child may be astute enough to know how to inflate a buddy's BCD, then surface and call for help, or ditch a weight belt.

Children, their knowledge of safety and awareness of danger

Two published studies conducted to determine the extent to which children are aware of the dangers in several situations are of interest to training children how to safely scuba dive and indicate that eight- to 11-year-olds can understand and identify danger.

In the first study, thirty seven grade-three children (seven to nine years old) were tested by showing them drawings of children engaged in ten activities.¹⁰ The students were asked what the children in the drawings were doing and how the children could get hurt. Depending on the drawing, 84–100% of the students identified the activities depicted appropriately, and 85–100% identified significant dangers in the situations depicted. The researchers concluded that, in general, the group of students tested appeared to be quite knowledgeable about the hazards represented in the set of drawings.

A second study investigated the ability of 64 children between five and 11 years old to select safe places to cross the road.¹¹ The children were presented with situations that were either extremely safe or manifestly dangerous and were asked to correctly identify these. All the experiments showed a similar pattern of results. Five- and seven-year-olds exhibited very poor skill in identifying dangerous road crossing sites. Nine-year-olds showed a higher level of ability and 11-year-olds showed good skill in these judgments. The results suggest that young children up to about nine years old do not have the ability to recognise a location as dangerous.

Although similar studies have not been performed with children for scuba diving, application and benefit for teaching scuba diving to children can be derived. The importance of utilizing all of the visual, audio and live-delivery media and information available for each diving programme, and thoroughly explaining the risks and dangers, can be inferred from these results. Thus, the child will be made aware of and identify the dangers and hazards associated with the given activity.

Social benefits

To a large extent, getting children interested in recreational diving takes them out of harm's way in a broader context in that it provides an active, rewarding recreation. It provides a focus that sets the stage for a healthy lifestyle away from drugs and other destructive pathways. It is also

a means to bond families together with a common interest.

Evaluating motivation, knowledge and ability

How does an instructor evaluate motivation, readiness and ability in a child? It may be important to first assess motivation. Does the child really want to dive, or is there too much parental pressure? Parents should not pressure their children into training. Scuba diving is not an appropriate activity for a young person if that interest does not stem from a personal desire to learn.

Parents value programmes that are educational, interactive and activity based. PADI programmes allow children to learn about the underwater world and acquire new skills. Children learn to take responsibility for their actions and meet established goals, which builds confidence and pride. All of these benefits can build character and self-esteem. As for ability, instructors are obligated under PADI standards to conduct an assessment of knowledge and skill prior to making open-water dives. The point of pre-assessment is to give the instructor an opportunity to assess ability, strength, aptitude, readiness, emotional and psychological maturity, and attitude before progressing to the open water.

Safety and responsibility

Divers' health and safety are of paramount importance in the creation of every programme PADI has ever developed. Safety is integral to the long-term success of any business, including PADI. Many of us at PADI who develop standards changes are both instructors and parents. So consider this: we would not have introduced Bubblemaker, SASY, Junior Scuba Diver and Junior Open Water Diver programmes for children younger than 12 if we did not feel that decision was appropriate for our own children.

At a glance: PADI youth programmes

AGES FIVE AND OLDER:

May participate in Supplied Air Snorkelling for Youth (SASY) experiences. SASY allows youths to breathe from a regulator at the surface while wearing a flotation device in a pool environment.

AGES EIGHT AND OLDER:

May participate in PADI's Bubblemaker programme. This programme introduces participants to scuba diving in a pool or pool-like environment and has a maximum depth limit of two metres.

AGES 10 AND 11:

May participate in Discover Scuba and Discover Scuba Diving experience programmes, and can earn restricted certification as either a PADI Junior Scuba Diver or Junior Open Water Diver. PADI Junior Scuba Divers are limited to a maximum depth of 12 metres and may only dive with

a PADI professional. PADI Junior Open Water Divers are also limited to 12 metres, and may dive with a PADI professional or a certified scuba-diver parent or guardian.

AGES 12 TO 15:

No recent changes. Divers in this age range earn junior certifications and can dive only when accompanied by a certified, adult scuba diver. During training, these divers are limited to 12 metres for the first two dives and 18 metres for dives three and four. Divers in this age group are limited to a maximum depth of 21 metres for all other PADI continuing-education courses.

Acknowledgements

DAN International for providing their data review.

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