

A close-up photograph of a hand being fitted with a black neoprene diving glove. The background is a solid, vibrant blue. The text is overlaid on the upper right portion of the image.

THE Younger DIVER:

The Challenges and
Concerns of Childhood Scuba



I've always had difficulty thinking of scuba diving as a sport because of its fundamentally noncompetitive nature. In diving, there's no such thing as "par," and the only time the topic of an "average" ever comes up is when talking about how long a tank of air might last. But the lack of any competitive nature or spectator appeal of diving also presents an advantage; that being almost anyone in reasonable health can participate. Age, too, is no significant obstacle. As there are numerous octogenarian divers still active, the upper end of the age limit is anyone's guess. Yet, it's the lower limit that's been the subject of more than a little interest and controversy in recent years.

Just how old one should be to become a scuba diver has been a subject of fierce debate for almost as long as recreational diving has been around. Scuba's own pappy, Jacques Cousteau, had both of his sons on scuba by the time they were barely out of diapers; and for many years the scuba training organizations had no lower age limit for certification. In fact, it wasn't until the early 1980s that an arbitrary minimum age of 12 was set for the restricted credential called "Junior Diver"; but that all changed in 2000 when several of the training agencies reduced the minimum age of certification to a mere decade of life. Today, PADI (Professional Association of Diving Instructors) alone certifies more than 15,000 youngsters per year between the ages of 10 and 14, and that's just in this hemisphere.

The purpose of this article is not to debate the justification of the minimum age for scuba certification. (For those interested in that topic, see "C-Cards for Kids: Boon or Abomination?," *Dive Training*, November 2000.) Instead, this discussion accepts the reality that a growing number of young people — some of whom haven't even reached puberty — are active scuba divers. Of course, any diver below the age of majority — 18 in most but not all cases — requires parental permission; and making the decision of whether to allow their child to become a scuba diver is not an easy matter for a parent. It's an especially tough decision if the parent isn't a qualified diver, thus lacking any perspective or appreciation for the challenges involved. So what's a parent to do?

By Alex Brylske Photos by Joseph C. Dovala



It is important that younger divers be equipped with gear that fits properly. Avoid the temptation to select gear “they’ll grow into.”

On one end of the continuum there are some parents, diving educators and child health care professionals who take an uncompromising position that children have no place in diving. Some instructors even refuse to train anyone who’s not an adult. (See the link to an article “Why I Do Not Train Kids” in the sidebar.) The other extreme are those who see virtually no difference between children and adults when it comes to risk. “Yes,” they say, “there are some 10-year-olds who should never become divers, but there are also plenty of 40-year-olds who have no business, either.” As with most issues in life, the truth seems to lie somewhere in between the extremes. One point is for certain: Children are certainly not miniature adults, neither from a physiological nor psychological perspective. Their growth and development does warrant special considerations that no prudent parent, diving instructor or potential diving buddy should ignore.

The Kid Body

What distinguishes kids from adults psychologically is pretty obvious. Less obvious, aside from size, is what makes them different in their physiology, especially as it relates to the challenges of being at depth. So let’s start by looking at some of the issues that concern medical experts when the subject of child divers arises.

A few years ago, pursuant to a request from the Recreational Scuba Training Council, the Divers Alert Network (DAN) conducted a search of medical literature going back to 1966 and found no studies dealing with how the physiological differences between adults and otherwise healthy children would alter the child’s capability and risks associated with diving. Therefore, they concluded, “any recommendations made [about the minimum age for certification] would be based on theoretical considerations taking into account what is known about normal growth and de-

velopment.” Using this approach, DAN prepared a document that addresses salient issues, such as decompression risk, pulmonary development, asthma, oxygen toxicity and equalization problems. The issues it raised provide a useful perspective on concerns that medical experts — as well as parents — should consider in determining the risk of scuba diving to children. Accepting its speculative nature, let’s look at each topic, and what we might conclude from the medical evidence.

One of the first concerns ever raised by medical experts when the child diver issue was first raised many years ago was the susceptibility of growing bones to injury from decompression sickness or silent bubbles. To understand this requires some background. Long bones (arms and legs) mature from growth regions known as epiphyseal plates. The last of these growth plates generally does not cease activity until the late teens or early 20s. The epiphyseal plates

consist mostly of cartilage and, having no blood supply, they depend on diffusion from adjacent tissues that do have a blood supply for oxygen and nutrition. Diving medical experts have long had a theoretical concern that nitrogen bubbles may damage these critical tissues. Damage to growth plates is a very serious matter because, if injured, abnormal bone growth will occur. The result could be the affected leg or arm not growing to a normal length, a condition seen normally as a result of fractures or injuries from sports that require heavy weight-bearing activity, like skiing, rollerblading, ice hockey or football.

We know from studies of adult bends victims that joints are affected in musculoskeletal decompression sickness, and furthermore that osteonecrosis (bone death) occurs in commercial divers and caisson workers who engage in very prolonged (several hours to days) exposures to depth. Still, it's impossible to draw any definitive conclusions because scientists still do not know the exact anatomical site of joint pain, and there's no published evidence suggesting that the growth plates are more susceptible to decompression sickness in children compared with other tissues in adults. Furthermore, like all recreational (no-decompression) divers, kids are unlikely to be exposed to the conditions associated with osteonecrosis in adults. (However, some recreational divers do occasionally develop the condition.) The take-home message from this should be abundantly clear: However unlikely, even a theoretical risk to growing bones requires that measures be taken to minimize the risk for decompression sickness in children.

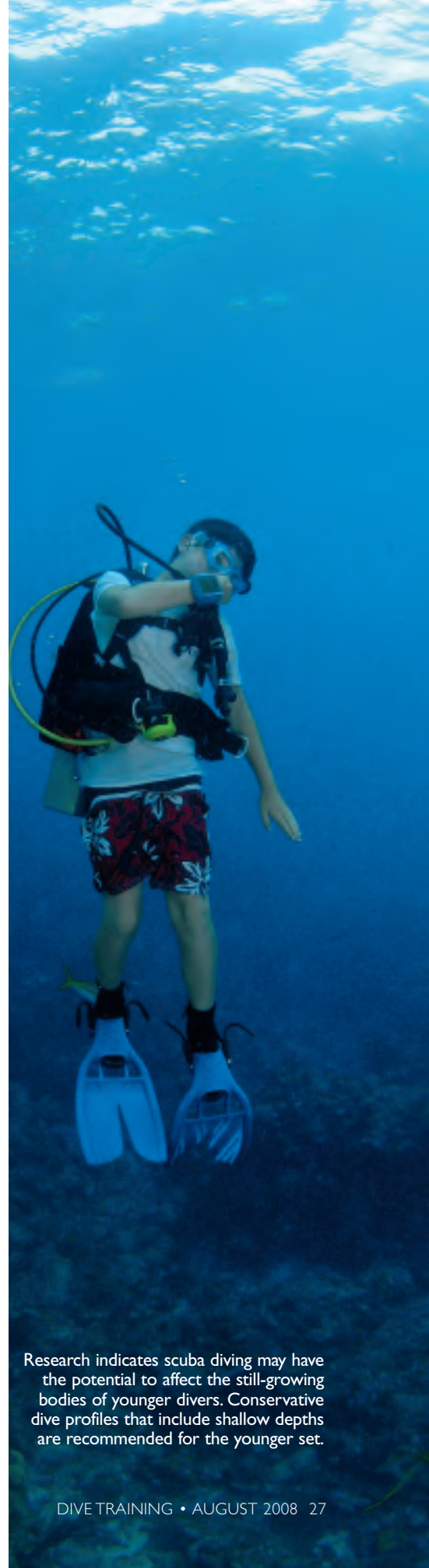
Other questions regarding decompression illness in children have been raised as to whether they have a higher propensity to develop silent bubbles, whether they're innately more susceptible to DCI, and whether the disorder in kids is likely to be more severe than in adults. However, to date no studies have been done comparing post-dive silent bubbling incidence in children with adults; and there are no published data

that can provide a basis to draw any conclusions about either the susceptibility or severity of DCI in children.

One area where there's both concern and at least some data is the increased incidence of patent foramen ovale (PFO) in children. The foramen ovale is an opening in the upper chambers of the heart. In a fetus, the lungs are inoperative, so this opening facilitates transfer of oxygenated blood via the umbilical cord. At birth this opening is supposed to close, shunting blood to the now-functioning lungs. Usually this opening seals by the third month of life, but in many cases remains partially open; and when it doesn't close completely, it's termed "patent." An incomplete closure means that blood can flow from the right to the left side of the heart without passing through the lungs. When divers equalize their ears using the common "pinch and blow" procedure (Valsalva maneuver), there's an increase in right chamber pressure that can move blood through the opening, bypassing the lungs. Having bypassed the filtering action of the lungs, nitrogen bubbles in the venous blood can pass directly into the arteries. This mechanism has long been suspected in some cases of decompression illness.

It's known that the rate of closure of a PFO is highly variable, and in some children it will not have completely closed until around age 10 (in some individuals it never closes completely). Some have suggested that there may be an incomplete closure in as many as 50 percent of children. But while the true percentage is unknown, medical authorities believe the percentage of children with PFO could be higher than the known rate of 25 percent in the general population. One study found, by looking for PFO on autopsy in 703 cadavers down to age 10, an increased incidence was observed in the 10 to 20 age group compared with those older.

In the light of such uncertainty over decompression illness, all diver training organizations impose significant depth restrictions on junior divers as a way to reduce decompression stress. Divers be-



Research indicates scuba diving may have the potential to affect the still-growing bodies of younger divers. Conservative dive profiles that include shallow depths are recommended for the younger set.

Piaget's Developmental Stages (excluding sensory-motor)

Stage

Characterized by:

Pre-operational (2 through 6-7 years)

Recognizes self as agent of action and begins to act intentionally: e.g., pulls a string to set mobile in motion or shakes a rattle to make a noise.

Achieves object permanence: realizes that things continue to exist even when no longer present to the senses.

Learns to use language and to represent objects by images and words.

Thinking is still egocentric: has difficulty taking the viewpoint of others.

Classifies objects by a single feature: e.g., groups together all the red blocks regardless of shape or all the square blocks regardless of color.

Concrete operational (6-7 through 11-12 years)

Can think logically about objects and events

Achieves conservation of number (age 6), mass (age 7) and weight (age 9).

Classifies objects according to several features and can order them in series along a single dimension such as size.

Formal operational (11-12 years and up)

Can think logically about abstract propositions and test hypotheses systematically.

Becomes concerned with the hypothetical, the future and ideological problems.

low 12-15 years of age are limited to depths of 60 feet (18 m), while those programs that allow divers 10-11 years of age typically allow no diving deeper than 40 feet (12 m). But like all diving practices, these are voluntary standards, so it's incumbent on parents and other adult supervisors to ensure unyielding adherence to these limits.

While concern over DCI tends to get most of the focus, there are other medical issues unrelated to bends. One important issue involves lung development, and whether differences in lung tissue or the chest wall might make children more susceptible to pulmonary barotraumas. Such concerns are based on the fact that, up to the age of about 8, pulmonary alveoli are still multiplying, pulmonary elasticity is decreased, and chest wall compliance increased. Although there have been no published data addressing this specifically, this puts children 8 and younger

at a theoretically increased risk of pulmonary barotraumas. This is, however, the rationale for why no North American-based diver training organization allows any form of compressed air experience — even in a swimming pool — with children younger than age 8, and another rationale for why age 10 is the absolute minimum set for open-water diving.

In almost any discussion of medical conditions that affect children the subject of asthma will arise. The reason is that this serious lung disorder has reached almost epidemic proportions in children. And as it is a lung ailment, asthma is also a major concern — and long a subject of controversy — within the diving community. One question asked is whether children are more likely to have an asthmatic episode while diving than adults. Medical authorities agree that for all asthmatics, because of the possibility of saltwater

aspiration, diving imposes an added risk that just isn't a concern on dry land. Some have expressed concern that a child's reaction to an asthmatic attack underwater may induce panic sooner or more intensely than in an adult, putting them at increased risk of injury. The problem is that there's simply no data to support or refute such an assertion. The only advice to parents of asthmatics is to stay informed about the disease, and the implications it has on diving. (For a more in-depth look at this topic, see "When You Can't Breathe Normally: The Latest on Asthma and Diving," *Dive Training*, November 2006.)

Another concern for younger divers is equalization, and whether children have an increased propensity for ear barotrauma. The rationale for such concern is based on the structure and development of the eustachian tube. Up until the age of around 8, the eustachian tube is narrower, more horizontal and more tortuous than later in life. This is why ear infections are more common in children than adults. Perhaps not surprisingly, one unpublished study from a European dive club of 234 children between the ages of 6 and 12 found ear barotrauma and infections to be the most common medical problem reported. By age 12, the eustachian tubes develop into their more adultlike form, and equalization problems become less likely. The take-home message here is that younger divers need to understand the importance of equalization, and be trained to recognize, and not be hesitant to tell someone, if they are experiencing problems.

A lesser-known concern in younger divers involves oxygen toxicity, and whether kids might be more susceptible to it than adults. Some have raised the issue of if, and how, elevated oxygen partial pressure might affect the development of bone and connective tissue. Here again, no one knows. DAN has stated that clinical experience at Duke Medical Center shows no difference in susceptibility of children down to age 8 to either pulmonary or CNS (central nervous system) oxygen toxicity (the

variety seen in most diving incidents). In the literature search conducted by DAN described earlier, only one study was found that addressed this issue, and it stated only that studies in animals showed that the effect of age on susceptibility to pulmonary oxygen toxicity was species-specific. In some, younger animals were less susceptible to oxygen toxicity than adults, but in other species there was no difference. As with most other issues, when it comes to how kids are affected, the jury is still out.

While issues involving DCI, lung development and oxygen toxicity are still speculative, there is one area where there are clear and important differences between children and adults: heat loss. Kids have a higher surface area-to-volume ratio and smaller body mass. This means that under similar conditions with similar thermal protection a child will cool faster. So, parents, educators and anyone who dives with kids must understand this, and pay particular attention to ensure that children do not become hypothermic while diving. Pediatrician Dr. Maida Taylor provides some excellent and rarely considered insight into this problem of heat loss, specifically among female divers. She cites some evidence showing that girls incur higher oxygen expenditure when exercising than women, meaning that girls generate more metabolic heat and burn more energy than adult women. So, girls get colder more quickly than women do under similar environmental conditions. In studies of open-water swims in water 20.3 degrees Celsius (28 degrees Fahrenheit), girls age 8 showed a 2.5-3 C decline in core temperature, while girls age 16-19 showed little thermal stress. "These characteristics, in combination with higher rates of peripheral blood flow in children," Taylor says, "put preadolescent and early adolescents at an increase risk of cold stress." Furthermore, she says that understanding the full implications of heat loss in child divers is important because, as adults don't lose heat as fast, they may not understand or even perceive that a serious level of cold stress

is happening right before their eyes. "A bad wet suit," she says, "is almost worse than no wet suit for the young diver." According to Taylor, the double whammy of increased heat loss and poorly fitting gear can easily lead to accidents. So, in smaller children, postponing diving until they're a bit older (bigger) is often the better option, rather than providing a miserable or even potentially dangerous experience.

Taylor's emphasis on size as opposed to age highlights a longstanding concern raised several years ago when the idea of reducing the minimum age for certification to 10 was first discussed: Does a child have the strength and endurance to cope with the challenges diving may present? Obviously, children have less strength and endurance than adults; and there certainly have been no studies done to determine whether kids have sufficient capabilities to deal with emergencies (or even deal with other demanding but non-emergency situations). Some dive-savvy pediatricians recommend that, given the challenges of the environment and cumbersome equipment, any child being considered for certification should have a body mass of at least around 100 pounds (45 kg) and be at least 5 feet (153 cm) in height. For girls, some pediatricians have recommended that diving be postponed until 6 to 12 months after their first menstrual cycle, when most physical growth is completed. Clearly, this would exclude a large number of kids who are active divers today, which points up the need for great care in selecting gear that's small enough to fit properly. This is no time for hand-me-downs, or the "good enough" attitude. If anything, outfitting a child requires even more careful consideration than for adults. So, equipping your kid is certainly no place to scrimp.

In the final analysis, most diving professionals advise that, when diving with any child, you should assume that you're essentially diving buddyless. Because of this, some even advise that buddy teams involving children should be threesomes, with two adults, so that

there's adequate provision for emergency situations.

The Kid Mind

While it's vital to consider medical and physiological factors in determining the risk of diving to youngsters, most experts in the field believe that psychological and behavioral issues are even more important. Just as kids aren't simply scaled-down versions of adults physically, so to do they differ in fundamental ways psychologically. At issue is how the cognitive and emotional capabilities of children develop. Most cognitive development theory today draws on work done by the well-known Swiss biologist-turned-psychologist, Jean Piaget. He proposed that children pass through four developmental stages (only three of which will be considered here) as they mature into adulthood. These stages conform, generally, with age. (See the sidebar "Piaget's Developmental Stages" on Page 30.) Understanding these developmental stages is important because stage of development of a child will determine his or her ability to acquire, manipulate and comprehend information.

Piaget's first stage is termed the Pre-Operational, and begins at about age 2 extending to about age 6 or 7. (The exact age at which individuals enter each stage is somewhat variable.) This is when children develop symbolic thinking; meaning that they can represent objects and events in their minds without the physical object or event being present. In the later phase of the Pre-Operational stage, a kid does acquire an intuitive but rudimentary grasp of some logical concepts, but only in a very limited sense. For example, a kid will tend to focus attention on only one aspect of an object or task and ignore the rest. At this stage they're incapable of comprehending underlying principles. In terms of behavior, they must rely on rules imposed by authority.

Most children pass from the Pre-Operational stage to the Concrete Operational stage by the age of 8. When it comes to diving, perhaps the greatest concern is that a late-developing child,

Some **Advice** for Parents

One of the concerns often expressed by both dive professionals and those in the mental health professions is that parents might push their children into diving even if they aren't especially interested or capable. And, as a child is far less likely to object to or question an adult, they may too easily agree solely to please a parent. This imposes a tremendous responsibility on parents in evaluating whether diving is appropriate for their child. It's imperative that the motivation and desire to dive be authentically that of the child and not of the parent. There's simply too much at stake for a parent to make the decision on the basis of their own wishes instead of their kid's. Under no circumstances should an unwilling, or even a minimally motivated, child be coerced into scuba.

The other concern is the capability and readiness of kids who are honestly enthusiastic about becoming divers. Here, some important and sometimes difficult decisions are necessary. Regardless of the level of supervision, all divers, be they children or adults, can be placed in dangerous situations. Therefore, parents must recognize that before enrolling their children in scuba classes, they should first look for evidence that their child has the requisite psychological and emotional maturity. Ask yourself questions such as: What evidence do I have that my youngster will understand concepts such as pressure/volume relationships or decompression illness? From the emotional perspective, ask questions such as: How might my child react in a stressful situation? Does my child sometimes engage in foolish risk-taking behavior that could result in serious injury if he or she were diving? While these may be difficult questions to assess, and the true answers may be difficult to accept, such an unabashed evaluation is absolutely essential, and it's only a parent who can truly make such an assessment.

Furthermore, parents should accept their role in supervising their children once they become certified. In the final analysis, should the child not understand or forget some important concept, or be unable to perform a skill, an attentive adult will be there to respond immediately. This means that when an adult is diving with a child, the adult's enjoyment must be secondary to the child's safety. I also believe strongly that parents should never even consider scuba as an option for their younger children until they themselves are highly competent and experienced divers. As a diving educator, I simply do not believe that the supervision of a young child is a role that should be relegated totally to another diver or even to a dive professional. In my opinion, the only appropriate buddy for a very young diver is his or her parent.



who's incapable of grasping the concept of pressure/volume relationships, could forget to continue to exhale while making an emergency ascent. Emotionally, such a child will also not tend to place someone else's safety on par with their own.

The Concrete Operational stage covers the ages of 6-7 through 11-12, and is when logical thought processes develop. But what's important to understand is that, while adult-like logic appears, it's limited to reasoning about concrete reality. It's vital that parents and diving educators understand the implications of a child in this stage of development because it imposes important limitations on their understanding. For example, a kid at this stage may be able to understand basic pressure/volume relationships, and solve a simple problem related to the concept. However, he or she could not make any hypothesis about how such principles extend to a wider application, such as understanding the concept of a reverse sinus squeeze or deduce why it's important to avoid diving with a cold. Of even greater concern is that children at this developmental stage are able to generate multiple solutions to a situation, a necessary skill when faced with an emergency situation.

Around the age of 11 to 12 children enter the final stage of development called Formal Operational. Gradually, thinking becomes less tied to concrete reality and becomes more abstract. Children acquire the ability to generate abstract ideas on their own, can form multiple hypotheses, and are able to assess the possible outcomes of their actions. In essence, this is when a child is able to think about what might be, rather than just what is. This, of course, is the ideal stage of development for children to engage in open-water scuba diving.


One important aspect of understanding the psychological development of kids is how this relates to behavior. Certainly, children are notorious for being exuberant and impul-

sive. They also believe that they're invincible. These are normal childhood traits that are going to be part of a kid's psyche until their late teens. In fact, we now know that brain development continues, especially in males, beyond even the teenage years. As unrestricted diver credentials are awarded to those 15 and above, this can have important implications for the appreciation and avoidance of risk, as well as the ability to act as a responsible dive buddy.

Those who study children also recognize that emotional development is very closely tied to cognitive development. As a result, children often do not understand their limitations, or the realities of a situation. They're also used to others, such as parents or teachers, looking out for their welfare, and can become overly reliant on an adult dive buddy. Under conditions of stress, this can be problematic because a child may panic or become helpless, waiting for someone else to solve a problem for them.

It's also important to recognize that there's a link between emotional development and problem solving. As one child psychologist has put it, "We often make mistakes not because we don't think of the right answer, but because we don't act on it." In other words, our emotions can overrule our thinking in many situations; and this is a very common problem with children. There's also the issue of whether a child will even be willing to tell an adult buddy that he or she is cold, or is low on air or having some other problem.

While there's a theoretical debate over just when a child is ready for diving, the reality is that we now have several decades of experience, and hundreds of thousands of dives performed by junior divers indicating overwhelmingly positive results. But as I began diving myself at the young age of 13 — and have trained several 10-year-olds — I'll admit that I'm probably a bit biased in my view. Clearly, diving is certainly not without

risk, but it does seem unjustified to deny children access to diving, and yet allow them to participate in activities that are far more likely to result in serious injury. It can be a tough decision, but no one ever said that parenthood was easy. 

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