Rapid recovery: Research fights cardio, muscular fatigue in navy divers

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A diver performs physical exercises at the Navy Experimental Diving Unit (NEDU) in Panama City, Florida. Dr. John Florian, director of NEDU's Warfighter Human Performance Program, is conducting Office of Naval Research-sponsored work focusing on oxygen toxicity and fatigue in Navy divers. Credit: Dr. John Florian

To determine the cause of extreme fatigue in Navy divers after routine missions, the Office of Naval Research (ONR) is sponsoring work examining the most critical weapon in a diver's arsenal—oxygen itself.

The research is inspired by anecdotes from Navy divers suffering from severe exhaustion after dives. These tough individuals—among the fittest in the world—would be sluggish and weak for a day or two after a dive, even getting winded climbing flights of stairs.

"This academic work is truly groundbreaking because the observation hasn't been addressed before," said Dr. William D'Angelo, program manager of ONR's Undersea Medicine Program. "It could have major ramifications for divers, aviators and even astronauts, all of whom rely on breathing high levels of oxygen."

The research is being conducted by Dr. John Florian, director of the Warfighter Human Performance Program at the elite Navy Experimental Diving Unit (NEDU) in Panama City, Florida.

Florian believes the cause of the exhaustion lies in too much exposure to oxygen, a condition called hyperoxia. In fact, most of the divers complaining of fatigue conducted dives using 100 percent oxygen, or gas mixtures high in oxygen. Florian theorizes this increased exposure leads to a form of hyperbaric oxygen toxicity—a life-threatening byproduct of breathing too much oxygen.

Ironically, this toxicity results from divers' physiological need to breathe oxygen underwater, which can become hazardous the deeper they submerge and the longer they breathe it. Divers often breathe oxygen-rich mixtures to minimize the risk of decompression sickness and other side effects that can arise from breathing compressed air.

However, too much oxygen can lead to lung inflammation, seizures,

convulsions, nausea, dizziness and even coma or death—all symptoms of oxygen toxicity.

Florian thinks he's identified a type of oxygen toxicity that causes cardiovascular and muscular performance to temporarily deteriorate between dives. To test this theory, he's working with groups of divers at NEDU—home to an ocean simulator and experimental diving facility, a 50,000-gallon test pool and a cardiopulmonary laboratory.

Each group comprises nearly 20 Navy-qualified divers, who complete five consecutive six-hour dives with 18 hours of recovery time between them. Before and after a dive, Florian has participants perform exercises to compare performance; monitor strength, oxygen consumption and blood flow from the heart; and evaluate length of recovery times. Exercises include biceps curls, leg extensions, hand grips and treadmill runs to exhaustion.

During dives, Florian has participants breathe either compressed air, which is basically regular surface air, or a mixture of nitrogen and oxygen. In 2016, Florian will begin conducting tests using 100 percent oxygen.

"From our previous work, we've noticed greater incidents of oxygen toxicity and increased fatigue in divers breathing oxygen-heavy mixtures than in those breathing only compressed air," said Florian. "It will be interesting to see how this plays out with the current performance measures when we begin using 100 percent oxygen next year."

D'Angelo said Florian's work at NEDU offers an excellent opportunity to impact Navy practices.

"NEDU is like NASA [National Aeronautics and Space Administration] for diving and undersea medicine," he said. "Divers are being pushed to

the limits of human endurance. Dr. Florian's research has the potential to find the cause of extreme fatigue, develop ways to treat it and affect Navy diving protocols."

Florian's research aligns with the Naval S&T Strategy, which emphasizes health and resilience as key components of warfighter performance. Last year, ONR hosted a Focus Area Forum to discuss how science and technology can improve warfighter performance and resilience.

Provided by Office of Naval Research