PHYSIOLOGICAL EPISODES: UNDERSTANDING THE HUMAN SYSTEM

By Andrea Watters

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Fleet aviators have not experienced a significant physiological event (PE) in more than a year due in part to increased understanding of breathing dynamics and how to mitigate symptoms in the cockpit, according to the Navy's flight surgeon on the Physiological Episodes Action Team (PEAT).

Cmdr. Allen "Doc" Hoffman said he celebrated that milestone May 31, which is one of the PEAT's many contributions toward resolving PEs since 2017 when they became Naval Aviation's No. 1 safety priority.

In addition to technological improvements, the PEAT attributes the decline of PEs to educating and communicating directly with aviators during roadshows. Over the last two years, these roadshows have evolved from presentations in large auditoriums to briefings in less formal settings—squadron ready rooms (see article on page 28).

Focused on Navy's High-Performance Athletes

Hoffman is a residency-trained flight surgeon who is board certified in aerospace and occupational medicine. He joined the PEAT in September 2018 to help unravel the mystery behind PE

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symptoms and develop a long-term treatment plan designed to return aviators to flight status.

Hoffman chairs the Air Medical Action Team (AMAT) created by the U.S. Navy Bureau of Medicine and Surgery (BUMED) in 2017 to evaluate the human side of the equation. Comprised of more than 40 specialists, the team meets monthly to plan and analyze research studies and develop clinical practice guidelines to treat and prevent PEs.

"Treatment accessibility and quality are key successes. It's one thing to treat people once they've been injured, but it's the gold standard to prevent the injury. And that's what we've done for the last year," Hoffman said.

The AMAT's investigations have shifted the emphasis from the aircraft to the men and women who fly those aircraft.

"PEs happen to people, not to aircraft," Hoffman is quick to point out.

Renewed emphasis is on increasing stakeholder's understanding of what aircrew experience physiologically in the inherently stressful flight environment in the cockpit as well as training and equipping naval aviators as professional athletes.

"We don't train pilots how to fly the aircraft, we train pilots on how to fly their bodies. People tend to forget that the human system is the most important part of the aircraft system," said Capt. James R. Linderman, the aeromedical physiologist on the PEAT and AMAT. Linderman, who earned his Ph.D. in physiology, has brought his experience in molecular, cellular and human physiology to the effort since 2019.

"Flights are basically athletic events where you need more oxygen. Your heart's racing, you're pulling Gs; it's an athletic event and you need a constant supply of oxygen," Hoffman said.

Acknowledging the physical demands of flight, the Navy holds pilots to a higher physical and mental standard than the general Navy population, Hoffman said. To be an aviator, one must meet the general duty standards plus the specific physical and functional requirements to fly, including perfect vision and hearing. Psychological requirements include an even-keel mentality with the ability to stay in control to solve problems in an emergency.

Aviators must also "fit" into their aircraft. Depending on the platform, one may be too tall, weigh too much or have arms that are too short or too long.

"We look at all those things to make sure that the right people go into the right aircraft, and they have the right physiological margins to tolerate that abnormal work environment," Hoffman said.

A student naval aviator prepares her flight gear at Training Air Wing (TW) 4 aboard Naval Air Station (NAS) Corpus Christi, Texas, on June 23.

U.S. Navy photo by Lt. Michelle Tucker

U.S. Navy photo by MC2 Robyn B. Melvin

Aircrew Survival Equipmentman Airmen, assigned to the "Sunliners" of Strike Fighter Squadron (VFA) 81, test oxygen flow in pilot gear in a paraloft aboard aircraft carrier USS Harry S. Truman (CVN 75).

Re-Examining Hyperventilation, Breathing Dynamics

Prior to recent findings, the aeromedical community and aviators believed hypoxia—oxygen deprivation at the tissue level—and decompression sickness (DCS) were the two major threats to aviators in the tactical air cockpit, Linderman said.

"While those are two conditions to be concerned about, they may not be what we're seeing with respect to physiological events," he said.

During its investigation, the AMAT analyzed the 57 reported symptoms and narrowed them down to two categories of physiological events—pressure-related or non-pressure-related, Hoffman said.

"Once we ruled out hypoxia and decompression sickness, it took us about 14 months to identify the two types of PEs and develop treatment," he said. [The physiology and treatment of pressure-related PEs will be covered in a future issue.]

In the non-pressure related category, the AMAT discovered other contributing physiological states such as respiratory alkalosis—a decrease in blood carbon dioxide (CO2) levels called hypocapnia can lead to a rise in blood pH and create an area of regional hypoxia in the brain.

"Initially, people were saying 'the aviators are hyperventilating; they're causing their own problem,'" Hoffman said. "People associate hyperventilation with a conscious choice to breathe too fast because you are anxious or scared, but that's not the case for aviators. Just by putting on your flight gear and sitting down in the aircraft, you have decreased your respiratory ability and your body will naturally start breathing faster to compensate. It's not a conscious choice; it's an involuntary reaction to maintain your physiological margins."

In 2017, student pilots were reporting inadequate oxygen during their T-45 Goshawk flights. While investigators found no contaminants or toxins in the Onboard Oxygen Generating System (OBOGS), they did, however, find and resolve inadequate air flow caused by a 90-degree bend in the pipe.

What can happen in a low flow state is that chemoreceptors send signals to the brain triggering an unconscious response to breathe slightly faster, Linderman said. "That increase in breathing, again, not in a normal situation, could lead to a cascade of events that ultimately ends in this person getting hypocapnia."

Hypocapnia is caused by an increase in blood pH, which must remain between the very tight range of 7.35 and 7.45. Anything above that causes a structural change in the hemoglobin causing it to hang on to oxygen instead of releasing it.

"It has nothing to do with not breathing in enough oxygen. You have plenty of oxygen, you just don't release it to the tissue because your hemoglobin is 'being selfish' and holding onto it because of that high blood pH," Hoffman said.

Airflow was improved in the T-45 by adjusting the engine idle and straightening out the bend in the OBOGS pipe, an earlier effort by the PEAT.

"We haven't seen issues of low airflow in the T-45 since the [OBOGS] pipe was straightened," he said.

The lungs' ability to exchange oxygen and carbon dioxide is also affected by two of the most physically demanding aspects of flying a tactical aircraft: high altitudes and pulling Gs, Hoffman said.

Since these two situations occur above 10,000 feet cabin altitude, aviators breathe supplemental oxygen at 94 percent, which is a much higher concentration than the 21 percent oxygen and 78 percent nitrogen in ambient air, Hoffman said. Cockpit ambient air with adequate partial pressures of oxygen are found at sea level and below 10,000 feet cabin altitude.

Studies have found that one of the negative effects of breathing 94 percent oxygen is the potential for nitrogen to be washed out of the lungs which leads to atelectasis, Hoffman said. Atelectasis is the complete or partial collapse of a part of the lungs called alveoli. Nitrogen keeps the alveoli—the little sacs in the lungs that handle gas transfer—inflated. A lack of nitrogen can cause the alveoli to collapse which, in turn, increases the respiratory rate, he said.

BUMED is funding research projects exploring the effects of high levels of oxygen, how long before these effects occur and whether it is beneficial to use a lower percentage, Hoffman said.

The team has also learned more about breathing dynamics and how the position of the body affects one's breathing. For example, while performing on stage an opera singer is standing upright, chest extended, shoulders back with lowered and tightened abdominal muscles, which enables maximum respiratory capacity, Linderman said. A pilot, on the other hand, is sitting in the cockpit wearing aviation life support systems, all of which reduces their respiratory capacity. It can also cause one to unconsciously change their breathing dynamics, ultimately affecting gas exchange and cellular processes within the body, he said.

Strategic Air Breaks Proposed

To mitigate non-pressure related events, BUMED and the PEAT are introducing "strategic air breaks" or periodic breathing techniques to improve aircrew's respiratory function.

One of these breaks includes finding a time during the administrative part of a flight to drop below 10,000 feet cabin pressure, take off the mask and take deep breaths for a period of time to reintroduce nitrogen into the lungs and help re-inflate the alveoli.

"This will help mitigate, not just normal flight, but the physiological effects of pulling Gs. With the physiological margin of fully expanded lungs, the body is in a better position to handle G forces. When you pull Gs you are going to naturally have atelec-

PEAT Communicates with Fleet

The Physiological Episodes Action Team (PEAT) has been relaying its findings to aviators in the form of roadshow presentations. At first, the roadshows occurred in larger settings, but the team realized meeting with aviators in their squadron ready rooms was more effective, and the new approach seems to be resonating with aviators, according to Cmdr. Adrian "Catfish" Jope, PEAT lead.

"Initially the PE Roadshows were very much aircraft-centric without much discussion on the aeromedical front," Jope said.

As more information came out regarding the aeromedical aspects involved with PEs during the Naval Air System Command's (NAVAIR) Root Cause Corrective Action (RCCA) investigation, the team decided to shift some of its roadshow focus to address these important aeromedical findings.

"Since PEs happen to aviators and not the aircraft, we placed aeromedical professionals who were familiar with PEs at the forefront of the discussion. This enabled us to educate aircrew about the dynamics of aerospace physiology as well as what an aviator could expect should they experience a PE. Additionally, we felt that it was vital to help strengthen the relationship and restore trust and confidence between aircrew and flight surgeons, especially when it came to the subject of PEs," Jope said.

In March, the PEAT held its first round of what Jope refers to as the "PE TED Talk" at ready rooms across the Naval Air Station (NAS) Oceana, Virginia, flight line.

"Utilizing the same tools that aviators use on a daily basis to conduct flight briefs and debriefs, namely a whiteboard and dry erase markers, the team was able to communicate with aircrew in a way that is familiar to them," he said.

During the discussions, the PEAT shares in depth information about the aircraft systems often associated with PEs, specifically the Environmental Control System (ECS) and the On-Board Oxygen Generating System (OBOGS) and how they function in a normal and degraded fashion. Additionally, the

U.S. Navy photo

Flight Surgeon Cmdr. Allen "Doc" Hoffman discusses the aeromedical impacts of flight on human physiology with the "Cougars" of Electronic Attack Squadron (VAQ) 139 during a Physiological Episodes Action Team roadshow at NAS Whidbey Island, Wash., in October 2019.

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tasis; you can't mitigate the effect from centrifugal force. However, if your lungs are at 100-percent capacity when you start, you're going to be able to handle it much better," Hoffman said.

Strategic air breaks and more information on breathing dynamics will be introduced in a new section in the Naval Air Training and Operating Procedures Standardization (NATOPS) General Flight and Operating Instructions Manual CNAF M-3710.7, Hoffman said. The updated instruction is expected to be finalized in August.

"While aviators have been trained in this all along, what we've found is that they haven't been trained extensively enough. We believe educating the pilots and the medical professionals is so significant that we've rewritten the entire physiology chapter in CNAF 3710. It is about twice the size of the original, and once published, it will do a great job in educating new aviators and re-educating veteran aviators on exactly what their bodies are experiencing in flight," Hoffman said.

Armed with this knowledge, aviators will become more aware of symptoms, correlate those symptoms to what happened in the cockpit and know how to mitigate them, Hoffman said.

Andrea Watters is editor in chief of Naval Aviation News.

PEAT's flight surgeon systematically breaks down human physiology as it relates to the harsh aerospace environment, but at a level that everyone can easily understand.

"By doing this, we have been able to take a lot of the mystery out of PEs and dispel many misconceptions or concerns that aircrew have coming into the conversations," Jope said.

Positive Feedback

"I initially was skeptical about how the Navy was handling PEs, mostly because of 'word of mouth' and other aircrew's experiences. I was fortunate enough to sit through a PEAT roadshow in March which changed my mind completely," said Cmdr. Anthony "YoYo" Scigliano, Strike Fighter Wing Atlantic (SFWL) Safety Officer. "After the PEAT's roadshow, I went around talking to aircrew to get their perspectives. Everyone I talked to had the same view I did and came out much more informed."

Lt. Cmdr. Kyle "Mooch" Jones, Safety Department Head with Strike Fighter Squadron (VFA) 106 at NAS Oceana, had a similar reaction.

"That roadshow was great because everyone was there, from the admiral down, and it was an honest assessment of what we, as a Navy, knew to that point. That type of delivery plays well with aviators and I think that helped change some perspectives," Jones said.

The PEAT plans to continue its PE roadshows once COVID-19 travel and social distancing restrictions are lifted.

Changing the Culture

Part of the challenge in mitigating PEs is the reluctance of aircrew to talk to the doctors because of their apprehension of being placed in a down status or "grounded," Jope said.

"While it's not necessarily right, it's a cultural thing. Many aviators have Type A personalities, and, like athletes, they want to be involved in the game. If they're on the sidelines, they feel like they're not helping the team.

"To begin to change the culture, the new message has to be 'if you're not playing at 100 percent, you're not only hurting yourself, but the entire team,'" Jope said. "This goes beyond feeling sick, too. Similar to athletes, aviators need to make sure that they are getting the proper nourishment, exercise and rest to keep themselves in top condition to take on the harsh and sometimes unforgiving environment in which they work. If they don't, they are risking injury, or if already playing hurt, they risk making the injury worse and possibly finding themselves out of the 'game' for weeks or even months."

There have been multiple PE reports over the past few years that could have been prevented had aviators taken an honest assessment of their overall fitness for flight prior to stepping into the cockpit, Jope said.

The Naval Aviation Enterprise is encouraging aviators to take themselves off the flight schedule if they're not up to it, and that is happening more frequently at SFWL.

"I think that aircrew feel comfortable enough to take themselves off the flight schedule if they aren't feeling up to snuff. They will get respect for owning up to the fact that they don't want to put others at risk," Scigliano said. —*Andrea Watters*

U.S. Navy photo

Lt. Cmdr. Kyle "Mooch" Jones, Safety Department Head with Strike Fighter Squadron (VFA) 106, prepares for a flight in an F/A-18F Super Hornet.