



© Chris Sorensen Photography

# Dry *and* High

**Dehydration causes an insidious degradation of pilot performance that must not be lightly regarded.**

BY LINDA WERFELMAN

**E**xcessive loss of water from the human body can lead to dehydration, marked by fatigue and a deterioration of mental and physical performance that can have serious consequences for pilots.

Pilots with health problems, including intestinal viruses or food poisoning, and pilots of small airplanes and helicopters without air conditioning and/or with large, heat-intensifying

windshields — especially those operating on hot days — may be most susceptible to the ill effects of dehydration. However, pilots of air carrier aircraft are not immune.

For example, the first officer of a Boeing 737-700 said, in a report submitted to the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS), that she had become ill in July

2004 during a flight from Nashville, Tennessee, U.S.<sup>1</sup>

In her report, the first officer said that the night before the flight, she had been sick with nausea, vomiting and diarrhea, which she assumed to be associated with food poisoning, but that she felt “physically fit to fly” when she reported for duty. During cruise, she experienced repeated bouts of nausea and complied with the captain’s eventual instructions to leave the cockpit to rest in the cabin while he diverted the airplane to an en route airport for landing. Emergency medical services personnel met the airplane, examined the first officer and determined that her nausea was not a sign of serious illness and her lingering weakness was caused by dehydration.

Dehydration occurs when water consumption is inadequate or when the human body loses an excessive amount of water — through heavy perspiration, exposure to hot weather, fever, vomiting or diarrhea, use of diuretics to increase urine excretion, and some diseases. The low humidity in pressurized air carrier aircraft also is a contributing factor. In addition, alcoholic beverages — such as those consumed a day before a flight — and caffeine have diuretic effects.

Water accounts for about two-thirds of body weight and is an essential component of the human body, needed for replicating cells, moving nutrients and waste products, and regulating body temperature. The kidneys excrete between 1.0 pt (0.5 L) and several gallons (1.0 gal equals 3.8 L) daily — a typical amount is 3.0 to 4.0 pt (1.4 to 1.9 L); in addition, varying amounts of water are lost to perspiration.

To stay healthy, an individual must consume enough water to offset these losses. For years, typical recommendations have called for drinking 2.0 qt (1.9 L) of water daily, although some medical specialists question the rationale for that recommendation (see “Recommendations for Preventing Dehydration”).

An editorial in the April 2008 *Journal of the American Society of Nephrology* said that the origin of the recommendation is unknown but that different studies have made a variety of claims about the supposed benefits of drinking water,

ranging from improving kidney function and aiding weight loss to preventing headache.<sup>2</sup>

“There is no clear evidence of benefit from drinking increased amounts of water,” the editorial said. “We concede there is also no clear evidence of lack of benefit. In fact, there is simply a lack of evidence in general.”

Nevertheless, aeromedical specialists say that failing to drink an adequate amount of water can result in an increased susceptibility to fatigue.

For example, the U.S. National Transportation Safety Board (NTSB) discussed dehydration and fatigue in its final report on the crash of a Bell 206B during a sightseeing flight on the Hawaiian island of Kauai on Sept. 24, 2004. The pilot and all four passengers were killed in the crash, which also destroyed the helicopter. The NTSB report said that the operator’s schedule included no breaks for pilots, who typically ate lunch in their helicopters and remained at the controls for up to eight hours, and that the staging area had no restroom facilities.<sup>3</sup>

“The lack of scheduled breaks, the short turnaround times between flights and the unavailability of private restroom facilities probably discouraged consumption of food and liquids during the workday because there was little

## Recommendations for Preventing Dehydration

The following are recommendations for preventing dehydration and other heat-related problems:<sup>1</sup>

- Drink about 2.0 qt (1.9 L) of water every 24 hours, although the exact amount varies widely. Drink before you become thirsty, and drink from a container that allows you to measure daily water consumption;
- Limit consumption of alcohol and caffeine. Both are diuretics, which increase the excretion of urine;
- Monitor work and recreational activities, and stop what you are doing if you feel light-headed or dizzy. Exercise can result in water loss that is difficult to overcome quickly;
- Be aware of your physical condition, especially if you have recently been ill; and,
- Remember that your body’s adjustment to a major change in weather, such as the sudden onset of hot weather, can take one to two weeks.

— LW

### Reference

1. Shaw, Rogers V. III. “Dehydration and the Pilot.” *The Federal Air Surgeon’s Medical Bulletin* (Spring 2000): 10.

opportunity to go to the bathroom,” the report said. “This increased the risk of dehydration and other physiological problems, which could have degraded performance.”

As a result of its investigation, the NTSB issued nine safety recommendations, including two involving development and enforcement of operational practices to provide for rest breaks for the pilots of sightseeing helicopters.

Quay Snyder, president and CEO of Virtual Flight Surgeons, an aeromedical consulting group, said that dehydration is “a definite contributing factor” not only to fatigue but also to the formation of kidney stones — stonelike masses that form in the urinary tract and can cause severe pain. Medical specialists attribute their formation to a concentration of mineral salts in the urine or to the absence from the urine of substances that inhibit formation of the stones.

Although smaller kidney stones may be asymptomatic, larger ones can cause abdominal pain, nausea and vomiting, fever and blood in the urine. Recurrent kidney stones can result in loss of medical certification.

Formation of kidney stones generally can be prevented simply by drinking enough water, Snyder said.

He said that some flight crewmembers might have intentionally reduced their fluid intake since the terrorist attacks of Sept. 11, 2001 — and the subsequent adoption of an elaborate set

of requirements for pilots who leave the flight deck, even for a visit to a lavatory.

“It’s a bad idea for health reasons,” Snyder said, noting “at least a perception” that more pilots have been calling his office about kidney stones in recent years than in the period before September 2001. “But it’s perhaps a convenient idea for the flight crew.”

Snyder and other aeromedical specialists recommend that pilots drink fluids — but not caffeinated fluids — “on a regular basis” throughout their flights. Although some specify a precise amount of liquid that should be consumed, Snyder does not. Instead, he says that it should be enough to keep their urine clear and light in color. Sometimes the amount may be less than 2 qt; other times it may be more.

“I believe in what I’m saying,” Snyder said. “As a glider pilot, I consume 170 to 200 oz [5 to 6 L].”

Similar quantities are not necessary for air carrier pilots, who do not operate in the hot, sunny environments typical of gliders, he said.

Similar advice comes from Rogers V. Shaw III, team coordinator of the Airman Education Program of the U.S. Federal Aviation Administration Civil Aerospace Medical Institute Aerospace Medical Education Division, who said that a primary consideration is for pilots to continually be aware of their physical condition.<sup>4</sup>

“Most folks will become thirsty with a 1.5-quart [1.4-liter] deficit, or a loss of 2 percent of total body weight,” Shaw said. “This level of dehydration triggers the thirst mechanism. The problem, though, is that the thirst mechanism arrives too late and is turned off too easily. A small amount of fluid in the mouth will turn this mechanism off, and the replacement of needed body fluid [will be] delayed.”

Medical authorities say that symptoms accumulate as the body continues to lose water (Table 1). After a deficit of about 3.0 qt (2.8 L), symptoms may include fatigue, nausea and emotional instability.

Transport Canada (TC) calls this “a very dangerous level for pilots, as this is where your faculties start to become affected, but you may not be aware of the deteriorated performance.”

### Symptoms of Dehydration

Amount of Water Lost	Symptoms
1.5 L (1.6 qt)	Thirst
3.0 L (3.2 qt)	Sluggishness, fatigue, nausea, emotional instability
4.0 L (4.2 qt)	Clumsiness, headache, elevated body temperature, elevated pulse, elevated respiratory rate
5.0 L (5.3 qt)	Dizziness, slurred speech, weakness, confusion
6.0 L (6.3 qt)	Delirium, swollen tongue, circulatory problems, decreased blood volume, kidney failure
9.0 L (9.5 qt)	Inability to swallow, painful urination, cracked skin
12.0 L (12.7 qt)	Imminent death

Source: Maidment, Graeme. “Chapter 15: Thermal Physiology,” In *Aviation Medicine*, Third Edition, edited by Ernsting, John; Nicholson, Anthony N.; Rainford, David J. Oxford, England: Butterworth Heinemann, 1999.

Table 1

One TC publication described experiments involving U.S. Army helicopter pilots and said that the pilots' self-reporting of problems related to dehydration was inaccurate, even at the early stages of dehydration, and pilots who felt no adverse effects had "clear, objective difficulty with cognitive tests."<sup>5</sup>

A 4.0-qt (3.8-L) deficit can result in clumsiness, headache and elevated temperature. After loss of a little more than 12.7 qt (12.0 L), death is imminent.<sup>6</sup>

### Water vs. Sports Drinks

Under normal circumstances, medical authorities suggest that water is usually the best drink for a pilot to consume, although there is a place for rehydration drinks, including so-called sports drinks, that have been formulated not only to replenish lost fluids but also to restore the proper concentration of electrolytes — dissolved minerals such as sodium and potassium — in the blood. The electrolytes are electrically charged molecules that are key to many essential bodily functions.

"I don't believe there is any harm in sports drinks, et cetera, as long as individuals don't drink excessive quantities, but they are of little additional benefit for a pilot who has a normal, balanced diet," said Dr. Anthony Evans, chief of the International Civil Aviation Organization Aviation Medicine Section.

Rehydration drinks may be required if pilots undergo significant or prolonged heat stress, he said.

### Heat-Related Illnesses

In some situations, such as prolonged exposure to very hot temperatures in a cockpit that is not air conditioned, dehydration can progress to a heat-related illness, such as heat cramps — characterized by muscle cramps, profuse sweating, fatigue and thirst.<sup>7,8</sup> Treatment typically includes drinking a sports drink or other fluid containing electrolytes and moving to a cooler spot.

Without such treatment, heat cramps can develop into heat exhaustion, with symptoms

including headache, dizziness, nausea and dark urine. Without treatment — again, drinking a fluid containing electrolytes and moving to a cooler spot — the result can be heatstroke, a life-threatening condition in which the body temperature climbs to 104 degrees F (40 degrees C) or higher. Heatstroke can lead to shock or organ damage.

Treatment for heatstroke is more aggressive than treatment for less serious forms of heat-related illness and may include immersion in cold water or wrapping the victim in a cooling blanket and placing ice packs at the neck and other areas of the body. The goal is to quickly reduce the body temperature to normal in order to limit damage to the brain and other vital organs. ●

### Notes

1. NASA ASRS. Report no. 624470. July 2004.
2. Negoianu, Dan; Goldfarb, Stanley. "Editorial: Just Add Water." *Journal of the American Society of Nephrology* Volume 19 (2008). <[www.asn-online.org/press/pdf/2008-Media/Water%20Study.pdf](http://www.asn-online.org/press/pdf/2008-Media/Water%20Study.pdf)>.
3. NTSB. *Weather Encounter and Subsequent Collision Into Terrain, Bali Hai Helicopter Tours Inc. Bell 206B, N116849, Kalaheo, Hawaii. Sept. 24, 2004*. The NTSB said that the probable cause of the accident was "the pilot's decision to continue flight under visual flight rules into an area of turbulent, reduced-visibility weather conditions, which resulted in the pilot's spatial disorientation and loss of control of the helicopter." Among the contributing factors was "the operator's pilot-scheduling practices that likely had an adverse impact on pilot decision making and performance."
4. Shaw, Rogers V. III. *Dehydration and the Pilot*. <[www.faa.gov/pilots/training/airman\\_education/topics\\_of\\_interest/dehydration/index.cfm](http://www.faa.gov/pilots/training/airman_education/topics_of_interest/dehydration/index.cfm)>.
5. TC. "I Need a Drink." *Aviation Safety Vortex*, March 2002.
6. Maidment, Graeme. Chapter 15, "Thermal Physiology." In *Aviation Medicine*, Third Edition, edited by Ernsting, John; Nicholson, Anthony N.; Rainford, David J. Oxford, England: Butterworth Heinemann, 1999.
7. Shaw.
8. Mayo Clinic. *Heatstroke*. <[www.mayoclinic.com/health/heat-stroke/DS01025/DSECTION=3](http://www.mayoclinic.com/health/heat-stroke/DS01025/DSECTION=3)>.