SOARING SAFETY FOUNDATION

THE MEDICAL ASPECTS OF SOARING

The Soaring Safety Foundation continues its drive to reduce accidents and incidents in soaring by presenting information that could help you avoid being involved in an accident. This quarter's presentation deals with several medical aspects directly related to soaring, and is aligned with the FAA'S "Back to Basics" program.

There are several areas of medical aspects that affect soaring:

1. The pilot's overall medical and mental condition.
2. Medications, "over the counter" drugs, and illegal drugs.
3. Liquids and electrolyte balance, including effects of alcohol.
4. High altitude physiology.

As you may have noticed in other parts of *Soaring*, this is the 50th year of publishing. Over the years, several very good articles on medical aspects have appeared in *Soaring* magazine, and excerpts will be made from some of them. (For complete articles, see the reference list at the end of the article.)

OVERALL MEDICAL AND MENTAL CONDITION

We have spoken over the years about the "general medical, physical, and mental condition" of the pilot and how this affects his flying. We have known, for instance, that to remain alert during a Diamond Distance flight or a contest flight, one must be in good physical condition. We also know that when there have been major changes in our life, that we may not be capable of concentrating on the task at hand, thus making it difficult to fly safely. We will discuss Stress in another article, but for now, to quote from "THE JOY OF SOARING" (Ref. 1), "applicants for glider pilot licenses are spared the expense of a physical examination and must only certify that they have no known defect that would render them unsafe to fly a glider. This policy puts the responsibility squarely on the pilot to be certain he meets the requirement. If there is the slightest doubt in his mind in this regard, the best procedure is to be examined by an FAA designated medical examiner who has special training and experience in the field of aviation medicine.

"Any ailment that might cause a person to be suddenly incapacitated is sufficient reason not to be a pilot. Examples are epilepsy, serious heart troubles, and some diabetic conditions; there are doubtless many others. Some temporarily disqualifying ailments are peptic ulcers, anemia, and acute infections.

"There are causes other than serious disease that affect a pilot's ability to fly, to exercise good judgment, and, as a student, to absorb instruction. One of these is the common cold. In addition to hampering the efficiency of the pilot, there is the danger of middle ear pain and of spreading the infection into the sinuses. Anything like a bad cold should ground a pilot until the symptoms abate.

"Habit-forming and hallucinogenic drugs and alcohol are out for pilots. So is flying when suffering from hangover, even when the worst effects of it are masked by aspirin or other medication.

"The scuba diver is well aware of the danger of the bends. He may not realize, however, that soaring soon after a dive can create a secondary hazard of the bends if the blood has not yet had time to normalize fully. The 'diving pilot' should be aware of the possibility, and at the first sign of discomfort should descend to a more comfortable altitude.

"Fatigue makes a poor student and a poor pilot. It is a waste of time and money to try to fly when just plain tired out. Fatigue is also an in-flight problem. Power pilots usually run out of gas before they run out of pep, but glider pilots don't run out of gas. *(Except motorgliders.*—ED.) A cross-country often lasts eight or ten hours, and at the end, when judgment is most needed, an exhausted pilot may be trying to decide where to land. He should be ultra-conservative in his planning and flying at such a time, knowing that neither his reflexes nor his judgment are as good as they were earlier.

"Because of the glider pilot's continuous need to think clearly and make decisions, it is wise to follow the example of the Air Force and breathe supplementary oxygen when above 10,000 feet MSL.

"Airsickness is not too frequent among pilots because the control a pilot exerts over the glider eliminates the feeling of helplessness that is so much a part of motion sickness. The pilot is in charge, and that makes all the difference. Some people with a tendency toward airsickness get over it after a few flights as they become more at home in the air. Alas, a few do not, and lose interest in soaring; others of weak stomach but stronger determination continue soaring but carry an airsickness bag. These are the authentic heroes of the sport.

"The brilliant light encountered when flying soon converts most pilots to the wearing of sunglasses. In soaring, the polarizing type is especially valuable. With these glasses, when the head is tilted to the proper angle there is a pronounced darkening of the blue of the sky. Against this background, other gliders stand out more sharply, an obvious safety factor. The first appearance of wispy new cumulus cloud can be spotted earlier with polarizing glasses than with the naked eye. Some competition pilots claim that under certain conditions they can detect the presence of a thermal. These are all good things, but the prime reason for wearing sunglasses is still the protection they provide for the eyes, as attested by most aeromedical specialists."

HIGH ALTITUDE PHYSIOLOGY

Searching for the elusive Altitude Diamond creates several medical problems; hypoxia, hyperventilation, cold and fatigue. The following article appeared in *Soaring* ten years ago, and is just as valid today. (Ref. 2)

"How many times have you heard someone say they flew above 12,500 feet without oxygen, or 'the thermal or wave lift was so good I climbed to 15,000 feet without oxygen before starting my glide'? Each time a pilot does this he is asking for trouble. Hypoxia is generally recognized to be the single greatest hazard to the aviator. For example, some 75 hypoxic fatali-

ties occurred in Europe during World War II at altitudes between 17,000 and 31,000 feet. Twenty-seven (one third) of these fatalities occurred within 10 minutes of loss of oxygen. Two deaths occurred at altitudes between 17,000 and 20,000 feet, altitudes which are not too uncommon for glider pilots.

"In general terms, hypoxia can be defined as an oxygen deficiency in the body tissues sufficient to cause such functional impairment as poor judgment, euphoria, mental confusion, and loss of consciousness. For the purpose of discussion hypoxia will be divided into three major phases of breathing—ventilation, transportation and utilization.

VENTILATION

"The ventilation phase of respiration refers to back and forth movement of outside air into the small air sac of the lung where exchange of vital gases occurs. This phase is of particular importance to the glider pilot because an oxygen deficit in the inhaled air will mean an oxygen deficit in the pilot. This form of hypoxia is know as altitude *(hypoxic)* hypoxia.

TRANSPORTATION

"Assuming an adequate amount of oxygen is inhaled, the next phase necessitates transporting it to the tissues where it will be used. The oxygen molecule is picked up by the hemoglobin molecule in the red blood cell as it passes adjacent to the air sac in the lung. The hemoglobin molecule then carries the oxygen to the tissues where it is needed and releases it.

"Any condition which alters the hemoglobin adversely affects this phase of respiration. Acute blood loss or chronic anemia both decrease the amount of hemoglobin available to transport oxygen and hence lead to hypoxia. Toxins, particularly carbon monoxide either from smoking cigarettes or breathing exhaust fumes, inhibit the normal binding of oxygen to hemoglobin. This form of hypoxia is termed anemic *(hypemic)* hypoxia.

"A second form of transportation hypoxia is termed *stagnant* hypoxia. This refers to either a localized or generalized decrease in blood flow seen with excessive g-forces, heart failure, shock, or exposure to temperature extremes.

UTILIZATION

"The utilization phase of respiration refers to the ability of the cell to use the oxygen it receives. Certain compounds cause the cell to malfunction so it cannot utilize the oxygen delivered to it. This is termed tissue-poisoning *(histotoxic)* hypoxia. Alcohol,

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drugs, cyanide, and carbon monoxide have their effect here. The latter may be of potential importance with motorgliders.

ALTITUDE HYPOXIA

"As mentioned earlier, this form of hypoxia is the most important one to glider pilots. It generally happens by ascending to altitude (relative to the individual) without oxygen, or by equipment malfunction.

"At sea level with an atmospheric pressure of 760 millimeters of mercury (mm Hg) we breathe 21 percent oxygen and 78 percent nitrogen. As we ascend in altitude from sea level, the gaseous distribution of nitrogen and oxygen maintains the same percentages, but the atmospheric partial pressure of each decreases with increasing altitude. For example, at 10,000 feet MSL, the atmospheric pressure is 523mm Hg, air sac oxygen is 62mm Hg—considered hypoxic—and supplemental oxygen is required.

"Similarly, at 15,000 feet MSL, the atmospheric pressure is 429mm Hg, air sac oxygen is 45 mm Hg, hemoglobin saturation is 80 percent and arterial oxygen 44 mm Hg—enough said.

SYMPTOMS OF HYPOXIA

"There is individual variation in time of onset and character of hypoxia symptoms, but within an individual these are generally the same. Night vision is usually the first thing to go and may be affected as low as 5,000 feet MSL. This is followed by air hunger, anxiety, headache, nausea, dizziness, fatigue, blurred vision, slow thinking, impaired judgment, tunnel vision, blue discoloration of the skin and nail beds *(cyanosis)* followed by mental confusion, loss of consciousness and death.

"It should be noted that some symptoms of hypoxia are very similar to and difficult to distinguish from hyperventilation. This will be discussed in more detail later.

PREVENTION OF ALTITUDE HYPOXIA

"Adding supplemental oxygen as altitude increases will prevent altitude hypoxia (see Table 1). It is important to maintain air sac oxygen at 60 to 100mm Hg and consequently maintain hemoglobin saturation at 87.98 percent. Given these parameters we can now look at the theoretical altitude ranges of various oxygen systems.

TABLE 1

Altitude	Barometric Pressure mm Hg	Total inspired Oxygen Requirement (%0)
Sea level	760	21
5,000	632	25
10,000	532	31
15,000	429	40
20,000	329	49
25,000	282	62
30,000	225	81
34,000	187	100

"With the A-8 continuous flow oxygen system on 100 percent oxygen, theoretically one can go to 40,000 feet and be at the equivalent of 10,000 feet or 87 percent hemoglobin saturation. That's theory. In actual practice, considering mask leaks, activity and anxiety vs. total rest. etc., this system should not be used above 30,000 feet. In view of the practical experience in military aviation, an altitude ceiling of 25,000 feet has been established for this type of equipment. The diluter demand pressure breathing oxygen regulator operates to 30,000 feet by supplying the exact amount of oxygen needed to supplement the ambient air. At 30,000 feet, 100 per cent oxygen is delivered. Beyond 30,000 feet, inboard mask leakage is eliminated by the addition of oxygen at approximately 4cm H_2O pressure. With the specially designed mask, this provides a tight seal with minimum leakage. At 40,000 feet, additional pressure is added in excess of the ambient pressure. By means of a series of physiologic principles this positive pressure breathing maintains normal air sac oxygen par-

tial pressures to approximately 45,000 feet.

"However, pressure breathing is the reverse of our normal ventilation cycle. Normally, we actively inhale and passively exhale. With pressure breathing, inhalation is passive and under pressure, while exhalation is active and also against pressure. It is very tiring! The best technique is to keep some positive (outward) pressure on during inspiration (slows rate of inspiration), pause, then slowly exhale. This pattern of smooth rhythmic breathing should prevent one from hyperventilating when pressure breathing.

"The above are theoretical and practical applications of commonly used commercially available oxygen systems. It is important to note that any system may fail and therefor a backup system must be immediately available. Notice the time of useful consciousness (TUC), or effective-performance time (EPT) as shown in Table 2. These values give you some idea how rapidly things occur at high altitude and how little time there is to correct any malfunction.

TABLE 2

Altitude (feet)	Time of Useful Consciousness
18,000	20-30 minutes
22,000	10 minutes
25,000	3-5 minutes
28,000	2.5-3 minutes
30,000	1-2 minutes
35,000	30-60 seconds
40,000	15-20 seconds
43,000	9-12 seconds

HYPERVENTILATION

"Hyperventilation is an abnormal increase in the rate of ventilation. As a result of the increased rate, carbon dioxide is blown off which in turn makes the blood more alkaline. The alkalosis in turn has a number of effects including muscle spasms; numbness and tingling (particularly around the mouth and hands); decreased blood flow to the brain leading to dizziness and lightheadedness; and unconsciousness.

"Soaring pilots are most likely to hyperventilate while flying under stress or at high altitude. Since there is an overlap of symptoms between hypoxia and hyperventilation it may be difficult to tell which is occurring. Should any of the symptoms occur, switch immediately to 100 percent oxygen and at the same time consciously slow the respiratory rate to 12 to 16 times per minute (do not hold the breath); with the former, hypoxia has been treated (unless altitude is above 30,000 feet), and with the latter, hyperventilation has been treated. As soon as symptoms decrease, oxygen should be switched back to its appropriate setting. If symptoms recur, it was hypoxia; if not, hyperventilation.

"The soaring pilot should be prepared and keep equipment up-to-date and in good repair. Before making a high-altitude flight, the following mnemonics **are** useful as check lists:

Drugs
Exhaustion
Alcohol
Tobacco
Hypoglycemia

Pressure--(1800-2000 PSI)
Regulator
Indicator—blinker
Connection—mask, radio
Emergency—bailout bottle

"There are several locations where a pilot and crew can take the FAA physiological training. Inquiries to:
Dept. of Transportation
Federal Aviation Administration
Aeronautical Center
Civil Aeromedical Institute
Physiologic Operations and Training Section AAC-143
P. O. Box 25082
Oklahoma City, Oklahoma 73125

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To add some further observances regarding hypoxia, the bad thing is that the symptoms are very insidious and observable symptoms may not be obvious until too late. There may be a sense of "well being", that everything is going "just great", maybe even euphoria, which leads the pilot to not act on such things as sloppy flying, confused thinking, or unusual fatigue.

There are lots of other references for information on high altitude flight and oxygen use, including the American Soaring Handbook, Chapters 6 and 7.

We have also received a forceful warning—from the soaring pilot involved—concerning the use of the hospital-type mask (which is sold for flying use) with the plastic rebreather bag through which the incoming oxygen passes to the bottom of the mask. The mask stays flexible in the extreme cold, but the bag becomes stiff and brittle, and in this condition can pull off unnoticed from the bottom of the mask, leaving the pilot without any supply whatever. In the instance referred to, the pilot lost consciousness above 25,000 feet and finally came to and regained control at 10,00 feet. Ever since, he's has been quick to persuade his friends not to use this "Mickey Mouse" rig, and the Safety Foundation would like to do the same.

Here are some other suggestions from soaring pilots who have been up there:

1. Catalytic heaters may cause burns if placed to close to the skin and in such a way that they cannot be relocated or removed later on.

2. The breather valve in a mask may freeze and have to be cleared. Were a pair of thin gloves under your mittens so your hands won't stick to the bare metal when attending to such tasks.

3. When descending, remember to equalize the pressure to the middle ear by inhaling, holding your nose, and—with mouth closed—gently pushing air through the eustachian tubes to equalize pressure. But gently, as damage can be done by forcing to hard.

4. Skin divers should never attempt any flight to altitude within 48 hours after exposure to heavy underwater pressure. (Ref. 3)

A PRESCRIPTION FOR DISASTER

What about medications and drugs? Are "cold capsules" dangerous if taken when we plan to fly?

"A chain is no stronger than its weakest link" is a saying familiar to all of us. This axiom applies to many aspects of life, including flight. To avoid being the weak link that causes disaster, the pilot should include himself in his preflight planning. He should get plenty of rest prior to flight and never fly when he is ill.

There are many slightly incapacitated pilots who continue to fly, using their home remedies and over-the-counter drugs. Some people have taken medicine for a long time, sometimes so casually that they don't even realize that they are being affected by it. Drugs, as well as the conditions for which they are taken, can interfere with perception, understanding, emotion, or performance.

Here are some of the common types of medicines:

Aspirin: Two aspirin tablets may be taken safely by pilots who have used them before without ill effects. Other pain medicine and mixtures should be shunned since they often cause sleepiness, depression and nausea.

Decongestants: Nasal decongestants are useful in clearing a nose, ear, or sinus. The sprays or drops may be used safely in moderate amounts. Excess use may cause increased heart rate, nervousness, or visual disturbance.

Antihistamines: Common cold remedies often contain both antihistamines and decongestants. These frequently cause sleepiness and impairment of both mental and physical activity. Pi-

lots should not take the short-term antihistamines for at least eight hours before flight—the long lasting ones should not be taken for at least 16 hours before flight. Many have the admonition on the container to not operate machineray after taking the drug, and gliders surely are machinery!

Antispasmodics: Often used for ulcer treatment and other abdominal cramping pains, these medicines cause blurred vision and dilated pupils. Since these medicines are usually combined with barbiturates and other sedatives, the combination may also cause drowsiness.

Tranquilizers: Over 80 million tranquilizer prescriptions are written each year, so I'm sure a few pilots are occasional users. Most of these preparations are mildly sedative, but they all have a measurable effect on alertness, efficiency, and overall performance. They should not be used within 24 hours of a flight.

Stimulants: A few cups of coffee can be safely used as a stimulant, but the pep pills and appetite-control medications should not be used while flying. These medications cause a feeling of euphoria, an exaggerated sense of well-being which impairs judgment and causes reckless actions. Psychotic reactions have occurred with large doses.

Blood Pressure Medication: If high blood pressure is a problem, it is wiser to control it with weight reduction and physical fitness rather than with pills. Medicine that reduces blood pressure often makes a person sensitive to G forces, unexpected fainting, nasal congestion and mental confusion.

"The above groups are only a small sampling of drug types. In general, drugs and flying do not mix. In every case, get the advice of your Aviation Medical Examiner or Flight Surgeon before using prescription drugs or home remedies before flying." (Ref. 4).

MARIJUANA AND FLYING

While on the subject of drugs, what about the effects of marijuana? Two studies showed some interesting (and shocking!) results (Ref. 5).

"Not much has been written about the effects of marijuana on a pilot's flying ability. Because of the FAR's on alcohol and barbiturate use we see their use as dangerous. But what of the effects of marijuana? The purpose of the study was to observe power pilots under the influence of marijuana while operating an instrument flight simulator. The tasks were those typically assigned while flying in a holding pattern and in many respects comparable to thermaling. However, the tasks were considerably less difficult than in actual flying. All of the tasks required psychomotor coordination, as well as such cognitive abilities as short-term memory, concentration and orientation in time and in three-dimensional space.

The pilots in the study considered themselves, at most, moderate users of marijuana. That is to say, if they used the drug three or more times a week, they considered themselves moderate users, for the "social high". Their performance was measured at 30-minute intervals, covering a six hour period. Under the influence, all pilots had significant errors in performance after 30 minutes. A decrease in ability lasted at least two hours and the performance of all pilots returned essentially to baseline levels in four hours.

The study's findings were that marijuana affects short term memory, sense of time, and also caused alterations in concentration and attendant behavior. What happened is that pilots would forget where they were within a given sequence or how long they were performing the task. The pilot subjects also tended to concentrate on one variable to the exclusion of another, and as a result they over-controlled in an attempt to compensate

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for variables previously ignored. At times this led to a complete disorientation which resulted in grossly unpredictable flight performances.

On an average, pilots made two and a half times as many gross errors and four times as many minor errors. A major error was one that took the airplane out of its designated air space with potentially dire consequences such as stall, making gross altitude or navigational deviations greater than (plus or minus) 100 ft. or heading deviations of (plus or minus) 39 degrees.

Although the gross detrimental effects of marijuana appear to last for less than four hours, more subtle effects may persist for longer periods of time and are not measurable at this time, using existing research instrumentation.

"We know of the detrimental effects of barbiturates and alcohol, and FAR's prohibit their use for at least eight hours before flying. It would appear from the documented effects of marijuana on simulated flying ability that such a prohibition should also apply for marijuana."

ANOTHER TEST: A group of ten volunteer pilots, all experienced, and all admitted marijuana smokers, agreed to be tested in a simple task in a relatively simple airplane. They were to use a 172 Cessna simulator, take off, climb to 700 AGL, fly a traffic pattern, and land. Their performance was to be tested and recorded before being given a 19 mg. dose of THC (the active ingredient in marijuana), which is (in the words of the National Institute of Drug Abuse) probably about the equivalent of a strong social dose. They were tested again one hour after the dose, three hours after the dose, and 24 hours later. They all agreed to not smoke marijuana or use any other drugs during the experiment.

On the day of the test, each pilot was given two practice flights to get used to the simulator, and one recorded flight to establish a baseline. Then each was administered the THC, and flew the first flight one hour later, and the three-hour later flight. They returned the next day, took two more practice flights and flew the recorded 24 hour later flight.

During questioning prior to the flight, the pilots had no feeling of being high, more anxious, or more happy, but felt quite normal.

Aha! The problem surfaces!

On the original baseline flight, the average distance from centerline on landing was 12 feet, increasing to 32 feet one hour after the THC, with no report of the three hour result. However, 24 hours later, the average was 24 feet, or double the baseline! One pilot missed the runway entirely.

The pilots had difficulty lining up, judging height, and landing precisely as much as 24 hours after the dosage described. The results of these two tests should be evidence enough to avoid marijuana . . . and other drugs as well, when planning on going flying.

WHAT ABOUT LIQUIDS?

Most of us have heard about dehydration and the effects it can have on our judgment. We have read about highly experienced pilots having an accident and later heard that dehydration had played a large role in that accident.

There's more to it than just drinking water, however. One must consider those things which may cause dehydration, such as too much caffeine, or even our favorite, beer. We've been reminded again and again not to fly within 8 hours of any alcohol consumption, but dehydration was not given as one of the reasons. It is there, however, so add it to the list.

Other things, such as salt and other chemicals play an important part in our body's balance. (Ref. 6)

It has only recently become clear that gliding causes considerable

changes in the water and salt balance in humans.

In a study carried out during the Dutch championships in 1981, substantial reductions in body weight (3 to 5 kg!) were observed after a flight, accompanied by a simultaneous drop in the specific weight of the urine and changes in the urine pH. Significant differences could also be demonstrated between a group of flyers who took in fluid during the fight and those who drank nothing.

An explanation for this fact lies in what is termed the Henry-Gauer effect. Because of the semi-recumbent position adopted in modern gliders, a center-wards shift in blood volume takes place. In particular, this stimulates tonus and the production of the antidiuretic hormone and aldosterone at brain stem level and in the hypothalmus, in addition to suppressing the feeling of thirst.

These changes are aimed at cancelling out the quasi increased volume. They are followed by increased excretion of urine with a low specific gravity and a changed electrolyte composition. The pilots who took in fluid were able to maintain their acid excreting power at a higher level in contrast with their colleagues who drank nothing. The actual drop in the circulatory volume was also demonstrated in a large-scale German study in which distinct decreases in haematocrit were to be seen after the flight as compared with before. It may be concluded that drinking during the flight is absolutely essential in order to keep the fluid balance up to the mark.

"Here one must think in terms of quantities of two to three litres for between four and five hours' flying, in order to compensate for the loss of weight (i.e., fluid loss). (Ref. 6).

SUMMARY

These few facts are only the tip of the iceberg when discussing medical factors. When all is said and done, the pilot who—for whatever reason—does not feel well, should not attempt to fly, at least not solo.

General discomfort, whether due to colds, indigestion, nausea, overwork, lack of sleep, worry, or any other bodily weakness, is not conducive to safe flying.

All medication should be considered hazardous unless specifically approved by an Airman Medical Examiner.

Every high altitude flight attempt should be done under only the best possible medical conditions; i.e. proper physical, medical and mental condition, proper equipment, and proper supervision.

Last, but certainly not least, dehydration must be considered on every flight, whether the temperature is +100 or -100.

As they used to say on "Hill Street Blues", *be careful out there!*

REFERENCES:

(1) "JOY OF SOARING", Carle Conway, Chapter 18, page 111

(2) *Soaring*, March, 1977, Page 31, "Soaring Hypoxia", Charles Fisher

(3) *Soaring*, Nov, 1969, page 39, "Safety Corner", Miles Coverdale

(4) *Soaring*, Feb, 1967, page 11, "Safety Corner", Coverdale

(5) *Soaring*, Dec, 1976, page 41, "Saftey Corner", Will Hayes

(6) *Gliding Kiwi*, reprinted by *Westwind*, author unkown