DIVINGMEDICINE

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CAFFEINE AND DIVING

(Coffee does much more than make you pee in your wetsuit!)

Caffeine is so ubiquitous in our culture that we often forget it is a drug that can have many negative side effects, especially in diving.

Caffeine is one of a group of compounds called methylxanthines. The common methylxanthines are theophylline (1,3-dimethlyxanthine), theobromine (3,7-dimethylxantine), and caffeine (1,3,7-trimethylxanthine). Methylxanthines naturally occur in coffee beans (caffeine), tea leaves (theophylline), chocolate, cocoa beans (theobromine), and cola nuts. In addition, caffeine is often added to soft drinks and medications. Caffeine is so wide spread it is virtually impossible to avoid and it is quite difficult to determine how much we consume each day. In this column the word 'caffeine' will be used to refer to all of the methylxanthines.

People often consume significant amounts of caffeine in medications. Table 1 lists the caffeine content of current Canadian medications, many of which you might not expect to contain caffeine. The concentration of caffeine in beverages is highly variable but you can get some idea from the values in Table 2. In addition there are many 'energy drinks' that typically contain 100-375 mg of caffeine (see http://www.energyfiend.com/the-caffeine-database for the caffeine content of hundreds of drinks).

Caffeine is rapidly absorbed in the stomach and distributes to all parts of the body. The peak concentration is achieved 50-75 minutes after oral consumption (up to 3 hours in some individuals) and the half-time of elimination is 3 to 7 hours. Therefore the maximum effect will be felt at approximately one hour and 6 to 14 hours after consuming caffeine, 25% of the drug will still be active in the body. There is a large variation in the sensitivity of individuals to caffeine and people who consume moderate to large amounts of caffeine on a regular basis become resistant to its effects.

The primary effects of caffeine are stimulation of the central nervous system (CNS), augmentation of the analgesic effect of painkillers and stimulation of the respiratory system (breathing). Stimulation of the CNS is the primary reason people consume caffeine. Its ability to make painkillers more effective is the reason it is often added to analgesics. The respiratory stimulant effect of caffeine seems to be via enhancing the sensitivity of the medullary respiratory center (in the brain) to carbon dioxide.

Caffeine has many other effects. It increases the heart rate, the force of cardiac contractions and cardiac output. In some individuals, it causes cardiac arrhythmias. Caffeine inhibits uterine contractions (useful for treating menstrual cramps). Caffeine reduces the flow of blood to the brain (useful for treating migraines) and increases blood pressure via increased systemic vascular resistance.

Oxygen toxicity is a major limitation in technical diving. The effect of caffeine on oxygen toxicity is complex. It stimulates the brain, thereby making it more susceptible to oxygen toxicity. However, it also reduces blood flow to the brain, thereby reducing the delivery of oxygen to the brain. This should reduce the likelihood of oxygen toxicity. Which of these two opposite effects will predominate is impossible to predict in a given situation. It is not surprising that research has sometimes shown caffeine to enhance oxygen toxicity, sometimes caffeine seems to have no effect, and sometimes caffeine seems to protect the subject from oxygen toxicity. As the diver is unable to predict which effect will predominate, they should always assume that caffeine (and all other stimulants) will make them more susceptible to oxygen toxicity. Therefore, they should avoid caffeine before a dive in which they will be exposed to high partial pressures of oxygen (1.0 ata or higher).

Table 1 Caffeine Content of Various Canadian Medications (CPS 2010)
Caffeine: **Wake Ups** - 100mg or 200 mg
Caffeine/acetaminophen: **Tylenol Ultra Relief Migraine Pain** – 65 mg
Caffeine/acetaminophen/codeine phosphate:
Lenoltec No. 1, 2, 3, Tylenol with Codeine No. 1, 2, 3 – 15 mg
Caffeine/acetaminophen/pyrilamine maleate:
Midol Menstrual Complete, Midol Teen Complete – 60 mg
Caffeine/ASA/butalbital: **Fiorinol, Tecnal, Trianal** – 40 mg
Caffeine/ASA/butalbital/codeine phosphate:
Fiorinol C1/4, C1/2, Tecnal C1/4, C1/2, Trianal C1/4, C1/2 – 40 mg
Caffeine/ergotamine tartrate: **Cafergot** – 100 mg
Caffeine Citrate 30 mg = Caffeine 15 mg
Caffeine citrate/acetaminopen/codeine phosphate:
Atasol 8, 15, 30, Triatec 8, Triatec 8 Strong – 30 mg
Caffeine citrate/ASA/codeine phosphate: **222, 282, 292** – 30 mg
Caffeine citrate/ASA/codeine phosphate/meprobamate: **282 MEP** – 30 mg

Caffeine has several other interesting effects. It enhances voluntary skeletal muscle activity. It will not increase your maximum strength but it will allow you to work longer at a moderately heavy rate and will make the work 'feel' easier. Caffeine increases the percentage of energy that comes from fat metabolism, thereby sparing the body's limited supply of glycogen (the primary carbohydrate store of energy for working muscles). Caffeine increases the force of muscle contraction and reduces muscle fatigue. These effects are significant enough that athletes often use caffeine to enhance their training.

How do these effects interact with diving? If the dive is going to require prolonged, heavy work, caffeine will enhance your ability to do the work. If the dive is going to be deep, where the work of breathing might be a problem, caffeine should increase your ability to breathe. However, before you decide to drink three cups of strong coffee before every dive, read on and learn more about the negative effects of caffeine.

Table 2 Dietary Sources of Caffeine

Coffee, brewed:	40-180	mg per cup
Coffee, instant:	30-120	mg per cup
Coffee, decaffeinated:	3-5	mg per cup
Tea, brewed Imported:	25-110	mg per cup
Tea, brewed American:	20-90	mg per cup
Tea, instant:	28	mg per cup
Tea, canned:	22-36	mg per 12 ounces
Soft Drinks (caffeinated):	36-90	mg per 12 ounces
Cocoa:	4	mg per cup
Chocolate milk:	3-6	mg per ounce
Chocolate, bittersweet:	25	mg per ounce

Caffeine increases the secretion of both pepsin and gastric acid from the parietal cells of the stomach, thereby increasing the likelihood of heartburn and ulcers (not great during a dive). It affects the kidneys such that more urine is produced. This effect is not desirable if you are in a drysuit (maybe a plus in a wetsuit in cold water) and 'may' increase your risk of DCS. This effect is quite variable and does not seem to bother people who consume caffeine on a regular basis.

The effects of caffeine during pregnancy can be significant. Women who consume a lot of caffeine have an increased risk of spontaneous abortion and intrauterine growth retardation. Some fetuses have had cardiac arrhythmias. Animals that were given the equivalent of 12 to 24 cups of coffee per day for the entire pregnancy produced offspring with skeletal abnormalities. It is recommended that pregnant women consume less than 300 mg of caffeine per day. Although breast milk contains only 1% of the concentration of caffeine found in the mother's body, babies are hyperactive and do not sleep properly when the mother drinks 6-8 cups of coffee per day.

Sensitive individuals who consume too much caffeine can experience some pretty unpleasant side effects.

A large number of drugs (including some antibiotics) interfere with the elimination of caffeine, thereby potentiating the effects. Caffeine may inhibit the absorption of calcium (most women are calcium deficient). Smoking will hasten the elimination of caffeine (smoking stimulates the liver, the liver metabolizes caffeine).

Sensitive individuals who consume too much caffeine can experience some pretty unpleasant side effects. They can feel dizzy, irritable and have diarrhea, nausea, and/or vomiting. People who consume caffeine daily can experience problems if they suddenly stop. They can have anxiety, dizziness, headache, irritability, muscle tension, nausea, nervousness, stuffy nose, and unusual tiredness. Overdose on caffeine results in symptoms similar to those above but more pronounced.

Caffeine is ubiquitous in our society and we all consume some on a daily basis. If we continue our normal rate of consumption, it will most likely not affect our diving. If we suddenly stop, we can become quite ill and should therefore reduce our caffeine consumption slowly. If we suddenly increase our caffeine intake, we can also become quite sick.

Caffeine has a diuretic effect (makes you pee) in some individuals and this might be a problem during a dive. It has a variable effect on oxygen toxicity and should be avoided before a dive where the diver will be exposed to a high PO2. Caffeine enhances exercise tolerance and reduces the work of breathing. This effect might help competitive athletes train but the potential side effects make it incompatible with diving.

In general I recommend divers limit their caffeine intake to moderate levels and maintain or slightly reduce their caffeine intake before diving.

DAVID SAWATZKY, S.C., C.D., B.Med.Sc., M.D., M.Sc., is a diving medical specialist who was on contract at Defence Research and Development Toronto from 1998 to 2005. Previously he was the Canadian Forces Staff Officer in Hyperbaric Medicine at DCIEM (1986-1993) and later the Senior Medical Officer at Garrison Support Unit Toronto (1993-1998). He's written a monthly column on diving medicine in Canada's *Diver* Magazine since 1993, has been on the Board of Advisors for the International Association of Nitrox and Technical Divers (IANTD) since 2000, and is an active cave, trimix and closed circuit rebreather diver/instructor/instructor trainer. David's first love is cave diving exploration and he's been exploring and surveying underwater passages in Canada since 1985. David was responsible for the exploration and mapping of almost 11 kilometres of underwater passages in the Ottawa River Cave System. In 1995, he executed the first successful rescue of a missing trained cave diver. David received the Canadian Star of Courage for this rescue which took place in the chilly Canadian waters of Tobermory, Ontario. He still dives as much as possible, but admits his seven year old son Lukas, six year old daughter Emeline and wife (Dr Debbie Pestell) are currently higher priorities than diving!