



Caffeine consumption and its health implications

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Abstract

Caffeine is a bitter white crystalline purine, a methylxanthine alkaloid. It is a natural chemical with stimulant effects that is commonly found in coffee, black and green tea, cocoa, cola soft drinks and energy drinks. It may also be found in chocolate bars, energy bars and some non-prescription medications, such as cough syrup and slimming tablet. The prevalence rate of caffeine consumption is very high. It is the world's most consumed psychoactive drug. Unlike most other psychoactive substances, caffeine remains largely unregulated and legal in nearly all parts of the world. Caffeine consumption has both positive and negative health implications depending on the dosage consumed. Positive health implications of caffeine when consumed in moderate proportion include; mood and brain improvement, lowers the risk of suicide, protect against Alzheimer and Parkinson disease, boost metabolism and fat burning, enhance exercise performance and protect against heart disease and diabetes. While negative implications which occur when mostly when taken in excess dosage include; anxiety, irregular heartbeat, headaches, high blood pressure and it can easily cross the placenta and increase the risk of miscarriage or low birth weight. It is recommended that caffeine consumption should be minimized and recommended dosage should only be consumed, people should form the habit of taking nutrient dense foods and those going through addiction and withdrawal syndrome should seek the help of a therapist.

Keywords: Caffeine and Health

1. Introduction

Caffeine is a natural chemical with stimulant effects. It is a bitter, white crystalline purine, a methylxanthine alkaloid and is chemically related to the adenine and guanine bases of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (Lorist & Tops, 2003). It is naturally found in the seed, nuts, leaves and fruits of a number of plants native of Africa, East Asia and South America (Kristin, 2022) and helps to protect them against herbivores and from competition by preventing the germination of nearby seeds as well as encouraging consumption by select animals such as honey bees (Doherty & Smith, 2004).

Caffeine is commonly found in coffee, black and green tea, cocoa, cola soft drinks and energy drinks. It may also be found in chocolate bars, energy bars and some non-prescription medications, such as cough syrup and slimming tablets. Guarana (a popular additive in energy drinks) is also a natural source of caffeine. Coffee was reportedly discovered many years later by an Ethiopian shepherd who noticed the extra energy it gave his goats. Caffeinated soft drinks hit the market in the late 1800s and energy drinks soon followed. Caffeine-containing drinks are consumed globally in high volumes. In 2020, almost 10 million tonnes of coffee beans were consumed globally (Kristin, 2022). Caffeine is the world's most widely consumed psychoactive drug (Qush *et al.*, 2023). Nowadays, 80% of the world's population consumes a caffeinated product each day, and this number goes up to 90% for adults in North America. Unlike most other psychoactive substances, caffeine remains largely unregulated and legal in nearly all parts of the world. The European Food Safety Authority reported that up to 400 mg of caffeine per day (around 5.7 mg/kg of body mass per day) does not raise safety concerns for non-pregnant adults, while intakes up to 200 mg per day for pregnant and lactating women do not raise safety concerns for the fetus or the breast-fed infants (Kristin, 2022).

Caffeine is a stimulant, which means it increases activity in the brain and nervous system. It also increases the circulation of chemicals such as cortisol and adrenaline that improve mood, combat fatigue, and enhance focus. Caffeine works by stimulating the central nervous system, heart, muscles and the centers that control blood pressure. Caffeine can raise blood pressure, but might not have this effect in people who use it all the time because caffeine's stimulating effects become less noticeable over time as the body becomes tolerant or less responsive to its effects. Caffeine can also act like "water pill" that increases urine flow.

Caffeine has both positive and negative health effects. Caffeine-citrate is on the World Health Organization (WHO) Model List of Essential Medicines (Kristin, 2022). People most commonly use caffeine for mental alertness, headache, migraine, athletic performance, memory and obesity. It is also used for asthma, gallbladder disease, low blood pressure, depression and many other conditions. It confers a modest protective effect against parkinson's disease (Richard & Smith, 2015). Caffeine can produce a mild form of drug dependency associated with withdrawal symptoms such as sleepiness, headache and irritability when an individual stops using caffeine after repeated daily intake (Kristin, 2022). Tolerance to the autonomic effects of increased blood pressure, heart rate, urine output develops with chronic use (Mandel, 2002). For this reason, many people turn to their caffeine-containing beverage of choice to get their day started or pick themselves up from a mid-afternoon cravings.

2. How Caffeine Works In the Body

When caffeine is consumed either as a food or a medicine, the blood and body tissues absorb caffeine within around 45 minutes. It reaches peak level in the blood within one hour and remains there for 4 to 6 hours (Felman, 2019). Once consumed, caffeine is quickly absorbed from the gut into the blood stream. From there, it travels to the liver and is broken down into compounds that can affect the function of various organs. Metabolism of caffeine varies among individuals.

Caffeine main effect is on the brain. It functions by blocking the effects of adenosine, which is a neurotransmitter that relaxes the brain and makes you feel tired (Barone & Roberts, 1996). Caffeine has a similar structure to adenosine, a chemical that is present in all human cell. Normally, adenosine levels build up over the day, making a person increasingly more tired and causing one to want to go to sleep. Caffeine helps the body stay awake by connecting to adenosine receptors in the brain without activating them. This blocks the effects of adenosine, leading to reduced tiredness. It may also increase blood adrenaline levels and increase brain activity of the neurotransmitters dopamine and norepinephrine. This combination further stimulates the brain and promotes a state of arousal, alertness, and focus. Because it affects the brain, caffeine is often referred to as a psychoactive drug (Felman, 2019).

Additionally, caffeine tends to exert its effects quickly. For instance, the amount found in one cup of coffee can take as little as 20 minutes to reach the bloodstream and about 1 hour to reach full effectiveness (Kristin, 2022).

3. Foods and amount of Caffeine it contains.

Caffeine is naturally found in the seeds, nuts, or leaves of certain plants. These natural sources are then harvested and processed to produce caffeinated foods and beverages. Here are the amounts of caffeine expected per 8-ounce (240-mL)

serving of some popular beverages (Kristin, 2022):

- **Espresso:** 240-720 mg
- **Coffee:** 102-200 mg
- **Yerba mate:** 65-130 mg
- **Energy drinks:** 50-160 mg
- **Brewed tea:** 40-120 mg
- **Soft drinks:** 20-40 mg
- **Decaffeinated coffee:** 3-12 mg
- **Cocoa beverage:** 2-7 mg
- **Chocolate milk:** 2-7 mg

Some foods also contain caffeine. For instance, 1 ounce (28 grams) of milk chocolate contains 1-15 mg; whereas 1 ounce of dark chocolate has 5-35 mg. Caffeine can also be found in some prescription or over-the-counter drugs like cold, allergy, and pain medications. It is also a common ingredient in weight loss supplements.

Coffee

Coffee is a brewed beverage prepared from coffee beans, which are a natural source of caffeine. Coffee is consumed for its stimulating effects, which increases energy levels, mood and alertness (Lara, 2010). Some studies exploring the relationship between coffee consumption and the risk disease have suggested an increased risk of heart disease, while others have shown potential health benefits, including a reduced risk of type 2 diabetes (Barone & Roberts, 1996).

On average, an 8-ounces (240 ml) cup of coffee contains about 100 mg of caffeine. Coffee products may contain very different amounts of caffeine. For example, Starbucks' 16-ounce (475-ml) Grande Vanilla Latte provides 170mg of caffeine, while a Grande Blonde Roast of the volume provides 360 mg of caffeine

Decaffeinated coffee still contains caffeine. However, it has reduced levels compared with regular coffee. One cup of (240 ml) of decaffeinated coffee contains 1 -50mg of caffeine in a regular cup.

Cocoa beans and chocolate

Cocoa beans naturally contain caffeine. This means that all chocolate and foods flavored with chocolate contain some caffeine, but the amount of caffeine in the product depends on the percentage of cocoa it contains (Qush *et al.*, 2023).

According to (Kendler *et al.*, 2006) the following is the amount of caffeine 100 grams of different types of chocolate will contain

100% cocoa chocolate- 240mg of caffeine – the equivalent of 2.5 cups of regular coffee.

Bittersweet chocolate (55% cocoa): 124 mg of caffeine

Milk chocolate (33% cocoa): 45 mg of caffeine – around the amount of caffeine in a cup of black tea

Kola nut

Kola nut is a staple food prized for its cultural symbolism and economic and health importance to all socio economic classes and religious groups. It was once a main flavoring agent and source of caffeine in commercial colas like Coca-Cola. The kola nut is the seed of the kola tree and a natural source of caffeine.

Green tea

Another natural source of caffeine is green tea. It is an especially popular drink in Asian countries. An 8-ounce (240

ml) serving of green tea provides about 30-50 mg of caffeine, which is about half of the caffeine content of a cup of coffee. The caffeine content of green tea varies by the age of the leaf. Older leaves provide less caffeine than younger leaves (Lara, 2010).

Guarana

Guarana is a plant that is native to the Amazon rainforest in Brazil and known for its antioxidant and stimulant properties. It contains chemicals called methylxanthines, and caffeine is one of these (Ogawa & Ueki, 2003). Companies use guarana extract as a food additive in soft drinks, energy drinks, energy bar, and herbal dietary supplements.

Yerba mate drink

Yerba tea is a popular beverage in South America. It is made from the dried, crushed leaves of the large leafed *ilex paraguariensis* tree. Also known as Paraguay tea, yerba mate is a natural source of caffeine. The caffeine content of yerba mate varies depending on the brewing method, ranging from 20-180 mg per 8-ounces (240 ml).

Chewing gum

Chewing gum is a soft, rubbery substance traditionally made from tree sap. It is not a natural source of caffeine, but manufacturers may include caffeine in their recipes. This has made chewing gum popular among some athletes and others looking for an energy boost.

Energy drinks

Energy drinks are carbonated, sweetened beverages marketed for their ability to boost energy levels, mood, and alertness (Kendler *et al.*, 2006). They are food supplement products and they are not regulated. They can provide 50-505 mg of caffeine depending on the brand.

Positive Health Implications of Caffeine Consumption

There are positive health implications of caffeine consumption when consumed in moderate proportion. These include the followings:

1. May improve mood and brain function.

Caffeine has the ability to block the brain-signaling molecule adenosine. This causes a relative increase in other signaling molecules, such as dopamine and norepinephrine (Pettit & De-Barr, 2011). This change in brain messaging is thought to benefit to one's mood and brain function. One review reports that after participants ingested 37.5–450 mg of caffeine, they had improved alertness, short-term recall, and reaction time.

2. Lowers the risk of suicide

A study linked drinking 2–3 cups of caffeinated coffee (providing about 200–300 mg caffeine) per day to a 45% lower risk of suicide (Lara, 2010). Another study reported a 13% lower risk of depression in caffeine consumers. When it comes to mood, more caffeine isn't necessarily better. A study found that a second cup of coffee produced no further benefits unless it was consumed at least 8 hours after the first cup.

3. Protect against Alzheimer and Parkinson disease.

Drinking between 3–5 cups of coffee per day or more than 3 cups of tea per day may also reduce the risk of brain diseases such as Alzheimer's and Parkinson's by 28–60%. It is important to note that coffee and tea contain other bioactive compounds (besides caffeine) that may also be beneficial.

4. May boost metabolism and fat burning

Because of its ability to stimulate the central nervous system, caffeine may increase metabolism by up to 11% and fat burning by up to 13%. Consuming 300 mg of caffeine per day may allow one to burn an extra 79 calories daily. However, a 12-year study on caffeine and weight gain noted that the participants who drank the most coffee were, on average, only 0.8–1.1 pounds (0.4–0.5 kg) lighter at the end of the study.

5. May enhance exercise performance

When it comes to exercise, caffeine may increase the use of fat as fuel. This is beneficial because it can help the glucose stored in muscles last longer, potentially delaying the time it takes your muscles to reach exhaustion. Caffeine may also improve muscle contractions and increase tolerance to fatigue. Researchers observed that doses of 2.3 mg per pound (5 mg per kg) of body weight improved endurance performance by up to 5% when consumed 1 hour before exercise. Doses as low as 1.4 mg per pound (3 mg per kg) of body weight may be sufficient to reap the benefits. Consuming small amounts of caffeine about an hour before exercise is likely to improve exercise performance.

6. May protect against heart disease and diabetes

Caffeinated beverages like coffee and tea may reduce the risk of heart disease and type 2 diabetes, although this may depend on the individual. Evidence shows a 16-18% lower risk of heart disease in men and women who drink between 1-4 cups of coffee daily (providing approximately 100-400 mg of caffeine). Other studies show that drinking 2-4 cups of coffee or green tea per day is linked to a 14-20% lower risk of stroke.

One thing to keep in mind is that caffeine may slightly raise blood pressure in some people. However, this effect is generally small (3-4 mmHg) and tends to fade for most individuals when they consume coffee regularly.

It may also protect against diabetes. A review noted that those who drink the most coffee have up to a 29% lower risk of developing type 2 diabetes. Similarly, those who consume the most caffeine have up to a 30% lower risk. The authors observed that the risk drops by 12-14% for every 200 mg of caffeine consumed. Interestingly, consuming decaffeinated coffee was also linked to a 21% lower risk of diabetes. This indicates that other beneficial compounds in coffee can also protect against type 2 diabetes.

Other Health Benefits Of Coffee

Coffee consumption is linked to several other health benefits:

- **Liver protection.** Coffee may reduce the risk of liver damage (cirrhosis) by as much as 84%. It may slow disease progression, improve treatment response, and lower the risk of premature death.
- **Longevity.** Drinking coffee may decrease the risk of premature death by as much as 30%, especially for women and people with diabetes.
- **Decreased cancer risk.** Drinking 2–4 cups of coffee per day may reduce liver cancer risk by up to 64% and colorectal cancer risk by up to 38%.
- **Skin protection.** Consuming 4 or more cups of caffeinated coffee per day may lower the risk of skin cancer by 20%.
- **Reduced MS risk.** Coffee drinkers may have up to a 30% lower risk of developing multiple sclerosis (MS). However, not all studies agree.

- **Gout prevention.** Regularly drinking 4 cups of coffee per day may reduce the risk of developing gout by 40% in men and 57% in women.
- **Gut health.** Consuming 3 cups of coffee a day for as few as 3 weeks may increase the amount and activity of beneficial gut bacteria.

Keep in mind that coffee also contains other substances that improve health. Some benefits listed above may be caused by substances other than caffeine.

Negative health implications

Caffeine leads to temporary increases in blood pressure in individuals with minimal or no prior use. Caffeine, particularly in higher doses, can cause anxiety, as well as difficulty falling asleep if consumed late in the day. Abrupt cessation of caffeine in regular user may result in withdrawal symptoms, which typically peak at 1 to 2 days and include headache, fatigue, and depressed mood. Higher caffeine intake in pregnancy is associated with lower infant birth weight.

Ingestion of very high doses of caffeine (1200mg or more) can cause agitation, severe anxiety, elevated blood pressure and palpitations. This may occur with overuse of caffeine tablets or supplements in liquid form (energy drinks) or powdered form. Consuming caffeinated energy drinks or energy shots together with alcohol; is dangerous and has resulted in death.

Caffeine consumption is generally considered safe, although habit forming. Some side effects linked to excess intake include:

- Anxiety, restlessness, tremors, irregular heartbeat, and trouble sleeping
- Headaches, migraine, and high blood pressure in some individuals.
- In addition, caffeine can easily cross the placenta, which can increase the risk of miscarriage or low birth weight. Pregnant women should limit their intake.
- Caffeine can also interact with some medications. Individuals taking the muscle relaxant Zanaflex or the antidepressant Luvox should avoid caffeine because these drugs can increase their effects.
- Some studies suggest that drinking it regularly, even in moderate amounts, can cause chronic headaches and migraines. Furthermore, caffeine is considered mildly addictive, and some people may be more susceptible to developing dependence.

Association between Caffeine Intake and Stress, Anxiety, and Depression

The consumption of caffeine is known to be a coping strategy used in managing stress (Thoits, 1995), with 49% of a representative stratified sample of Puerto Rican students reporting caffeinated products to be useful for coping with stress (Kristin, 2022). Pettit and De-Barr (2011) reported a positive relationship between energy drink consumption and perceived stress levels in undergraduate students. Though the use of caffeine is moderately related to a range of psychiatric and substance use disorders in general population, the relationships appear not to be causal (Kendler *et al.*, 2006), and results between studies are equivocal (Lara, 2010).

In some cases, positive effects of caffeine have been observed. For instance, low doses have been shown to reduce

anxiety and elevate mood (Willson, 2018). Willson (2018) also reported that caffeine consumption was associated with reduced risk of depression compared with non-consumption in a population study.

Negative effects of caffeine on stress and mental health have also been observed, Smith (2009) reported higher anxiety levels in moderate and high caffeine consumers compared with abstainers in a student sample. Case reports also suggest that mania can be induced by a high intake of caffeine (Ogawa & Ucki, 2003) or energy drinks (Sharma, 2010). These results are supported by the finding of Kendler *et al.* (2006), that 250mg of caffeine can increase elation in healthy volunteers, whereas 500 mg increases irritability.

In the general population, negative effects of caffeine are usually observed in relation to excessive intake. At extremely high doses its consumption can induce a condition known as "caffeinism". Symptoms include anxiety, nervousness, restlessness, insomnia, excitement, psychomotor agitation, dysphoria, and a rambling flow of thoughts and speech, which have been considered to mimic a clinical picture known as 'mixed mood state' (Lara, 2010)

Recommended Dosages

Both the U.S. Department of Agriculture (USDA) and the European Food Safety Authority (EFSA) consider a daily intake of 400 mg of caffeine to be safe. This amounts to 2–4 cups of coffee per day. That said, it's worth noting that fatal overdoses have been reported with single doses of 500 mg of caffeine. Therefore, it's recommended to limit the amount of caffeine one consumes at one time to 200 mg per dose. According to the American College of Obstetricians and Gynecologists, pregnant women should limit their daily intake to 200 mg

Conclusion

Caffeine is a popular stimulating compound found in many foods and drinks, including coffee and tea. It is associated with many health benefits, but consuming too much of it may raise some concerns. Caffeine consumption may be associated with stress, anxiety and depression.

Recommendations

1. Caffeine consumption should be minimized and recommended dosage should only be consumed.
2. People should form the habit of taking nutrient dense food and rest when tired.
3. Those going through addiction and withdrawal syndrome should seek the help of a therapist.
4. Government should place a restriction on sale of on the counter drugs that contain caffeine

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