Energy Drinks and the Neurophysiological Impact of Caffeine

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People with fast-paced lives such as adults, college students, or individuals with a busy schedule in general could have a hard time being productive without caffeine consumption. As favorable as it might be to start your day off with a warm cup of coffee, a Celsius energy drink, or even a Red Bull, getting our body used to large amounts of caffeine affects our bodies as its effects can impact cardio-respiratory, endocrine, and most importantly neurological systems.

The article "Energy drinks and the neurophysiological impact of caffeine," written by Leeana Aarthi Bagwath Persad, aims to raise awareness about the neurophysiological effects of caffeine, specifically emphasizing its impact on the nervous system among the global increase in caffeinated energy drink consumption. Biochemical characteristics, cardiovascular, respiratory, endocrine, metabolic, gastrointestinal, and urinary effects are introduced.

Arousal and fatigue, perceptual processing, motor behavior, and learning and memory are also topics explained regarding the major neurophysiologic effects of caffeine. The consequences of ingesting caffeine can vary from caffeine intoxication, withdrawal, caffeine-induced anxiety disorder, and caffeine-induced insomnia.

Caffeine is a widely consumed psychoactive stimulant found in many natural sources. The sudden increase in energy drink consumption has led to concerns about caffeine abuse. Marketing has sugar-coated its negative effects by providing poor awareness of its consequences and making people think that overconsumption is tolerable. We must educate ourselves on the side effects of this stimulant before getting our body used to the feeling of its consumption.

Caffeine is a natural substance found in many sources, and it is said that it's the world's most consumed stimulant, with 49% of adults in America drinking 3 to 5 cups of coffee a day. Reports of caffeine intoxication have been on the rise due to the increasing popularity of caffeine, not only in beverages but also in multiple food products like potato chips and chocolates, potentially indicating an increase in caffeine dependence and withdrawal symptoms. Soft drinks, teas, and coffee are the most common sources of caffeine among Americans. European and North American statistics reveal that 90% of adults consume caffeine daily, averaging 227 mg.

On the physiology side we can say that in humans, caffeine is absorbed through the gastrointestinal tract, and it depends on whether it is hot coffee or cold drinks that will determine its absorption rate. It distributes throughout the body and penetrates membranes, the blood-brain barrier, and the placenta, but it does not accumulate in the tissues or organs. Peak plasma concentration is achieved 15–20 minutes after ingestion. This time is cut in half in adult males who smoke and doubles in women taking oral contraceptives, and it can also go beyond those times if pregnancy or chronic liver disease is present in an individual.

Caffeine metabolism is specific, having pathways leading to primary metabolites such as theobromine, theophylline, and paraxanthine. While caffeine is mostly removed overnight, some primary metabolites can stay longer. These metabolites are part of all body fluids, with paraxanthine further metabolized and found in urine. Theobromine is the largest portion of caffeine metabolites, only excreting 50% of them via the urinary tract.

The effects of caffeine on the cardiovascular system mostly contribute to arterial stiffness and elevated systolic and diastolic blood pressure. An increase in respiration rate is a well-known

effect related to plasma caffeine levels. In the metabolic aspect, we know that there is an increase in the basal metabolic rate including lipolysis.

Gastrointestinal and urinary effects include stimulation of the small intestine, leading to the secretion of sodium and water. It has also been observed to act as an antagonist to adenosine receptors for regulating blood vessel contraction and function as a psychoactive drug in Parkinson's disease treatment.

Arousal plays a role in neuropsychology because it is linked to enhanced task performance. Caffeine's effects are associated with dopamine functions, and increased firing rates in mesopontine cholinergic neurons, contributing to arousal. Caffeine increases arousal, as shown by higher skin conductance levels and lower heart rate and diastolic blood pressure. Studies have also shown that caffeine administration has increased driving performance demonstrating its alertness-enhancing properties even after sleep deprivation, and it also has beneficial effects on choice reaction time.

Learning and memory are also affected by caffeine. Learning involves retaining new information, and memory is the ability to store, process, and recall learned information. Long-term potentiation (LTP) is a crucial neurophysiological mechanism underlying learning and memory, involving glutamatergic, NMDA, and AMPA receptors, as well as neurotransmitters like dopamine, acetylcholine, serotonin, and norepinephrine. Caffeine's impact on learning tasks may vary depending on the information involved. It is known that caffeine can enhance alertness and decrease fatigue, leading to better performance in certain tasks.

We undergo stress when the human body has a hard time coping with physical or emotional threats that are responded to by the brain. Caffeine consumption often increases during periods of high stress, elevating cortisol levels by stimulating the central nervous system. For this reason, individuals with hypertension should avoid caffeine during periods of stress as these further increase blood pressure. Caffeine use can excite specific cannabinoid receptors, potentially explaining the reported relaxation and enhanced well-being during stress. The striatum, a major area for basal ganglia function, is affected by caffeine, reducing inhibition of dopamine transmission. It has been discovered that cannabinoid receptors are related to the mechanism and action of psychoactive drugs, stress, and the "high" of substances like ethanol, morphine, cocaine, and nicotine cause. The effect of caffeine on the striatal cannabinoid system can be compared to those of cocaine.

There are plenty of disadvantages of caffeine to the human body, especially to the nervous system. One of them is the fact that it can cause deficits in learning. Multiple doses of caffeine are frequently consumed by individuals with insomnia to help with fatigue and increase alertness, but research indicates that caffeine may have effects on cognition, especially in perceptual memory and learning. A study that looked at the effects of a nap and caffeine on verbal, motor, and perceptual memory says that caffeine results in the elevation of hippocampal acetylcholine, which could affect memory by interrupting the replay of memories. It is observed that a normal dose of caffeine negatively affects motor skills and does not replace the benefits of memory improvement or daytime sleep.

High caffeine doses might elevate anxiety, but it is uncommon in typical consumption patterns. A single dose of 300 mg of caffeine leads to anxiety and tension in some cases, while a 400 mg dose may intensify it when combined with a stressful task. The mechanism for caffeine's panicogenic potential is unknown, with adenosine receptor antagonism considered a likely pathway.

Caffeine dependence is another disadvantage of caffeine to the human body. On average, 98% of North Americans consume caffeine, making it the most used drug on the continent. Many of them claim a caffeine addiction. Caffeine dependence is challenging due to its highly variable effects, and how accessible and tasty it is.

The article digs into the extensive impact of caffeine on the neurophysiological aspects of the human body, covering its influence on various systems, including cardiovascular, respiratory, endocrine, metabolic, gastrointestinal, and urinary. The focus on arousal, fatigue, perceptual processing, motor behavior, learning, and memory emphasizes the multifaceted effects of caffeine on the nervous system. The commonness of caffeine consumption, especially in the form of energy drinks, raises concerns about potential abuse and a lack of awareness regarding its consequences. The article underscores the need for education on the side effects of caffeine, considering its widespread use in daily life. It also brings attention to the drawbacks of caffeine, especially concerning deficits in learning and potential negative effects on cognition.

While caffeine is a widely consumed stimulant offering various benefits, its effects on different physiological and psychological aspects need a balanced understanding. The article encourages individuals, particularly those with hectic lifestyles, to be mindful of their caffeine intake and to educate themselves on its potential consequences.