



Energy Drink Consumption: Caffeine-Related Adverse Health Effects

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Abstract: Energy drink (EDs) with caffeine is widely ingested. Over the past 20 years, use of energy drink has drastically increased, especially among adolescents and young people. Energy drink are aggressively advertised with the promise that they would offer you more energy and raise your mental and physical performance. With the help of clever and successful marketing techniques, the general public and athletes have increased their consumption of energy drinks (EDs). There are a growing number of reports of caffeine intoxication from caffeinated EDs as well as issues with dependence and withdrawal from caffeine. The neighborhood and the general populace. Energy drink usage poses health risks mostly because of their high caffeine content.

However, a number of unfavorable health effects have been linked to energy drinks, raising the question of their safety. This review was done to find and talk about the published publications that looked at the negative health impacts of caffeine and energy drink consumption. The goal is to evaluate consumption habits and identify any negative effects. The consequences of EDs and their possible harm are examined in greater detail in this article.

Keywords - Energy drinks, Beverages, Health effects, Consumption.

I. INTRODUCTION

Energy drinks (EDs) don't have a set definition. However, they are distinguished as being very sweet, caffeinated, and non-alcoholic. Given that they have extremely high caffeine content, these drinks have a stimulating effect on the CNS. This normally ranges from 80 to 100 mg per serving. EDs are known for their ability to increase energy and physical and mental performance in addition to their delicious taste. They also run the danger of causing a caffeine overdose ^{[1][2][3][4]}. Caffeine and other psychoactive substance like ginseng, guarana, vitamins B, L-carnitine, milk thistle, and ginkgo biloba are among the main components of EDs. Other complementary substances include taurine, ginseng, guarana, and taurine ^[5].

When combined with alcohol, they are also utilized as mood enhancers. A multi-million-dollar international market has emerged as a result of the sharp increase in the demand for and use of EDs in recent years. Although there are almost 300 different types of ED available on the global market, Red bull, Monster, Rockstar, and 5-hour energy drink are the most well-known brands ^{[1][2][3][4]}.

They perform the function of CNS stimulants. Known as an adenosine receptor antagonist, caffeine, the main stimulant in EDs, affects neuronal pathways in the central and peripheral nervous systems to raise

heart rate and blood pressure. Typical EDs typically contain 70-200mg of caffeine beverages ^[5]. A study among university students in Saudi Arabia found that the majority of participants had insufficient knowledge about the use of ED and the harmful ingredients in it during breastfeeding and pregnancy, which was supported by other studies that found ED consumers lacked knowledge about the ingredients and harmful health effects of consuming EDs ^[6].

Therefore, if customers are uniformed of the maximum daily intake of the specific ED, they may easily surpass the prescribed daily dose of caffeine intake, which could result in caffeine intoxication. Caffeine intoxication symptoms, such as nausea, vomiting, agitation, seizures, nervousness, headache, tremors, and sleep difficulties, are frequently linked to daily doses of more than 400mg of caffeine ^[7]. Arrhythmias, myocardial ischemia, and hypertension were also noted as negative cardiovascular consequences, which may be related to the pathophysiology of caffeine in the central nerves systems ^[8].

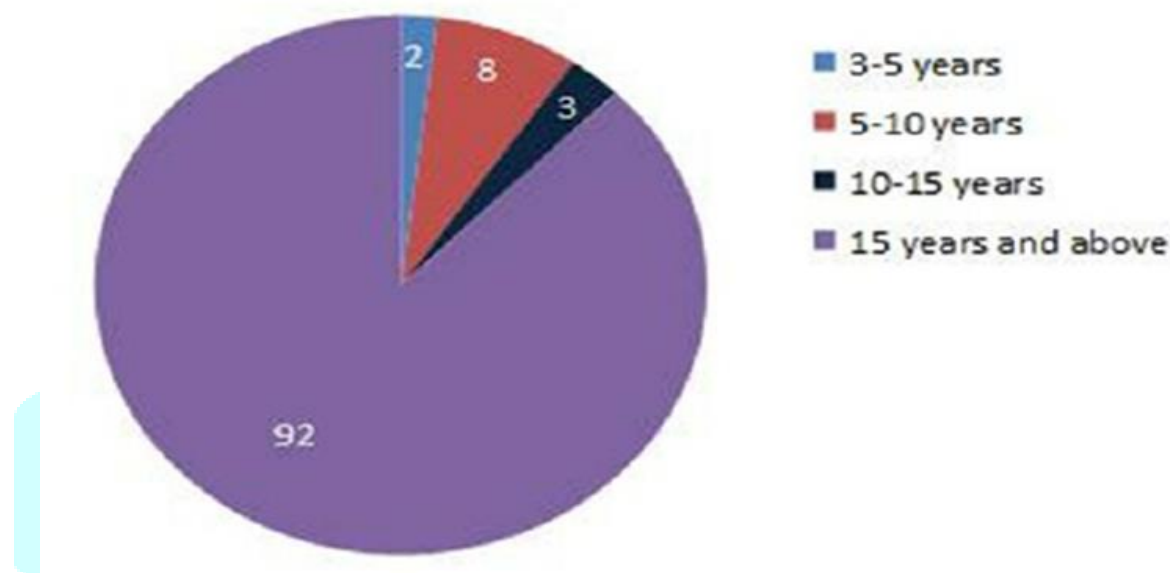


Figure 1. Age structure of energy drink users

(From: Consumption pattern of nutritional health drinks and energy drinks among university students in Ajman, UAE. Article in Gulf Medical Journal · June 2013)

I. CONSTITUENTS OF ENERGY DRINK

1. Caffeine

Caffeine is extracted from the raw fruit of sixty species of coffee plant (*coffea Arabica*), all part of the methylxanthine family. The caffeine in tea kola nuts, and cocoa is also extracted. The amount of caffeine in EDs varies between 50 and 505 mg per can or bottle ^{[9][10]}. While the amount in a cup of coffee or tea (250 ml) are 80-120 mg and 60 mg, respectively ^[11]. Caffeine is the main component in EDs and is frequently combined with other substances to create “energy drink” including taurine, glucuronolactone, guarana, and B vitamins ^[12]. The safest level of caffeine consumption is still unknown, although studies indicate that the daily maximum suggested intake ranges 2.5 mg/kg to for children, 100 mg for adolescents, and up to 400 mg for adults ^{[13][14]}. Caffeine is quickly absorbed (30-60 minutes) from the digestive system after ingestion, when it undergoes demethylation to produce the compounds paraxanthine (83%), theobromine (12%) and theophylline (4%). Caffeine has a half-life of 3 to 7 hours in adults, with 0.5% to 3.5% of its content excreted unchanged in urine and certain amounts removed by perspiration. In the small intestine, caffeine is completely absorbed in less than an hour, and it also diffuses quickly into other tissues ^[15]. All bodily fluids, including saliva and CSF fluid, include caffeine because it is soluble in water and lipids, quickly crosses the blood-brain barrier, and is a stimulant ^[15]. The physicochemical features of the product dose determine the variation in caffeine absorption time ^[13]. The effects vary with age and depend on intricate genetic and environment interaction ^[15].

2. Guarana

Paullinia cupana, South American shrub renowned for its stimulating effects, produces seeds that are used to make guarana. Guarana contains significant levels of tannins, theophylline, theobromine, and caffeine (4%-8%), but low levels of saponins and flavonoids [16]. Guarana use boosts energy, improves physical performance, and encourages weight loss. The high caffeine level is mostly responsible for these effects. According to some research, the caffeine level of guarana (40 mg per gramme of extract) may not always be disclosed on packaging and may be higher than that of energy drink [16]. Hence, the caffeine dose may be higher than that listed on the beverage ingredients list. Furthermore, it is more slowly absorbed into the gastrointestinal tract and thus has a longer lasting effect than caffeine sourced from coffee beans [17]. Guarana is currently thought to have no adverse effects other than potential caffeine toxicity [18].

3. Ginseng (Panax ginseng)

A popular botanical extract known as ginseng is said to have stimulant and aphrodisiac effects. It has not been reported to be hazardous and is contained in energy at quantities that are lower than average daily intake. However, depending on the quantity of ginseng consumed as well as dose and frequency of the medications that could become clinically relevant. Ginseng poisoning has been linked to a variety of symptoms, including agranulocytosis, Stevens-Johnson syndrome, rashes, headaches, nausea [19]. Some of these symptoms could be caused by processing-related pollutants including phenylbutazone and aminopyrine [16].

4. L-Carnitine

It is an amino acid necessary for the fatty acid oxidation process. It encourages the metabolism of fat and improves endurance. It can induce nausea, vomiting, abdominal pain and diarrhea at high dose. According to reports, it makes patients with seizure disorders more prone to seizures [16].

5. Taurine

Humans naturally produce taurine as a metabolite, which is used to regulate neuronal excitability, stabilize membranes, make bile salts and detoxify certain xenobiotics. Humans consume between 40 and 400 mg of taurine per day, according to estimates. Some energy drinks include taurine levels that are more than ten times the recommended daily allowance for an average individual [20]. The intracellular calcium concentration in smooth muscles is affected physiologically by taurine, just like caffeine, and this could lead to coronary vasospasm [21].

6. Glucuronolactone

This is a naturally occurring chemical that the body produces in trace levels. Supplementing with D-glycerates, such as glucuronolactone, may help the body's natural defenses against cancer-causing agents and agents that promote tumor growth as well as their effects [22]. The limited human data are consistent with the rat toxicokinetic findings on glucuronolactone, which demonstrate bioavailability and lack of build-up with peak plasma levels 1 to 2 hours after oral dosing. Unfortunately, there has not been much research on this chemical in humans, and there is not much information available right now. Therefore, it is impossible to draw conclusions about whether this substance is dangerous or useful.

7. Additional ingredients

Additional components include amino acids, vitamins, herbs and other dietary supplements that are said to improve mental and physical performance [24][25].

- A. Folic acid is required for DNA synthesis, RBC synthesis, and cell growth. According to the National Academy of Sciences, the daily intake of folic acid in adults should not exceed 1000 µg. Very high doses (>15,000 µg/day) can cause stomach problems, sleep problems, skin reactions, and seizures [26].
- B. Vitamin B12 is involved in nucleic acid metabolism, the formation of red blood cells (RBCs) and myelin synthesis and repair. It has a very low potential for toxicity even when taken in large doses [26].
- C. Vitamin B6 is important in heme, nucleic acid, lipid, carbohydrate and amino acid metabolism. Toxicity occurs when megadoses of vitamin B6 (>500 mg/day) are ingested [26]. Symptoms of toxicity include peripheral neuropathy with deficits in a stocking-glove distribution, progressive sensory ataxia and severe impairment of position and vibration sense [26]. Symptoms of toxicity include peripheral neuropathy with deficits in a stocking-glove distribution, progressive sensory ataxia and severe impairment of position and vibration senses [26].
- D. Vitamin B3 (Niacin) and its derivatives are vital to cell metabolism. They have been associated with skin flushing and rarely to hepatotoxicity [26].
- E. Citicoline functions as a neuroprotection agent. It exhibits a very low toxicity profile in humans. Tyrosine is involved in the synthesis of neurotransmitters in the brain. Phenylalanine is converted to tyrosine in the body.

and serves the same function as tyrosine. Toxicity symptoms include increased blood pressure, emotional agitation, insomnia, and headaches ^[26].

- F. Malic acid is important in boosting immunity; there are no known reported contraindications or toxicities linked to malic acid ^[26].
- G. Sugar Another common ingredient in most ED is some type of carbohydrate source (e.g., glucose, sucrose, maltodextrin, ribose, fructose). EDs contain approximately 25-30 grams of carbohydrate per 240 ml serving (range from 0 to 67 g per serving). A typical ED provides carbohydrates at a greater concentration, typically around an 11% - 12% solution. Ingesting higher percentages (>10%) of carbohydrate in fluids has been reported to delay gastric emptying and increase gastrointestinal distress ^[27].
- H. Antioxidant During exercise, inflammation and oxidative stress are linked by means of muscle metabolism and muscle damage ^[28]. Antioxidants are purported to aid the body in the recovery phase and reduce damage to muscle cell ^[29]. Through muscle metabolism and muscular injury, exercise links inflammation and oxidative stress ^[30]. Antioxidants are said to help the body recuperate and lessen muscle cell deterioration ^[31]. However, there is no solid proof that either short term or long-term exercise changes the need for antioxidants, and supplementation in skilled athletes has not been demonstrated to have any appreciable impact ^[32].

II. Health Adverse Effects

A. Cardiovascular effect:

Several studies have shown an increase in heart rate and arterial blood pressure after energy drink consumption. These findings were attributed to the ergogenic effects of the caffeine content of the energy drink. In addition, significant cardiac manifestations such as ventricular arrhythmias, ST segment elevation and QT prolongation have been documented following energy drink overconsumption ^[33]. Additionally, atrial fibrillation has been reported after high energy drinks ingestion in two healthy boys, 14 and 16 years of age ^[34]. Recently, energy drink consumption has been related to myocardial infarction in healthy 17- and 19-year-old boys ^{[35][36]}. This observation has been supported by the findings that consuming energy drinks reduces endothelial function and stimulates platelet activity through arachidonic acid induced relationship between energy drink overconsumption and arterial dilatation, aneurysm formation, dissection and rupture of large arteriae ^[38].

Neurological and psychological effect:

Caffeine intoxication symptoms typically appear in people who consume 200 mg or more. Anxiety, sleeplessness, gastrointestinal distress, twitching muscles, restlessness, and spells of inexhaustibility are among the symptoms ^[39]. High caffeine intake also promotes a pronociceptive state of cortical hyperexcitability, which is linked to both and persistent daily headaches. The diagnostic and statistical manual of mental disorders, fourth edition, has identified four caffeine induced psychiatric disorders caffeine intoxication, caffeine induced anxiety, caffeine induced sleep disturbance, and caffeine related disorder ^[41]. Research of 15 to 16-year-old teenagers found a direct link between caffeine consumption and conduct issues as well as violent behavior ^[42]. Several investigations have claimed that energy drink may that consume more than 300 mg of caffeine per day ^[44]. High cortisol levels that occur after consuming caffeine could be the cause of this. Stress physiological effects are amplified by cortisol, which makes people more likely to have hallucinations ^[45]. According to in vitro research, caffeine, taurine, and guarana may boost apoptosis by lowering the activity of the enzyme's superoxide dismutase and catalase in human neuronal SH-SY5Y cells ^[46].

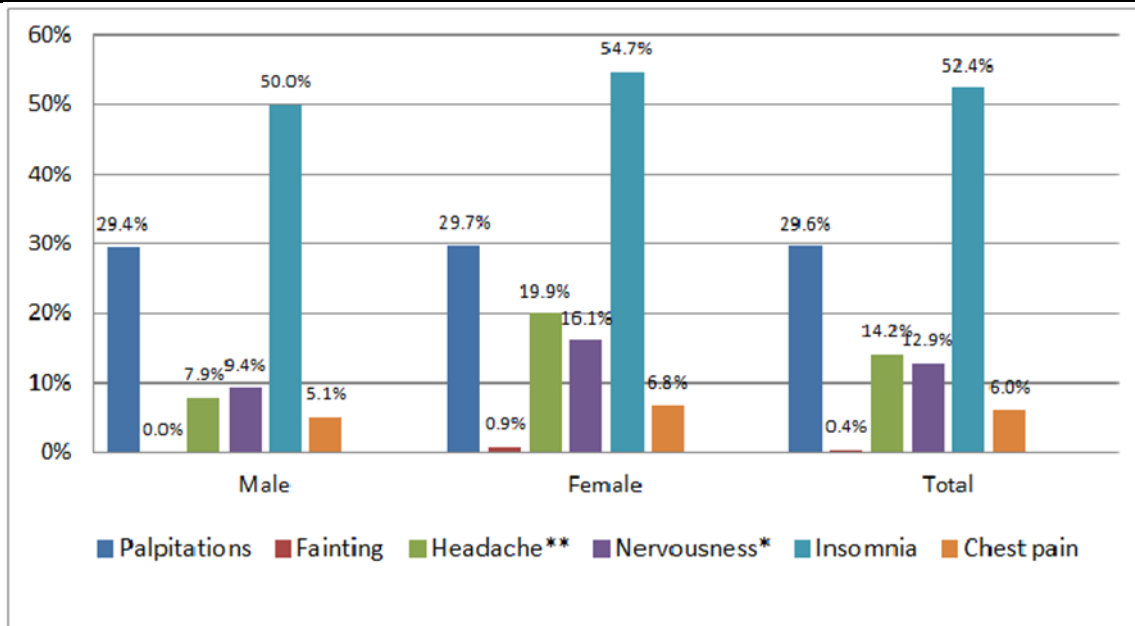


Figure 2. Frequency of symptoms post energy drink consumption for males, females and All participants

$P < 0.05$; ** $p < 0.01$ for male: female difference (From: British Journal of Medicine & Medical Research 3(4): 1900-1909, 2013 SCIENCEDOMAIN international www.sciencedomain.org)

effects Gastrointestinal and metabolic

Sugar content in energy drink typically ranges from 21g to 34g per ounce. The majority of the sugar is present as sucrose, glucose, or high fructose corn syrup. As a result, consuming a lot of energy drink may make you more likely to develop type 2 diabetes and obesity [39]. Furthermore, the high sugar content in energy drink may decrease the diversity, activity, and gene expression of gut bacteria, increasing the risk of obesity and the metabolic syndrome [47]. Acute caffeine intake reduces insulin sensitivity, which may account for increase in blood glucose levels observed after consuming energy drink as reported in several research [49]. Caffeine consumption decreases insulin sensitivity in a dose dependent manner, with a rise in insulin of 5.8% for every mg/kg increase in caffeine [50]. A case of an energy drink overconsume who came with jaundice, stomach pain, and significantly increased liver enzyme has been documented [51]. Huang et al. reported the identical results in a male who was 36 years old [52]. More research is required to ascertain who is more at risk and the underlying mechanism by which energy drinks harm the liver.

Renal Effects:

It has been demonstrated that the caffeine in energy drinks promotes diuresis. Energy drinks should therefore be avoided during extended exercise in a hot climate due to the risk of dehydration [53]. According to studies, a 1.5% level of dehydration after extended activity may cause an increase in body temperature, heart rate, and perceived exertion. [54] Caffeine also encourages salt excretion in the urine (natriuresis), which alters plasma volume and significantly affects cardiovascular performance during exercise. Furthermore, a lack of sodium during prolonged exercise in a warm climate may lessen the isometric power in the legs [55][56]. Greenet al. described an instance of acute renal injury in a 40-year-old man who had been consuming energy drinks every day for about 2-3 weeks. The serum creatinine was increased fivefold from baseline and returned to normal two days drinks consumption was discontinued. [57].

Effects on the teeth:

A Swedish study found a direct link between energy drinks and deterioration. Marshall et al. also demonstrated a comparable observation in American kids [58][59]. Consuming energy drinks was linked to a 2.4 – fold rise in tooth erosion. This has been related to energy drinks' high may cause cervical dentin hypersensitivity by eliminating the tooth's smear layer [61].

Conclusion:

Energy drinks may improve performance in a variety of sporting activities. Energy drinks may improve performance, but there have also been reports of potential health risks, particularly for children and teenagers. Energy drinks use has a harmful impact on several bodily parts. It is advised to use caution when using energy drinks in light of this fact and their rising popularity. Governments should regulate overzealous marketing and unfounded claims until further studies certify that these products are safe.

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