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Do they give you wings or cut you down - an analysis of the effects of energy drinks on human health

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Abstract

This work aims to study the effects of energy drink consumption on human health. In recent years, the consumption of energy drinks has increased significantly, which has sparked the interest of scientists and health experts. In Poland and a few other countries, new laws have been applied to regulate the consumption of energy drinks by minors. In this review paper, we analyze the available scientific research on the effects of energy drinks on physical and mental health. In this paper, we focus on the potential benefits and risks of consuming energy drinks, and the common and dangerous combination with alcohol. We discuss the effects of caffeine, taurine, guarana and other ingredients on the body, and their potential side effects. In addition, we consider the effects of these beverages on the cardiovascular system, cognitive ability, and possible health effects associated with excessive consumption. The conclusions of this work can help to understand the complex health effects of energy drinks and draw attention to the need for caution and moderation in their consumption. Ultimately, this work aims to provide up-to-date knowledge on this issue to assist in making informed decisions about energy drink consumption in the context of a healthy lifestyle.

Keywords: energy drink; caffeine; energy shots; taurine

1. Introduction

Energy drinks are the fastest growing product in the beverage industry. They contain active ingredients such as caffeine, taurine, vitamins and other stimulants. Their purpose is to provide a quick boost of energy and improve concentration. Energy drinks may also contain sugar or artificial sweeteners, as well as ingredients such as guarana, ginseng or L-carnitine. In today's fast-paced life, many people are looking for an instant energy boost, which makes energy drinks an attractive option. They are widely available in stores, vending machines and coffee shops, making them easily accessible and convenient to use. They attract with their colorful labels and are available in a wide variety of flavors. Young people often reach for energy drinks because of their stimulating potential and the fashion associated with them, but also because of effective marketing and scant knowledge of potential negative health effects [1].

The first energy drink called "Dr. Enuf" hit the U.S. market in 1949, while they first appeared in Europe in 1987 [2]. The popularity of these drinks began to grow after the release of Red Bull in 1997, which caused the market to expand worldwide [3]. Since then, the energy drink industry has grown rapidly, with new brands entering the market. In 2013, annual consumption of energy drinks exceeded 5.8 billion liters in more than 160 countries [4]. The retail market for such beverages in the United States was estimated to be worth about \$12.5 billion in 2012 [3].

2. What are energy drinks?

Energy drinks are beverages that contain stimulating ingredients such as caffeine, taurine, guarana, B vitamins, electrolytes and sometimes sugars, and are designed to increase energy levels and improve physical performance. These drinks are often consumed to improve concentration, increase arousal and combat fatigue. An important piece of information is the sheer number of interactions that energy drink ingredients enter into. It should be noted that

they differ significantly from sports drinks and vitamin waters, which are used to rehydrate the body and provide it with the necessary ingredients to help with physical exertion [1].

2.1 Caffeine

Caffeine is the most widely used psychoactive drug in the world, and the only drug legally available without the need to show a prescription, including for children, sold in grocery stores. In the United States, caffeine consumption is 60-70mg/day and ranges up to 800mg/day. It is a component of the adenosine receptor, which stimulates the central nervous system. It causes coronary and cerebral vasoconstriction, relaxes smooth muscle, and has chronotropic and inotropic effects on the heart. Large amounts of caffeine have a diuretic effect, stimulate sweat secretion and alter blood electrolyte levels. Other effects include increasing heart rate, increasing blood pressure, raising blood glucose levels and dilating bronchioles [1] [5] . It is a common stimulant well known to the public. In therapeutic applications, we find the treatment of apnea and bronchopulmonary dysplasia in premature infants, as it is used in the form of caffeine citrate.

The effect that energy drink manufacturers promise is to increase exercise tolerance and improve cognitive function and mood when tired and unwell. Moderate doses of caffeine have been shown to improve attention, verbal reasoning, concentration, and increase alertness. Recent findings emphasize that the young, developing brain is extremely sensitive to the effects of caffeine, and fatigue in a child should be reduced with rest, not caffeine administration [5].

Side effects of this compound include increased intracranial pressure, brain edema, seizures, and tachyarrhythmias. Consumption of caffeine in doses of 4 to 12mg/kg causes side effects such as headaches, fatigue, anxiety and irritability [6].

2.2 Guarana

An ingredient found in plants from the Amazon, which has cultural significance. Many bioactive compounds are found in guarana seeds whose seeds contain a significant amount of caffeine. Guarana seeds are rich in caffeine, the content of which is much higher than in coffee. As a result, guarana is often used as a natural source of caffeine, giving it a stimulating and invigorating effect. In addition, it also contains other components, such as theophylline and theobromine, which can further affect the body's energy and stamina levels. It does not find widespread therapeutic use in the present. It is an agent that has a stimulating effect. It is generally considered a safe ingredient by the FDA Center for Food Safety and Applied Nutrition.

2.3 Taurine

Taurine is an organic chemical compound, an amino acid that occurs naturally in animal organisms, including the human central nervous system, more precisely in large quantities in the brain and hippocampus and cerebellum of adult humans. It supports the formation of synapses, which are necessary for the formation of long-term memory [5]. It is an essential amino acid that has important biological functions. It is present naturally in foods such as meat and fish. Taurine has many functions in the body, including regulating water and salt levels, supporting metabolic processes, supporting brain and eye function. It is an important element in maintaining homeostasis, protects against oxidative stress [7]. It is also used in dietary supplements for its potential health benefits.

Proven to support healthy infant development, it is also used to treat alcohol withdrawal, diabetes, congestive heart failure (lowering blood pressure while improving heart contractility)

Considered safe by the FDA [1] . It is added to energy drinks because of its potential stimulating properties.

2.4 Vitamins

Niacin (vitamin B3), pantothenic acid (vitamin B5), vitamin B6 and vitamin B12 are often added to energy drinks because they play an important role in metabolism and transferring energy to the body. These are amounts that significantly exceed the recommended

intake. Symptoms of toxicity caused by excessive amounts include liver failure after using niacin or peripheral neuropathy caused by vitamin B6.

Adding vitamins such as C and E to beverages negligibly benefits the body [8].

2.5 Electrolytes

Some energy drinks contain electrolytes, such as potassium, magnesium and sodium, which help maintain the body's electrolyte balance, especially during intense exercise.

2.6 Sugar

Often, energy drinks contain sugars, such as glucose, fructose or sucrose, which provide a quick source of energy for the body, and are effective in attracting a young population of recipients [8]. As is widely known, consuming carbonated sweetened drinks, which include energy drinks, can lead to poor concentration, overweight problems and an increased risk of heart disease and cancer. Drinking them regularly may also have negative effects on the brain. It should be mentioned that consuming them is also harmful to your teeth as it can damage the enamel.

3. Positive effects of consumption

Energy drinks, although often the subject of controversy, can have several positive effects on the human body, especially if consumed on a short-term basis and their consumption is controlled.

Due to their caffeine and taurine content, energy drinks can help improve physical performance and endurance during intense workouts. They reduce the feeling of fatigue and improve endurance. It has been proven that caffeine contained in energy drinks stimulates the

recruitment of motor units in skeletal muscles and increases the pool of free fatty acids in the serum [8].

Some research suggests that energy drinks improve physical fitness, muscle strength, exercise performance and sports activities such as cycling and running. However, in the case of sprinting, no significant differences were observed [9].

Improved cognitive function: A study of 271 people examined the effects of energy drink consumption on mood and cognitive function. The results showed that these drinks maintained or improved performance during complex and strenuous cognitive exercises while maintaining arousal levels [10].

Source of additional nutrients: Some energy drinks contain additional nutrients such as vitamins (especially B vitamins), minerals and amino acids, which may benefit the body and support energy metabolism. Vitamin B12, B6, niacin and riboflavin are common ingredients that may contribute to improved overall well-being.

People studying difficult fields of study, who devote a lot of time to learning or mental work, may experience improved efficiency thanks to energy drinks. Increased concentration, improved short-term memory, and improved cognitive function can be beneficial during intense and long study sessions.

A 2001 study by Alford et al. confirmed that energy drinks increase alertness and concentration in students, especially in stressful situations such as exams [11].

A 2002 study by Brice and Smith found that caffeine combined with glucose often found in energy drinks significantly improved performance on tests of memory and alertness [12].

A 2016 study by McLellan, Lieberman and Caldwell showed that students who consumed energy drinks before testing performed better on tasks requiring attention and concentration compared to a control group [13].

For some people, energy drinks can provide motivation for an active lifestyle, improving the performance and energy needed for regular exercise.

After intense physical exercise, the body needs to quickly rebuild glycogen stores. Energy drinks contain sugar, which is a quickly absorbed source of energy and can help with this process.

Additionally, energy drinks provide a quick boost of energy, which makes them a practical solution in situations of fatigue and excessive effort. In situations of sudden fatigue,

such as a long and exhausting car trip, an energy drink can quickly increase your level of alertness and reduce the risks associated with fatigue, lack of concentration and attention.

The main ingredient of energy drinks - caffeine can also have a positive effect on mood, reducing the feeling of fatigue and increasing the level of dopamine in the brain, which can lead to an increase in motivation, and thus caffeine can also have a positive effect on mood, reducing the feeling of fatigue and increasing the level of dopamine in the brain, which can lead to improved well-being.

In a study by Seifert et al. (2011) showed that the consumption of energy drinks can lead to improved mood, especially in people under stress or fatigue [1].

Smith and Rogers (2000) examined the effects of energy drinks on mood and cognitive functions. The results showed that people consuming energy drinks had better mood and higher energy levels compared to the control group [14].

Contrary to popular belief, energy drinks can have a number of positive effects on the human body if they are consumed in a short period of time and only in situations that require a quick supply of energy and improved concentration. However, remember to consume them in moderation and responsibly to minimize the potential negative health effects associated with excessive use.

4. Negative effects of consumption

Consuming excessive amounts of energy drinks can have a number of negative cardiovascular, gastrointestinal, metabolic, renal and neurological effects. The effects of energy drinks on specific systems and organs are outlined below.

4.1 Effects on the cardiovascular system

There are studies that show an acceleration of the heart rate and an increase in blood pressure after drinking excessive amounts of energetic drinks. In addition, a number of other cardiovascular disorders such as ventricular arrhythmias, atrial fibrillation were found during the study, and the ECG also showed ST-segment elevation and QT-segment prolongation [15]. As a first example, two case reports describe two healthy boys aged 14 and 16 who were found to have an episode of atrial fibrillation after consuming energy drinks [16]. As another example, two healthy adolescents aged 17 and 19 suffered a myocardial infarction that was

linked to energy drink consumption. Confirming the link between myocardial infarction and energy drink consumption is the fact that energy drink consumption has been proven to reduce endothelial function and stimulate platelet aggregation [17][18][19]. In addition, it has been proven that excessive consumption of energy drinks can lead to aneurysms, arterial dilatation, dilation and rupture of large arteries [20].

4.2 Effect on the digestive system

Sugar in energy drinks mainly comes in 3 forms: sucrose, glucose or corn syrup. The sugar content in energy drinks is relatively high and, as is well known, excessive sugar consumption can lead to type 2 diabetes and may increase the risk of obesity [21]. It has been confirmed in studies that consuming caffeine in large amounts causes a decrease in insulin sensitivity, confirmed by studies that show an increase in blood glucose after drinking an energy drink and studies in which it was confirmed that for every mg/kg of caffeine, insulin sensitivity decreases by 5.8% [22] [23] [24] . In addition, it has been proven that high consumption of energy drinks with high sugar content can impair gut bacteria genes and thus increase the risk of metabolic syndrome and obesity [25] . In addition, caffeine reduces the tension of the lower esophageal sphincter which can lead to heartburn and gastroesophageal reflux [26][27].

Another important aspect is the effect of the drinks on dentition. There was a study that showed a high correlation between the frequent consumption of energy drinks and the destruction of teeth. The main culprit for tooth erosion was the high sugar content and low pH of energy drinks [28] [29] . Li H estimated that the incidence of dental erosion is as much as 2.4 times higher in people who frequently consume energy drinks compared to those who do not or consume them very occasionally [30].

4.3 Effects on the excretory system

Energy drinks also affect the excretory system. The caffeine in energy drinks has been proven to have a diuretic effect [31]. Taking large amounts of caffeine during very intense and prolonged exercise in a hot environment should be avoided, as this can result in dehydration. In addition, the increase in diuresis by caffeine leads to excessive excretion of electrolytes (mainly sodium) which affects plasma volume, thereby affecting the cardiovascular system during exercise [32].

A case is described of a man in his 40s who had been consuming energy drinks daily for about three weeks. This led to acute kidney damage. Testing of the man's creatinine concentration showed values 5 times higher than those of a healthy man, but just 2 days after he stopped consuming energy drinks, it returned to reference values [33].

4.4 Effects on the nervous system

The negative effects on the central nervous system include restlessness, irritability and tremor, confusion, stress, hypervigilance, and even an altered mental state, depression [8] [27] [34]. Studies have shown an increased frequency of manic episodes in patients with bipolar disorder following the consumption of energy drinks. It is believed that caffeine can lead to excessive brain excitability. One common side effect of daily energy drink consumption is chronic headaches caused by hyperactivity of the cerebral cortex. Energy drinks significantly affect both the quality, quantity and length of sleep [35] [36]. A link has also been shown between energy drink consumption and suicidal thoughts and the occurrence of depressive episodes [37] [38]. Combining energy drinks with drugs that affect the nervous system is unpredictable and highly dangerous [1].

Cases are described of excessive consumption of energy drinks that ended in death, newly diagnosed epilepsy and serious cardiac arrhythmias [39].

5. Social aspect and regulation

Data from 2001-2010 presented by the National and Nutrition Examination Survey shows that in the U.S., caffeine is consumed by as much as 89% of the population over the age of 19, with an average per capita consumption of 186 ± 4 mg. [40]. At the beginning of the current century, coffee was the main source of caffeine, accounting for 64% of total caffeine consumption, followed by soft drinks at 18%, closely followed by tea at 16%, and energy

drinks accounted for less than 1% of one percent of total caffeine consumption. Although energy drinks accounted for less than 1% of total consumption in 2001-2002, a marked increase in the consumption of caffeine contained in energy drinks could be noted throughout the first decade (2001-2010) [40]. In the United States of America, 30-50% of teens and young adults say they consume energy drinks [1]. About 6% of adolescents admit to consuming energy drinks daily [41]. A survey conducted by the European Food Safety Authority (EFSA) in 16 countries found that teenagers were the largest group consuming energy drinks - 68%. Adults accounted for 30% of energy drink consumers, and children 18% [3].

The main factors, according to young people, that motivate them to reach for energy drinks in the first place are: the desire to maximize their athletic performance, reduce feelings of drowsiness while studying, and act as a "recharge" during the party [36] [42] [43]. An additional element that encourages people to reach for energy drinks is that they are advertised as means that will strengthen, concentration, strength, add energy, accelerate learning, in other words "gives you wings". Another motivator to reach for energy drinks, especially among young people, are very flashy, colorful and inviting packaging and names [44].

It is also dangerous to combine energy drinks with alcoholic beverages [45]. People often combine energy drinks with alcohol because of perceived benefits such as increased energy, improved mood, prolonged partying, or increased endurance in alcohol consumption. For many, this combination is appealing because of the longing for stimulation and euphoria that can accompany the consumption of alcohol and caffeine. Studies show that combining alcohol with energy drinks is more risky to health than consuming them separately. An additional problem is that when a drink with caffeine, is combined with alcohol, there is an intensified desire to consume more alcohol. The study shows that among a group of 4271 students, in the past 30 days, as many as 697 of them consumed energy drinks with an alcoholic beverage, accounting for 24% of those surveyed [46]. Combining energy drinks with alcohol can increase the risk of side effects such as irregular heart rate, difficulty breathing or increased excitability. Studies also suggest that this combination may lead to a higher risk of health consequences such as hypertension, heart problems, and sleep disturbances.

There have been cases of death or serious injury after consuming more energy drinks. In 2022, a 21-year-old woman with a heart condition died after consuming lemonade with a high caffeine content, which led to arrhythmia and then cardiac arrest [47].

Another example is a 28-year-old man who drank 750ml of energy drink before a basketball game. Even before the game started, he felt palpitations and nausea. During a break in the match, he lost consciousness. He only regained normal heart action in the hospital thanks to a cardioversion procedure. Unfortunately, after three days in the hospital, he died [48].

Due to the growing popularity of energy drinks among young people, as well as concerns about their harmful effects, some European countries have banned their sale to people under 18, these countries include Poland, Lithuania, Latvia, Chechnya, among others [44] [49] [50]. In 2010, the FDA banned the sale of four brands of alcoholic beverages containing caffeine. It motivated its decision by concerns that combining caffeine with alcohol could lead to easier alcohol poisoning [51]. The Mexican government made a similar decision in 2011, banning the sale of alcoholic beverages mixed with energy drinks [52].

6. Conclusions

Energy drinks are becoming increasingly popular, especially among adolescents and children. They are tasty, come in colorful packaging and promise an energy boost, which makes them attractive especially to the younger population. In addition, drinking energy drinks in the midst of children seems to give them a sense of adulthood. Due to their prevalence and the substances they contain, their effects on health, especially among adolescents and children, should be studied. Studies clearly do not indicate that positive effects outweigh negative ones. In addition, excessive consumption of large amounts of caffeine found in energy drinks causes a number of negative effects. Their excessive consumption can lead to heart problems, anxiety, insomnia and addiction. It can also cause tooth decay and weight gain. Also, the aspect of consuming energy drinks along with alcoholic beverages seems worrisome, which is a common activity at young adult parties. Stopping the trend of drinking energy drinks and clearly emphasizing the harm resulting from drinking them is necessary to prevent damage to the body, especially for younger people, because the consequences can be tragic. Regulations, further actions and restrictions are required to reduce the availability and consumption of energy drinks especially in children

and adolescents. An effective method seems to be to educate children and make young people aware of the negative effects of excessive consumption of energy drinks. Parents' and educators help in this endeavor is also necessary. They must take an active part in making children aware of the harmfulness of energy drinks and exercise control over their purchases. The younger population may not realize how damaging the consumption of these drinks is to their health. In addition, some young adults may be aware of the harm of consuming large amounts of energy drinks, but may not be aware that combining alcohol with energy drinks amplifies the negative effects of consuming energy drinks. Peer influence and following trends can just motivate them to engage in these unhealthy behaviors. We must make people aware that in order to increase their energy, it is better to choose natural methods, such as regular exercise, a healthy diet and an adequate amount of sleep. As can be seen in the presented work, the consumption of energy drinks is an extremely important problem on a global scale, but together we can reduce the problem by educating others and presenting scientific facts confirming the dangers of their frequent consumption.

Disclosure

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