

Review

Some Popular Energy Shots and Their Ingredients: Are They Safe and Should They Be Used? A Literature Review

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Abstract: The current demanding and busy lifestyle has spawned the development of supplements that are marketed as energy and concentration boosters. Energy shots are one of the most popular such supplements due to their small volume and efficient packaging. The components of energy shots have very limited evidence supporting their effects, and their efficacy is not consistently proven. This literature review from the past 40 years utilized PubMed, MEDLINE, SCOPUS and EMBASE, using the following keywords: ‘energy beverage’, ‘energy drink’, ‘energy shot’, ‘power shot’, ‘power energy’, ‘exercise’, ‘caffeine’, ‘glucose’, ‘ginseng’, ‘guarana’, ‘L-tyrosine’, ‘green tea extract’, ‘quercetin’, ‘garcinia cambogia extract’, ‘yerba mate’, and ‘taurine’. The effects of each ingredient individually, as well as of energy shots in general, were summarized, and recommendations on use and safety of energy shots are provided.

Keywords: energy shots; 5-hour Energy; caffeine; energy boost shot; power shot; exercise; taurine

1. Introduction

The popularity of energy shots has increased over the years, especially amongst active teenagers, younger adults, and military recruits [1,2]. The reason for that is their marketing promotes these products to increase energy levels and mental alertness.

There are a great variety of energy shots available, and most have their own proprietary “energy blend”, which usually includes caffeine, B complex vitamins, taurine, ginseng, glucuronic acid, L-tyrosine, guarana extract, green tea extract, and other stimulants [3]. Despite the many energy shots on the market, 5-hour Energy shot is by far the most popular one in the US based on sales [4].

Most energy shots, including those discussed in this review (5-hour Energy, Stacker 2 Energy Shot, and Eternal Energy Shot) are marketed as dietary supplements. Although the FDA regulates both dietary supplements under the Federal Food, Drug, and Cosmetic Act (FFDCA), the requirements for these products are different, including the process for marketing and reporting of adverse events post-marketing. Specifically, dietary supplements require adverse events reporting, but contents not as strictly controlled, which provides manufacturers with loopholes regarding their specific contents, especially the amount of caffeine. As a society, we should consider legislation to re-label these products as “foods and beverages” so they are subject to higher FDA standards of safety and efficacy [5]. Unfortunately, many of the available studies on energy drinks are biased, have few participants, and have other issues of study design rendering solid conclusions difficult in many instances. Despite these shortcomings, we have attempted to summarize the available literature as best we can.

The purpose of this review is to describe the major ingredients of energy shots and discuss their safety and efficacy.

2. Methods

A search of the literature on databases such as PubMed, MEDLINE and EMBASE was performed for the period between January 1976 and November 2017. In addition, the Google Search engine was used for further information about the products analyzed on this review. The following keywords were used in this search: 'energy beverage', 'energy drink', 'energy shot', 'power shot', 'power energy', 'exercise', 'caffeine', 'glucose', 'ginseng', 'guarana', 'L-tyrosine', 'green tea extract', 'quercetin', 'garcinia cambogia extract', 'yerba mate', and 'taurine'. The selection was based on keywords found on peer-reviewed articles and research on energy beverages and energy shots. The goal was to include updated information on energy shots and provide recommendations to the athletic and general population.

3. Ingredients of Energy Shots

Table 1 includes a listing of the ingredients of popular energy shots as reported on their labels. We will now discuss in detail the main components of popular energy shots.

3.1. Caffeine

In our literature review, we noted that caffeine may have a stimulatory effect, a relaxation effect, or no effect in regards to sport performance [6].

For about 90 percent of the adult population, daily caffeine consumption, mainly via coffee or tea, is used to improve concentration and alertness. Caffeine stimulates both the peripheral and central nervous system via its effect on antagonizing the adenosine receptor [7]. Increased heart rate and blood pressure are the most common cardiovascular effects of caffeine ingestion. However, too much caffeine, especially in caffeine naïve, sensitive, or younger people can result in side effects. Studies have shown that ingestion of more than 200 mg of this stimulant can lead to nervousness, tachycardia, insomnia, nausea, arrhythmia, and headache [8,9]. With regards to insomnia, studies have shown that ingestion of four to five cups of tea or coffee per day (approximately 240 mg) the relative risk of experiencing insomnia is 1.4 when compared to individuals that abstain from caffeine [9]. When it comes to athletic performance and caffeine ingestion, the literature does contain studies that confirm the ergogenic potential of caffeine [6,10]. For example, a notable effect has been observed on the anaerobic running capacity that caffeine appears to exert in endurance athletes when taken in moderate quantities before or during running. That beneficial effect can be maximized when the athlete has abstained from caffeine intake seven days before using caffeine [6]. These effects, along with the effects of caffeine described by Glaister et al. and Schneiker et al. in regards to increase in intermittent sprinting [11,12], suggest that caffeine increases power output and decreases the feeling of fatigue. Of note, the International Olympic Committee includes caffeine in the list of banned substances. The oral bioavailability of caffeine has been tested by Blanchard and Sawers who showed that oral absorption is very rapid with a peak plasma concentration after about 30 min. However, this study showed variability in regards to plasma half-life and elimination amongst participants [13].

Table 1. Popular energy shot ingredients as reported on the label.

Ingredient	5-hour Energy Shot	Stacker 2 Energy Shot	Eternal Energy Shot
Caffeine	230 mg	Part of 2125 mg Energy Blend	Part of 2100 mg Energy Blend
Taurine	Part of 1870 mg Energy Blend	Part of 2125 mg Energy Blend	Part of 2100 mg Energy Blend
Vitamin C	No	No	111.1 mg (184.8% of RDA *)
Niacin	40 mg (200% of RDA *)	20 mg (100% of RDA *)	33.33 mg (166.67% of RDA *)
Vitamin B6	40 mg (2000% of RDA *)	40 mg (2000% of RDA *)	40.4 mg (2020% of RDA *)
Folic Acid	100 mcg (100% of RDA *)	400 mcg (100% of RDA *)	404 mcg (101% of RDA *)
Vitamin B12	500 mcg (8333% of RDA *)	500 mcg (8333% of RDA *)	505 mcg (8416% of RDA *)
Glucuronolactone	Part of 1870 mg Energy Blend	Part of 2125 mg Energy Blend	Part of 2100 mg Energy Blend
L-Tyrosine	Part of 1870 mg Energy Blend	Part of 2125 mg Energy Blend	Part of 2100 mg Energy Blend
Yerba mate extract	No	No	Part of 2100 mg Energy Blend
Garcinia cambogia extract	No	No	Part of 2100 mg Energy Blend
Guarana extract	No	No	Part of 2100 mg Energy Blend
Green tea extract	No	No	Part of 2100 mg Energy Blend
Quercetin	No	No	Part of 2100 mg Energy Blend
Citicoline	Part of 1870 mg Energy Blend	No	No
Sodium	18 mg (<1% of RDA *)	Not listed	10.1 mg (1.01% of RDA *)
L-Phenylalanine	Part of 1870 mg Energy Blend	Part of 2125 mg Energy Blend	No
Natural flavors	Yes	Yes	Yes
Artificial flavors	Yes	Yes	No
Sodium benzoate	Yes	Yes	Yes
Potassium sorbate	Yes	Yes	Yes
Sucralose	Yes	Yes	Yes
Polyphenols	No	No	Yes
Riboflavin	No	No	Yes
L-Glutathione	No	No	Yes
Water	Yes	Yes	Yes

* RDA: Recommended dietary allowance based on 2000 Calorie diet.

Furthermore, to support the 'antifatigue' properties of caffeine, certain studies measured muscle glycogen levels during exercise. The participants of these studies were able to exercise longer before over the point of physical exhaustion. That effect was attributed to caffeine's reduction of glycogen utilization up to 50 percent during the first 15 minutes of exercise [14]. Mechanistically, caffeine binds to adenosine receptors on the surface of heart muscles and that allows for mimicry of the epinephrine effects, resulting in positive chronotropy and inotropy [15]. Furthermore, the adenosine receptor binding by caffeine increases peripheral vascular resistance, which translates to increases in systolic and diastolic blood pressures [16]. Finally, caffeine can act as a diuretic [17,18]. However, the human body becomes tolerant to this effect within three to five days of regular caffeine intake, thus limiting the observed diuretic effect of caffeine [19–22].

3.2. Taurine

Taurine which is naturally found in the body as a lipid-membrane stabilizer, is a sulfur-containing amino acid. It has been described to aid in the antioxidant defenses of the mammalian system, and is abundant in human diet. The plasma half-life and the ration of clearance to its availability show less variability than caffeine. Specifically, a study of the pharmacokinetics found a half-life of one hour and a clearance to bioavailability ration of 21 L/h [23]. Aside from the antioxidant properties, taurine appears to modulate skeletal muscle's contractile function. It may also attenuate exercise-induced DNA damage, and there is limited data suggest taurine may improve performance and exercise capacity [24]. A double-blinded study looked at taurine's effect on endurance performance and metabolism. Specifically, trained cyclists between 18–29 years old, were subjected to an exercise protocol that involved 90 minutes of submaximal cycling that was followed immediately by a time trial, 1.66 g of taurine failed to impact performance parameters yet increased fat oxidation during the submaximal cycle by 17 percent although this amounted to 5 g of fat or 20 kcal [25]. In conclusion, taurine may improve osmoregulation, along with cell membrane stabilization and detoxification effects [26]. Popular energy shots that we investigated contain little amounts of taurine that are not expected to have such therapeutic effects that have been proposed by the current literature [8].

3.3. Glucuronolactone

Glucuronolactone is a sugar acid that occurs naturally in the body when glucose is catabolized by the liver. It is also a precursor of ascorbic acid, and therefore it is believed to aid in detoxification and biosynthesis of vitamin C [27]. However, there is evidence that glucuronolactone may promote elimination of carcinogens and tumor promoters through the body's natural defense mechanisms [28]. Studies have shown that glucuronolactone supplementation with 1–3 g per day, can increase in energy and alertness [29]. However, in those studies, glucuronolactone was not studied alone, but rather as an ingredient in products that also contained caffeine and taurine. Therefore, clear evidence does not conclusively support the benefits of this supplement.

3.4. B Vitamins

The role of the complex B vitamins on mitochondrial function and energy production has been well established [30]. The B vitamin complex is composed of the water-soluble vitamins B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), and B12 (cobalamin). Their primary role is to work as co-enzymes in many metabolic reactions [31]. According to Table 1, energy shots mainly contain Vitamin B2, Vitamin B3, Vitamin B6, and Vitamin B12.

Vitamin B2 is necessary for the synthesis of the co-factors FAD and FMN which are essential for the metabolic reactions and energy production [32,33].

Vitamin B3 is a precursor to the nicotinamide adenine dinucleotide (NAD⁺) which later can be converted to NADH and NADPH. These forms act as cofactors in oxidation/reduction reactions [34]. One of the most studied and most significant effects of Niacin is that of increasing the concentration of HDL cholesterol. However, a marked decrease in cardiovascular events has not been established [35].

Vitamin B6 is a cofactor in metabolic reactions such as gluconeogenesis and glycogenolysis [36]. Additionally, due its role in the synthesis of neurotransmitters, it is considered to affect cognitive function, but there is no strong evidence to support it [37].

Vitamin B12 is a very important co-factor in DNA synthesis. It has been well established that deficiency in vitamin B12 can lead to macrocytic anemia, and replenishing vitamin B12 can reverse it. However, there is no evidence that supplementing vitamin B12 in healthy individuals would have any benefit in their energy levels [38].

In general, due to their water solubility, the B vitamins are easily absorbed by the body, and excessive amounts are excreted by the kidneys. Some of the side effects that have been reported are flushing and upset stomach that is associated with niacin and peripheral nerve damage and pain associated with vitamin B-6. Achieving toxic levels would require ingestion of very large amounts of these vitamins, which are significantly more than what is contained in the popular energy shots [39].

3.5. Guarana

Guarana (*Paullinia cupana*) is a plant found in the Amazon. The locals have been using its fruits for years due to their beneficial effect on energy levels, awareness, and increased metabolism. Guarana seeds have four times the caffeine included in arabica coffee beans. A study using the planarian flatworm model showed that guarana provided additional locomotor stimulation over caffeine alone, but the stimulant effect was only short-term [40]. Another study, done on 56 human subjects, suggested that multi-vitamins with added guarana improved decision-making performance along with a stable autonomic regulation in the 1 h after ingestion [41]. Guarana also contains the stimulants theobromine and theophylline [42]. It is worth noting that guarana extract overdose can lead to caffeine poisoning and atrial fibrillation [43]. However, the amounts contained in a single energy shot are very limited and below the levels that would have such effects [8]. However, consuming multiple energy shots could result in side effects, especially in vulnerable populations.

3.6. Ginseng

Ginseng is an herbal supplement that has been used for centuries, most notably within Chinese medicine. It refers to Asian and American ginseng, both of which contain ginsenosides. It is considered an adaptogenic herb, since it is thought to boost the immune system, manage a healthy weight, encourage a balanced mood, and increase the body's resistance to stress and trauma [44,45]. A systematic review of 44 studies on ginseng's cardiovascular function, glucose metabolism, anti-oxidation, and anti-fatigue function, were inconclusive regarding its benefits. The main adverse effects reported were mild and included hot flushes, insomnia, and dyspepsia [46].

3.7. L-Tyrosine

L-Tyrosine is an amino acid involved in the pathways of dopamine and adrenaline production. Therefore, it is believed that further supplementation with this amino acid will eventually lead in increased production of adrenaline and dopamine. There is no experimental evidence of L-Tyrosine's effect on fatigue, on noradrenaline levels during stress [47,48]. According to The Code of Federal Regulations Title 21, L-Tyrosine is categorized as 'Generally Recognized as Safe' in the USA. Dosages used in different studies vary from 2 grams to 20 grams daily. However, there is not significant data on dosage and long-term use in healthy people, and its use cannot be recommended based on current literature [49].

3.8. Green Tea Extract

Green tea is extracted from the leaves of the plant *Camellia Sinensis*. The bioavailability of its catechins is less than 2% in humans [50]. Green tea extract has been studied for its effects on metabolism (minor fat reducing effect) and cognition. Of note, a meta-analysis on the effects of green tea on body weight concluded that consuming green tea will not increase weight loss [51]. When studying its

effect on cognition, a double-blind placebo study done on 45 subjects with mild cognitive impairment showed some beneficial effect [52]. However, another study done on healthy individuals showed no changes in cognition [53]. Overall, the studies in regard to green tea extract efficacy are inconclusive.

3.9. *Garcinia Cambogia Extract*

Garcinia cambogia, also known as Pazham or Bitter Kola is a plant that is usually used in culinary as a flavor enhancer. It is believed that *Garcinia Cambogia* may help with weight loss and lipid metabolism, but this is not supported by current research [54,55].

3.10. *Yerba Mate*

Yerba mate is a tea that is primarily used in South America [56]. Yerba mate contains caffeine (17.5 mg/gram) as well as flavonoids (Quercetin and Rutin) amongst other molecules [57]. Due to its caffeine content, yerba mate is marketed as an appetite suppressant and weight loss agent. A double-blind placebo controlled study done in 44 healthy, overweight patients showed significant weight loss and delayed gastric emptying in those who consumed the yerba mate capsules [58]. Another study showed that yerba mate supplementation can increase fatty acid oxidation during exercise [59].

3.11. *Sugars*

Glucose is the main source of energy for the human body and the brain. Therefore, adequate sugar intake is very important. When exercising, the proportion of energy that comes from glucose ranges from 10–80% depending on the intensity or the duration of the activity [60]. Current literature has shown that there is benefit in supplementing carbohydrates before or during exercise, but the effect depends on the type, intensity, and duration of the activity. Additionally, after exercising, it is important to replenish the glycogen storage by consuming carbohydrates, preferably in combination with protein [60].

3.12. *Antioxidants*

During exercise, the body adapts by forming reactive oxygen species, which normally work on the regulation of cell growth and proliferation, but can have adverse effects if they exist in excessive amounts. A recent literature review studying the effects of antioxidant supplementation on exercise concluded that no clear benefit has been found for the use of dietary antioxidants [61].

4. Do Energy Shots Work?

When reviewing the studies done on the effectiveness and safety of energy shots it is important to take under consideration the limitations of the current research. The majority of the studies are guided towards healthy, younger subjects, usually active college students or those enrolled in the military. Additionally, since most of the energy shots contain an 'energy blend' with unknown amount of the ingredients mentioned on the label, it is very difficult to identify if it is a specific ingredient or a combination of them, that leads to a certain effect. Finally, since the ingredients used in the energy shots are considered dietary supplements, they are not as highly regulated by the US Food and Drug Administration, thus there is no requirement for extensive research on their safety and efficacy prior to them becoming available for the consumer.

Energy shots are being marketed for their effect on improving alertness, cognitive function, and performance. In one study done on 94 partially sleep deprived, healthy subjects, the immediate effects on mood, attention, and memory after ingestion of an energy shot were compared with a matching placebo over a 6 h period. A variety of widely used automated tests were used for the assessment of each variable. The authors concluded that the energy shot moderately improved the self-reported

alertness, as well as some functions objectively measured through the tests. For some of these functions, the effect was noticeable even 6 h after the initial ingestion of the energy shot [62].

In another study, 14 healthy people in the ages of 18–29 participated in a three-session study that compared the effects of 5-hour Energy shot with a placebo or with no drink control. The effects that were studied were the self-reported state, and a behavioral control task. Also, their heart rate and blood pressure were recorded. The researchers found that the energy shots improved the subjective state, but did not improve objective performance. Most importantly, energy shot consumption resulted in an increase in both systolic and diastolic blood pressures, sustained for many hours [63].

A double-blind, random study done on 14 recreational cyclists, evaluated the effects of energy shots on response time and power output were evaluated. The subjects ingested two different energy shots, a “caffeine–carbohydrate–protein” (CFP) supplement shot and a “caffeine–taurine–niacin” (CFN) shot. A non-caloric placebo was also used as a control. The subjects alternated between a low intensity cycle for 13 min and a high output intensity 2 min cycle, for 2 h total. The results showed that the CFN shot was less beneficial compared to the CFP shot when measuring cycling power and equivocal when compared to the placebo [64].

A different randomized, double-blind, crossover study done on six male runners who consumed Guayakí Yerba Maté Organic Energy Shot™, Red Bull Energy Shot™, or a non-caloric placebo in three different trials. The athletes ran a 5-km time trial on a treadmill each time. The authors reported that no improvement was noticed with the ingestion of either energy shot, compared to the placebo [64].

Another review also concluded that ingestion of energy beverages before or during an event may lead to adverse effects including restlessness, irritability, elevated blood pressure, and dehydration [65].

5. Conclusions

Energy shots are increasing in popularity, especially in younger adults and athletes. Therefore, it behooves health care professionals, coaches, and exercise specialists to be well-informed about them and the possible risks associated with their use. Energy shots include a wide variety of ingredients that are not highly regulated by the Food and Drug Administration, and the effects of their combination has not adequately been studied. Many of the existing studies have been characterized as biased, with poor study designs and a limited number of participants, leading to difficulty in making solid conclusions. At the same time, excessive ingestion of caffeine has been shown to result in adverse effects, especially amongst certain vulnerable populations, including those younger than 18 years old, pregnant or breastfeeding women, caffeine naive or sensitive individuals, individuals taking stimulants or other caffeine-based medications, those with certain medical conditions, and/or heavy consumption patterns e.g., two or more energy shots in one session. For that conclusion to be drawn, however, more studies need to be performed in these individual groups. Current literature suggests consumption of energy shots affects the subjective perception of performance or mood, but when measured in an objective way, little or no benefit is noted. More research with appropriate clinical trials is needed to better define safety and efficacy of energy shots.

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