



# ENERGY DRINKS: Psychological Effects and Impact on Well-being and Quality of Life— A Literature Review

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## ABSTRACT

**Objective:** The market and degree of consumption of energy drinks have exponentially expanded while studies that assess their psychological effects and impact on quality of life remain in the early stages, albeit on the rise. This review aims to examine the literature for evidence of the psychological effects of energy drinks and their impact on the sense of well-being and quality of life.

**Methods:** Studies were identified through Pubmed, Medline, and PsycINFO searches from the dates of 1990 to 2011, published in English, using the keywords *energy* or *tonic drinks*, *psychological effects*, *caffeine and cognitive functions*, *mood*, *sleep*, *quality of life*, *well-being*, and *mental illness*. Three authors agreed independently on including 41 studies that met specific selection criteria.

**Results:** The literature reveals that people most commonly consume energy drinks to promote wakefulness, to increase energy, and to enhance the experience of alcohol intoxication. A number of studies reveal that individuals who consume

energy drinks with alcohol were more inclined to be involved in risk-taking behaviors. There was also excessive daytime sleepiness the day following energy drink consumption. Contrary to expectations, the impact of energy drinks on quality of life and well-being was equivocal.

**Conclusions:** Energy drinks have mixed psychological and well-being effects. There is a need to investigate the different contexts in which energy drinks are consumed and the impact on mental health, especially in the psychiatrically ill.

## INTRODUCTION

Energy drinks are a group of beverages used by consumers to provide an extra boost in energy, promote wakefulness, maintain alertness, and provide cognitive and mood enhancement. Although they seem like a new fad, these drinks have been available to the general public for some time. For instance, Red Bull (currently one of the most popular energy drinks) was introduced in Austria in 1987 and to the United States in 1997. Historically, cola soft drinks have been available in their current

caffeine-containing form since 1904, and in their original coca leaf (from which cocaine is derived) and kola nut (from which the caffeine is derived) form since 1886, with similar effects as energy drinks as they contain approximately 34mg of caffeine per 12oz can. These beverages have stimulant effects on the central nervous system (CNS) and their consumption is accompanied by an expectation of improving user's performance physically and mentally.<sup>1</sup>

Energy drinks mostly contain caffeine, taurine, l-carnitine, carbohydrates, glucuronolactone, vitamins, and other herbal supplements like ginseng and guarana among others. Additives such as guarana, yerba mate, cocoa, and kola nut may increase the caffeine content of energy drinks unbeknownst to consumers, as manufacturers of these products are not required to include the caffeine content of these herbal supplements in the nutritional information.<sup>2</sup> Different brands of energy drinks contain caffeine ranging from 50mg to 550mg per can or bottle.<sup>3</sup>

Caffeine is one of the most commonly consumed alkaloids worldwide in the form of coffee, tea, or soft drinks, and in high doses may cause abnormal stimulation of the nervous system<sup>4</sup> as well as adverse effects in the cardiovascular, hematologic, and gastrointestinal systems.<sup>2</sup> With energy drinks becoming a worldwide phenomenon, the short- and long-term effects of these beverages must be evaluated more closely in order to fully comprehend the psychological impact of these products.

The market and degree of consumption of energy drinks is increasing every year,<sup>5,6</sup> and while only few have detailed knowledge of their potential harmful physiological and psychological effects, the number of publications that have documented the potential adverse risks associated with the use of these beverages remains small.<sup>7</sup> Whereas most studies to date have examined

the physiological effects of energy drinks, this article reviews and compiles the body of knowledge of this increasingly important topic by examining the psychological effects of energy drinks on cognitive functions, mood, sleep, decision making, and overall impact on well-being and quality of life (QOL). A list of the top selling energy drinks and contents appears in Table 1.

## METHODOLOGY

Studies were identified through Pubmed, Medline, and PsycINFO searches from the dates of 1990 to 2011, published in English, using the keywords *energy* or *tonic drinks*, *psychological effects*, *caffeine and cognitive functions*, *mood*, *sleep*, *quality of life*, *well-being*, and *mental illness*. The identified articles were then reviewed. Inclusion criteria were publication in English; peer-reviewed journal; and a study, of any design, focusing on energy drink consumption and its effects on quality of life and psychological functioning. The titles and abstracts identified by the first search were read by authors CU and WI. The two authors agreed independently on selected studies. Data were extracted by authors CU, CZ, and KB and checked for accuracy by authors WI, KB, and DK. Each selected study or article was analyzed by type of study, number of persons, age, psychological effects, main ingredient or type of energy drink consumed, and frequency or quantity consumed.

## RESULTS

Due to the large and nonspecific number of search results (838) obtained via a Pubmed search using the search term *energy drinks* (yielding 817 articles) and *tonic drinks* (yielding 21 articles), the authors used more specific search terms to target the subject of this review. Search terms that had greater specificity included *energy drinks and* and the following: *psychological effects* (9 articles), *cognitive function* (13 articles),

*mood* (58 articles), *sleep* (12 articles), *quality of life* (11 articles), and *well-being* (108 articles). Of the 11 articles found using the term *energy drinks and quality of life*, none specifically addressed the effect of energy drinks on QOL, thus they were excluded from this review. Following this extensive literature search, 41 articles were included as they were clinical trials or reviews that demonstrated a clear effect of an ingredient or several ingredients in energy drinks on QoL as it relates to psychological functioning.

Most energy drinks contain caffeine, which is a stimulant. Studies researching taurine, one of the other ingredients in energy drinks, revealed that it may interact negatively with caffeine and alcohol due to its effect on cell volume and renal-mediated transport.<sup>8</sup> Schoffl et al<sup>8</sup> illustrate this negative interaction in a case study where a patient consumed an energy drink-alcohol mix containing 4,600mg of taurine, 780mg caffeine, and vodka with resultant acute renal failure. Thus the effects of interactions between the components in energy drinks seem to be as important to study as the effect of each single ingredient.

Several studies have evaluated the specific ingredients in these beverages for potential benefits. A double-blind, randomized, controlled study by Childs et al<sup>9</sup> sought to find the beneficial role of caffeine. Participants were asked to stay awake from 5pm to 5am, with the treatment group receiving a 200mg caffeine-containing supplement and the control group receiving placebo at 3:30am. Computer tasks and mood questionnaires were completed by participants at the beginning of the trial (5pm) and twice following a period of sleep deprivation, once prior to the administration of the supplement/placebo and once following. Despite experiencing prolonged wakefulness, subjects that received the caffeine pill had significantly improved reaction times when completing the computer tasks and questionnaires. In addition to

cognitive performance, the subjective mood state of participants also seemed to improve with the help of the caffeine supplement.<sup>9</sup> Again, this research trial is limited, as it did not study energy drinks as a whole but only one of its main ingredients. In attempting to replicate this study, the authors of this review article propose that subjects are given an energy drink with predetermined amounts of caffeine to consume while performing the tasks designed for this trial.

In a study by Clauson et al,<sup>10</sup> the authors attempted to link the various ingredients in energy drinks to potential beneficial or adverse effects. In studying this specific aspect of the beverages and identifying these potential links, the authors hypothesized that they would be better able to evaluate whether the amount of specific ingredients contributed to the elucidated benefits or adverse effects. After identifying what they found to be the most common risks (insomnia, nervousness, headache, and tachycardia), the authors also reported the finding of four documented case reports of caffeine-associated deaths, as well as four separate cases of seizures associated with the consumption of energy drinks.<sup>10</sup> However, the authors were quick to point out that the amounts of ginseng, taurine, and guarana found in these beverages are less than the amounts thought to beget any harmful reaction or curative benefit. While this might be true of the above ingredients, the authors concluded that the amount of sugar and caffeine represented in these beverages is beyond that of nutritional value, to the extreme of being potentially detrimental to one's health.

**Energy drinks and cognitive functions.** Energy drinks are known to improve mental performance. For example, concentration and memory (immediate recall) improved in a study of 36 volunteers who consumed Red Bull energy drink.<sup>11</sup> A limitation of this study, however, is

**TABLE 1.** Top selling energy drinks and contents\*

CONTENTS PER SERVING	RED BULL	MONSTER	ROCKSTAR	FULL THROTTLE	SOBE NO FEAR
Caffeine	80mg	80mg	80mg	141mg	32mg
Taurine	ND	1000mg	1000mg	ND	ND
Guarana	ND	ND	25mg	ND	ND
Sugar	27g	27g	31g	57g	27g
Sodium	200mg	180mg	40mg	160mg	15mg
Vitamin B6	5mg	2mg	2mg	4mg	ND

ND=not disclosed

\*These contents are per the nutritional labels on the energy drink containers and per [www.dietfacts.com](http://www.dietfacts.com)

that it does not address the questions of how each component of energy drinks, the combination of ingredients, or the differing concentrations of individual components have differential effects on consumers.

Three studies published in two articles by Kennedy and Scholey demonstrate the positive effects of energy drinks on cognitive performance.<sup>12,13</sup> In the first article, they showed that combinations of caffeine and glucose may improve cognitive performance and self-reported fatigue during extensive periods in which high cognition is required.<sup>12</sup> These double-blind, placebo-controlled, cross-over studies asked subjects to complete Serial 3s and Serial 7s subtraction tasks and a five-minute version of the Rapid Visual Information Processing task (RVIP). The researchers rated subject performance a total of seven times per study, once before a drink was consumed and six times after. A total of two studies were conducted with 30 and 26 participants, respectively. In the first study, participants received, on three separate days, three drinks consisting of a combination of

glucose and a lower dose of caffeine (68g glucose/36mg caffeine), glucose and a higher dose of caffeine (68g/46mg), and placebo. In the second study, participants received two drinks on two separate occasions: a combination of 60g glucose and 30mg caffeine and a placebo. The accuracy of the RVIP performance was improved in subjects that drank the glucose-caffeine beverages. Mental fatigue was also rated lower in the sub-set of participants that received the higher dose of caffeine in the first study and those who received the glucose-caffeine beverage in the second study.

In a separate study published by the same authors, the investigators evaluated cognitive performance and mood state following administration of an energy drink as well as beverages consisting of the individual components of the energy drink.<sup>13</sup> This randomized, double-blind, balanced, five-way crossover design included 20 participants who consumed 250mL drinks containing either 37.5g glucose, 75mg caffeine, ginseng, or ginkgo biloba, a whole drink (containing all of the aforementioned substances), or a

placebo. Cognitive performance and mood were assessed for each participant in each drink condition immediately prior to drink administration and 30 minutes after. There was a seven-day washout period between each of the five groups. The study results showed that subjects randomized to receive the whole drink, as compared to those who received placebo, demonstrated significantly improved performance on “secondary memory” (a combination of delayed picture and word recognition), immediate and delayed word recall, and “speed of attention” factors (simple reaction time, choice reaction time, and digit vigilance). In regard to the individual components of the drinks, none led to significantly improved performance on tasks assessed, but caffeine alone demonstrated a trend toward significance on quality of memory, delayed word recognition, and accuracy of attention, which may be borne out with a larger study sample. There were no significant differences between groups on measures of mood. The investigators concluded that evidence from this study suggests some connection exists between the cognition-modulating effects of glucose and caffeine.<sup>13</sup> While their conclusions provide further evidence of the benefits of these beverages, the authors do suggest that more studies are performed to further validate these findings.

The effect of energy drinks on cognitive function was indirectly measured in a study<sup>14</sup> performed in England in which researchers asked subjects to consume energy drinks with glucose or caffeine. These were found to increase the size of the motor-evoked potential (MEP), which was used as a measure of increased cognitive function. Those drinks without caffeine or glucose did not increase MEP. This study, however, failed to determine whether the increase in MEP was due to glucose or caffeine. This would have been important since

most energy drinks contain both caffeine and glucose.

**Energy drinks and mood.** A double-blind, placebo-controlled study of 10 graduate students investigating an energy drink containing the three main ingredients found that in most energy drinks, caffeine, taurine, and glucuronate demonstrated positive effects on cognitive performance and mood.<sup>15</sup> Mood was assessed through a questionnaire that measured feelings of well-being, vitality, and social interaction, all of which were reduced in the placebo group as compared to the energy drink group.

The findings above were confirmed in a study<sup>16</sup> performed on healthy volunteers. The researchers investigated the effects of carbohydrates, carbonation, and caffeine in energy drinks with hopes of finding the benefits to their consumption. They found that these beverages improve and/or maintain mood and performance during fatiguing and cognitively demanding tasks relative to placebo.<sup>13</sup> The energy drinks also upheld levels of arousal as compared to placebo. A double-blind, mixed-measures study of 81 subjects by Sunram-Lea et al<sup>17</sup> found similar results. The authors hypothesized that energy drinks can elevate mood states in acute stress situations, such as fire-fighting training. They tested this hypothesis by administering a 50g glucose plus 40mg caffeine drink, a 10.25g glucose plus 80mg caffeine drink, or placebo to the subjects and evaluating mood and physical and cognitive performance pre- and post-consumption. Those who consumed the 50g glucose plus 40mg caffeine beverage endorsed reduced anxiety and elevated mood following the stressor of fire-fighting training.<sup>17</sup>

In a study of low-dose discrimination (lowest dose of caffeine that produced identified mood effects when compared to placebo by normal volunteers) and self-reported mood effects in normal volunteers, five of the 15 subjects acquired the caffeine versus placebo

discrimination ( $\geq 75\%$  correct) with the least amount of sessions.<sup>18</sup> Four subjects showed discrimination and self-reported mood effects at 100mg caffeine. The effect of caffeine on the mood of 35 healthy volunteers who were given 200mg of caffeine-containing supplement capsules was examined in another study.<sup>9</sup> They found an improvement in mood even in individuals experiencing fatigue. When this is compared to the 80mg of caffeine found in a can of Red Bull, one can understand why most users of energy drinks consume multiple drinks. For Red Bull, three cans contain 240mg, which is just 40mg above the 200mg found to enhance mood in the Childs study.<sup>9</sup>

#### **Energy drinks and sleep.**

Reyner and Horne<sup>19</sup> studied the effects of energy drinks on sleepiness. Their study sought to show that consuming these beverages reduced driving mistakes, such as lane swerving, and self-reported sleepiness when driving for extended periods of time. The double-blind study concluded that those who consumed a drink containing the ingredients also found in energy drinks (caffeine, taurine, sucrose, and glucose), as compared to those who were given a nonactive placebo drink, reported less sleepiness and increased alertness while driving.<sup>19</sup>

In a study of college students, 67 percent of the respondents consumed energy drinks to prevent falling asleep, 65 percent to increase energy, and 54 percent consumed the beverage to mix it with alcohol.<sup>20</sup> The study involved completion of a questionnaire-based survey in 496 randomly selected college students in the United States. Perhaps the most interesting finding in this study was that individuals who mixed their energy drinks with alcohol in a social setting had more drinks ( $\geq 3$ ) per sitting compared to those who only consumed energy drinks to prevent falling asleep or to increase energy. With such a difference in use within the same age group, there is a need for more studies to determine



situations or settings in which greater consumption of energy drinks occur.

Energy drinks can also have a negative effect on sleep, which may be modulated by caffeine. A study of 197 high school students found that 95 percent of participants reported recent caffeine use. Mixed users of caffeine and soda reported early morning awakening and daytime sleepiness compared to the low caffeine group.<sup>21</sup>

A separate study performed by Calamaro et al<sup>22</sup> found that there was a 76-percent higher consumption of energy drinks among those students who reported daytime sleepiness. The students' use of these beverages was linked to their use of modern technology gadgets late at night, therefore leading to the high consumption of energy drinks. The consumption of these beverages led to a reduction in alertness and an increase in daytime sleepiness the following day. The study suggested that the daytime sleepiness was due to high energy drink consumption the night before, but failed to address the impact of insufficient sleep the preceding evening. There is need for more detailed studies quantifying the actual number of hours slept, the amount and intensity of physical activities performed at night, and their association with energy drink consumption and daytime sleepiness. In a study conducted by Anderson et al,<sup>23</sup> the authors showed that energy drinks with low caffeine content (30mg) did not counteract sleepiness and led to lower reaction time. They also found that although high levels of glucose may have a short-term alertness-enhancing effect, in the long term they increased sleepiness in those subjects who were sleep deprived. Jay et al<sup>24</sup> investigated the effects of energy drinks on sleep hygiene following a period of wakefulness. The authors found that use of energy drinks to maintain alertness prior to an eight-hour period of recovery sleep negatively impacted total sleep time and sleep efficiency, but did not have a measurable effect on

subsequent performance. Those who consumed energy drinks prior to sleep had 29.1 minutes less sleep and sleep efficiency was decreased from 91.8±0.9 percent to 84.7±2.7 percent.<sup>24</sup>

The results on the influence of energy drinks on sleep are conflicting and further study remains to be done.

**Energy drinks and impact on decision making.** Individuals drink these beverages at various times of the day, whether it is in the morning, middle of the day, or at night. Energy drinks may be consumed alone, during a meal, or mixed with alcohol. The frequency of consumption of energy drinks and the reason for consuming alcohol may be related. The frequency of consumption of energy drinks was studied in a descriptive and cross-sectional study.<sup>25</sup> Of 137 physical education college students queried, 39.4 percent had consumed energy drinks six or more times in the last month and 87.6 percent of these users mixed it with alcohol.<sup>25</sup> The most common reason students gave for consuming energy drinks in this study was to improve the taste of alcoholic drinks.

In a cross-sectional study of 602 adolescents and young adults from universities in New York,<sup>26</sup> psychological effects, in terms of risk-taking behavior, were assessed via self-report. Frequency of energy drink consumption was positively associated with problem behaviors, particularly among Caucasian students. Across both races studied (African American and Caucasian), the increased problem behaviors exhibited were in the domains of sexually risky behaviors, marijuana use, fighting, and failure to use seat belts. Among Caucasian students, there was an additional association between frequency of energy drink consumption and prescription drug abuse, alcohol abuse, and cigarette smoking. The authors suggested that the frequency of use of energy drinks in combination with alcohol may increase one's chance of engaging in

risk-taking behaviors.<sup>26</sup> Although self-report as a method of data collection is not always reliable, several studies have corroborated these results that consuming a combination of alcohol and energy drinks is associated with increased risk-taking behavior.<sup>27-30</sup> In addition to the risk-taking behaviors mentioned in the previous study, combination alcohol and energy drink consumption has been associated with increased heavy episodic drinking and increased risk of either being taking advantage of sexually or taking advantage of others.<sup>29</sup> Of particular concern, is the association found between frequency of energy drink consumption and alcohol dependence. In a study of 1,097 college students, high-frequency energy drink consumption, defined as use 52 days or more in the past year, was associated with greater risk for developing alcohol dependence, as defined by *DSM-IV*, as compared to low frequency users and nonusers.<sup>28</sup> In a study of 802 randomly selected and self-selected patrons using anonymous interview and breath-alcohol concentration readings, it was found that the consumption of alcohol and energy drinks together increased the chances of nighttime risky behavior such as drinking and driving.<sup>31</sup> Those who only drank alcohol were less likely to drink and drive than those who drank alcohol and consumed energy drinks concurrently. This may be due to the finding that energy drinks reduced the depressant effects of alcohol intoxication.<sup>1</sup> It is not clear if the reduction in depressant effects is subjective or objective. This theory was examined in a double-blind, placebo-controlled study of 27 noncaffeine-deprived women.<sup>32</sup> Psychological effects were assessed using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS), which measures impairments in immediate memory, language, attention, visuospatial/constructional, and delayed memory. Those who consumed the energy drink and alcohol had significantly lower post-

test performance on a global score of neuropsychological status than those who drank a caffeinated beverage alone. Psychological deficits were specifically found in both visuospatial/constructional and language performance scores. These results contrast the commonly held belief of most young people that energy drinks nullify the negative effects of alcohol intoxication. In a related study, the combining effect of alcohol and energy drinks was found to subjectively reduce the perception of impairment in motor coordination and visual reaction time without any objective difference noted.<sup>33</sup> The combined consumption of alcohol and energy drinks is associated with decreased awareness of physical and cognitive impairment caused by alcohol intake, which may then lead to further alcohol consumption. Although there is a decreased awareness of impairment when these beverages are consumed together, there is no actual reduction in alcohol-induced impairment. Additionally, due to the stimulant properties of the added caffeine and the dilution of the alcohol, individuals may remain alert longer, allowing for extended time in which to consume alcohol, which in turn may lead to binge drinking. There is some evidence that at lower levels, caffeine may alleviate some of the intoxicating effects of alcohol, but at higher caffeine levels there does not appear to be any modulation of impairment.<sup>34</sup> Marczinski et al<sup>35</sup> also found that consuming a combination of alcohol and energy drinks reduced impairment of response activation/execution that is normally induced by alcohol, but the combination did not affect the alcohol-induced response inhibition portion of behavioral control.<sup>35</sup> Additionally, they found that the combination of alcohol and energy drinks was associated with increased subjective reports of stimulation. These two findings taken together—poorer behavioral/impulse control coupled with increased stimulation—may suggest that individuals drinking

alcohol-energy drink mixes may have a greater likelihood of engaging in risky behaviors. Also of concern is the perception of being less intoxicated than is actually the case while behavioral control remains impaired. As there are many studies with conflicting results on the alcohol-energy drink effect on alcohol-induced impairment, further investigation of the mechanism of action of this interaction is warranted.

**Energy drink impact on well-being and QOL.** Nutritional and tonic drinks, under which energy drinks can be classified, made up 43.1 percent of the modalities of use of complementary and alternative medicine in a Japanese study.<sup>36</sup> Though there is a common cultural/regional belief that energy drinks improve the quality of daily life, there are few studies to support this claim. This belief is not restricted to Japan. According to Smith and Atroch,<sup>37</sup> energy drinks that contain guarana have been used for hundreds of years as a tonic in countries like Brazil.

A study of the effect of the dietary supplement L-carnitine, which is among the contents found in energy drinks, showed its effects on QoL to be equivocal as measured by using the Anti-Aging QOL common questionnaire (AAQOL) in a double-blind study that involved 35 healthy volunteers.<sup>38</sup> Vitamins are also important components of energy drinks, and in a study performed to document the effects of vitamin B supplementation and walking on quality of life, improvement in QOL was found to be associated with walking but not with vitamin B supplementation.<sup>39</sup> QOL in this study was assessed using the population-specific Dementia Quality-of-Life (D-QOL) questionnaire to assess overall QOL and the generic Short-Form 12 Mental and Physical Component scales (SF12-MCS and SF-PCS) to assess health related QOL. Further research is needed to investigate the specific impact of energy drinks on QOL and wellbeing.

**Energy drinks and psychiatric patients.** The mechanism of action by which energy drinks induce or exacerbate mental illness is thought to be by way of caffeine and its effects on neurotransmitters.<sup>40</sup> Through adenosine A1 and A2A receptor antagonism, caffeine inhibits the inhibitory effects of adenosine on dopamine, thus increasing the psychoactivity of dopaminergic systems (D<sub>1</sub> and D<sub>2</sub> receptors acted on by A<sub>1</sub> and A<sub>2A</sub>, respectively)<sup>41</sup> affecting mood, executive functioning, salience attribution, cognition, and regulation of behaviors. This appears to be true as caffeine has been shown to induce manic symptoms in those without bipolar disorder, and psychosis in those without a previously diagnosed psychotic disorder.<sup>42-44</sup> These symptoms tend to resolve with discontinuation or significant reduction of caffeine consumption.<sup>42,43</sup>

It has also been hypothesized that the mechanism by which caffeine-containing energy drinks induce psychiatric relapse is via competitive binding at CYP450 sites. With increased caffeine intake, these binding sites are overwhelmed by caffeine molecules, thus inhibiting binding by psychotropic medications. By this process, many antipsychotics and antidepressants will not be metabolized, thereby inducing relapse by decreasing efficacy of psychotropic medications.<sup>45</sup>

In a case report by Cerimele, Stern, and Jutras-Aswad,<sup>46</sup> an individual diagnosed with schizophrenia was noted to experience psychotic symptoms resulting in readmission to the hospital after increased consumption of energy drinks. After his first beverage, the subject reported an increased interest in activities and improved mood. Eventually, the subject increased his consumption of energy drinks to 8 to 10 cans (16oz per can) daily. After two months, the subject was hospitalized with symptoms of paranoia, internal preoccupations, constricted affect, and delusional religious beliefs. Ten

days after hospitalization and discontinuation of the excess dietary caffeine, the degree of paranoia, preoccupations, and other psychotic symptoms displayed while consuming the energy drinks decreased to pre-study levels without an increase in maintenance antipsychotic medication.<sup>46</sup> The authors were convinced that the temporal evidence gathered by this case report demonstrates enough evidence to prove their hypothesis correct, although more studies are necessary to confirm these findings.

Chelben et al<sup>47</sup> reported on three patients who also demonstrated increased psychiatric symptomatology leading to inpatient hospitalization with use of energy drinks. The first case described a 41-year-old woman with cluster B personality traits consistent with borderline personality disorder (BPD) who drank five or more energy drinks per day for one week. Upon dissolution of monetary assets, she abruptly stopped her energy drink intake and was hospitalized the following day with signs and symptoms of hypervigilance, aggression, psychomotor agitation, and impulsivity. The second case described in this report was of a 38-year-old woman with a psychiatric history significant for comorbid bipolar disorder, BPD, and polysubstance dependence. She began drinking 5 to 10 energy drinks per day with a resultant “high, like on drugs,” and improved affective control with better control over her anger. Like the previous case, on hospital admission she exhibited impulsivity and psychomotor agitation with additional onset of self-injurious behaviors and beginning insomnia. The final case described a 25-year-old man with schizophrenia who, for one month prior to hospitalization, had been consuming 8 to 9 energy drinks in one sitting. He too exhibited signs of hypervigilance, aggression, and psychomotor agitation, as well as thoughts of self-harm. These authors also acknowledge that while the

temporal relationship between intensification of energy drink consumption and mental deterioration appears to be associated, this does not confirm a causal relationship.<sup>47</sup> However, there are several reports of caffeine-induced mania in patients with bipolar disorder<sup>40,48</sup> and suicidality in those with depression<sup>49</sup> with doses of caffeine greater than 300mg per day. At doses greater than 450mg per day, caffeine has been shown to induce or exacerbate anxiety,<sup>50</sup> especially in patients with panic disorder,<sup>51</sup> and in family studies, the same effect was detected in first-degree relatives.<sup>52</sup> Caffeine was also shown to exacerbate anxiety in depression,<sup>51</sup> generalized anxiety disorder,<sup>53</sup> and social anxiety disorder-performance subtype.<sup>54</sup> Paradoxically, in a double-blind, placebo-controlled study, Koran et al<sup>55</sup> showed that a single large dose (300mg) of caffeine daily may provide added symptom reduction when used to augment a selective serotonin reuptake inhibitor in those with treatment-resistant obsessive compulsive disorder (OCD).<sup>55</sup> Caffeine may be beneficial in OCD as compared to other anxiety disorders due to the differential symptomatology.<sup>44</sup> Whereas most anxiety disorders consist of irrational or disabling worries and fears, in OCD, individuals suffer from ruminative thoughts leading to compulsive behaviors. Koran et al<sup>55</sup> hypothesized that the caffeine-induced increase in dopamine may lead to increased D<sub>1</sub> receptor binding in the prefrontal cortex resulting in enhanced attention and working memory. Thus, individuals with OCD should be able to divert their attention away from intrusive thoughts, which then decreases reactive compulsive behaviors. By the same mechanism—increased D<sub>1</sub> activity in the prefrontal cortex—caffeine may be beneficial in attention deficit hyperactivity disorder by increasing the ability to sustain attention, resulting in decreased reaction times, enhanced

executive functioning, and increased processing speed.<sup>44</sup>

At moderate doses, defined as less than 150 to 200mg of caffeine per day, caffeine has been shown to have neuroprotective effects as well as positive effects on mental illness. Moderate intake has been associated with fewer signs and symptoms of depression,<sup>44</sup> including decreased risk of suicide,<sup>56</sup> and cognitive improvement/delay of cognitive decline.<sup>57</sup> However the mood-enhancing effect of caffeine appears only to occur in regular consumers of caffeine, whereas caffeine-naive consumers tend to derive performance-enhancing benefits.<sup>58</sup>

## DISCUSSION

This review of studies focusing on the psychological effects of energy drinks reveals several pertinent issues. There is a widespread belief that energy drinks ameliorate the negative impact of alcohol consumption, specifically cognitive impairment. Several studies have shown that this is an inaccurate assumption and can be quite dangerous if not corrected. A much-needed intervention is to educate individuals, especially adolescents and young adults who are the major consumers of energy drinks, on the dangers of combining energy drinks and alcohol. This will require educational campaigns on various levels to counteract the massive marketing campaigns of energy drink manufacturers that insinuate that energy drinks can improve mental performance without consequence. Additionally, further investigation is warranted into the various aspects of energy drink use as there is still conflicting data concerning many facets of its consumption and the interactions between components.

One reason consumers drink energy drinks is to prolong wakefulness and maintain alertness. Unbeknownst to many consumers, consequences of drinking energy drinks include excessive daytime sleepiness and reduced reaction time, negating the short-term effects.

There is a clear need to make these negative consequences known to consumers. Perhaps future studies can target a specific amount and precise combination of ingredients a consumer of these beverages could drink in order to obtain the desired effect and perform a task successfully. This way, individuals may learn to consume appropriate amounts of these beverages for the tasks they need a boost to complete.

Almost all the effects of energy drinks are related to the frequency and quantity of consumption, as well as the concentration and interaction between the contents. For example, the quantity of caffeine can vary from 50mg to 505mg per can or bottle of these beverages. As such, all energy drinks are not the same and should not be treated the same. There is a need to categorize energy drinks into one of three groups: low, moderate, or high caffeine energy drinks. One of the findings of this review indicates that psychological effects may be dose dependent, so consumers should also be encouraged to reduce the frequency of consumption. Another potential intervention is to require the manufacturers of energy drinks to fully disclose all their contents and their potential adverse effects so consumers can make more informed choices.

As there remains a dearth of literature on the effects of energy drinks on patients with psychiatric illness, save for scattered case reports, the short- and long-term effects on these individuals' mental health remains unknown. But based on the four aforementioned case studies, it appears that energy drinks may trigger acute psychiatric decompensation as manifested by increased hypervigilance and alertness, psychomotor agitation, exacerbation of psychosis, and self-harm behaviors leading to inpatient hospitalization. Further studies are needed to elucidate whether it is the frequency or amount of use, the type of energy drink, or the individual or combination of components that

have the greatest impact on mental health. Also, further investigation is needed to evaluate the desired effects sought by consumers as they may vary differentially in those with mental illness as compared to those without. The literature does suggest that individuals with mental health issues may use energy drinks as a form of self-medication as has been shown with other types of cognitive and mood altering substances.<sup>47</sup> Additionally those with mental illness, given their vulnerability, may be predisposed by virtue of their underlying illness to respond differentially, positively and negatively, to energy drinks as purported mood- and cognitive-enhancing substances.

Given the positive and negative effects of energy drinks referenced above, there is no doubt that these beverages may provide consumers with temporary benefits, including increased cognitive performance, increased or maintained mood, more physical energy, and promotion of wakefulness. However, while these beverages may provide a quick fix to temporary difficulties faced by the consumers, the prolonged and continued use of these drinks may affect the QoL of an individual. The question may be what QoL measures could be used for more accurate assessment. Therefore, there is need for more studies to quantify the effects on QOL using measures like SF-36, EQ-5D, WHOQOL, or QLESQ. This will allow for different domains of QOL to be assessed in order to better understand the general feeling of well being engendered by energy drink consumption.

The limitations of this review include the paucity of studies examining the differential effects of various energy drinks. Moreover, it was difficult to distinguish effects of caffeine from the other contents of energy drinks as it is one of the main ingredients in most energy drinks.

## CONCLUSION

While some studies have found that energy drinks might have a

positive temporary impact on concentration and memory, there was no evidence to support the claim that energy drinks improve the sense of well-being or QOL. More research and increased public awareness is needed to bring about a greater understanding of their effects. There is a need for more stringent labeling of energy drinks so that the consumer knows the exact quantity of each ingredient. This is especially important since one of the findings of this review is that the psychological effects of energy drinks could be dose dependent. There is also a need for more studies to examine the consumption patterns of energy drink users since the quantity and frequency of consumption influence the psychological effects of energy drinks. As the number of users of energy drinks has been growing rapidly since the introduction of these beverages in 1997, it is crucial for science to keep up with understanding the psychological effects of public trends.

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