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Feature Article

Energy Drinks: A New Health Hazard for Adolescents

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A new hazard for adolescents is the negative health effects of energy drink consumption. Adolescents are consuming these types of drinks at an alarming amount and rate. Specific effects that have been reported by adolescents include jitteriness, nervousness, dizziness, the inability to focus, difficulty concentrating, gastrointestinal upset, and insomnia. Health care providers report that they have seen the following effects from the consumption of energy drinks: dehydration, accelerated heart rates, anxiety, seizures, acute mania, and strokes. This article is a comprehensive literature review on the health effects of energy drinks. Findings from this article indicate the need for educational intervention to inform adolescents of the consequences of consuming these popular drinks. School nurses are in a unique position to teach adolescents about the side effects and possible health issues that can occur when energy drinks are consumed.

Keywords: energy drinks; caffeine use; stimulants; health hazards; adolescents

BACKGROUND

High-energy drinks are rapidly becoming a public health issue. Schools across the United States have reported students becoming ill after...
consuming energy drinks (Crane, 2009). Teens have reported feeling jittery, dizzy, and not being able to focus (Bramstedt, 2007; Finnegan, 2003). As a result of the consumption of these types of drinks, a number of adolescents have had to go to emergency departments because they have suffered adverse health effects (Bramstedt, 2007). U.S. scientists have found that these energy drinks contain enough stimulant ingredients to cause anxiety, insomnia, dehydration, gastrointestinal upset, nervousness, flushed face, diuresis, and accelerated heart rates (Candow, Kleisinger, Grenier, & Dorsch, 2009; Iyadurai & Chung, 2007). The consumption of energy drinks has been linked to seizures, acute mania, and strokes (Iyadurai & Chung, 2007). Deaths attributed to energy drink consumption have been reported in Australia, Ireland, and Sweden (Reissig et al., 2009). Because energy drinks have only recently attained prominence in the adolescent market, few published studies have yet examined their implications for public health.

Energy drinks were first introduced to the market in 1987 and since then their growth worldwide has been enormous. These stimulant drinks typically contain caffeine, guarana, taurine, glucuronolactone, and B vitamins. There is no concrete definition of what an energy drink is (Finnegan, 2003). Hundreds of brands are now marketed, with caffeine content ranging from 50 mg to over 500 mg per can or bottle. The United States leads the world in total volume sales of these drinks (Reissig et al., 2009). They first appeared in Europe and Asia in the 1960s, in Austria around 1987, and in the United States in 1997. The acute and long-term effects from excessive and chronic consumption of these drinks alone and in combination with caffeine are not fully known.

Caffeine is the main ingredient in the majority of energy drinks that adolescents consume (Crane, 2009). Caffeine is a stimulant that affects the body by jolting the central nervous system (Heatherley, Hancock, & Rogers, 2006). It is a natural alkaloid methylxanthine, which is 99% absorbed after oral ingestion (Anderson & Horne, 2006). Caffeine increases intracellular calcium concentrations, causing noradrenaline release and sensitizes dopamine receptors (Rockett & Putnam, 2002). The energizing effect comes from caffeine’s ability to block adenosine from signaling the brain that the body needs to rest. The result is that caffeine tricks the brain into thinking that it is not tired. While the caffeine does keep individuals awake, it can also lead to adverse health effects such as anxiety, increased blood pressure, and an accelerated heart rate (Rockett & Putnam, 2002). Other active ingredients found in energy drinks include guarana, sucrose, glucose, taurine, glucuronolactone, vitamins, flavorings, other herbal supplements, and coloring. These ingredients provide a short-term energy boost and do not constitute suitable sources of rehydration or restoration of electrolytes (Miller, 2008a).

**SIGNIFICANCE FOR SCHOOL NURSING**

Adolescents who have been consuming caffeinated products for less time than adults are prime candidates to experience adverse health effects. They have not built up as much of a tolerance to caffeine compared to some adults who have had years of caffeine consumption (Malinauskas, Aeby, Overton, Carpenter-Abey, & Barber-Heidal, 2007). As a result of decreased tolerance, they are at more risk for caffeine intoxication due to an absence of caffeine tolerance (Finnegan, 2003). Caffeine intoxication is defined by specific symptoms that emerge as a direct result of caffeine consumption (Finnegan, 2003). Genetic factors may also contribute to an adolescent’s vulnerability to caffeine-related disorders including dependence and withdrawal (Shapiro, 2007). Caffeine overdose may be increased for abstainers of caffeine as well as those who consume caffeine habitually (Shapiro, 2007). The potential for acute caffeine toxicity may be greater than other dietary sources of caffeine.

The United States Food and Drug Administration (FDA) recommends that drinks contain no more than 65 mg of caffeine per 12 ounces (Rush, Schulz, Obolonkin, Simmons, & Plank, 2006). Most soft drinks fall into this suggested limit; however, energy drinks contain much higher amounts of caffeine (Rush et al., 2006). Regulation of energy drinks, including content labeling and health warnings differs across countries, with some of the most lax regulatory requirements in the United States (Crane, 2009). Energy drinks are not required to have labeling that discloses the amount of caffeine because they are marketed as dietary supplements rather than beverages.
The FDA does not have the authority to require warning labels on the hundreds of energy drinks on the market. It is up to the manufacturer for ensuring that its products are safe (Miller, 2008a).

Energy drinks are the fastest growing sector of the U.S. beverage industry (Bramstedt, 2007). The U.S. market for energy drinks was estimated at $5.4 billion in 2007 and is growing at an annual rate of 55% per year (Reissig et al., 2009). The United States is the world’s largest consumer by volume of energy drinks. An estimated 290 million gallons were consumed in 2007, and Americans drink 3.8 quarts per person per year (Reissig et al., 2009). It is estimated that the energy drink market will hit $10 billion in 2010 (Venables, Karlsson, Ostrom, & Messner, 2009). Approximately 35%–45% of adolescents and young adults report that they drink at least one energy drink per day (Reissig et al., 2009). The companies that manufacture these products deny that they advertise to children. Because the market is not regulated, there has been aggressive marketing to adolescents with promises of psychoactive, performance-enhancing, and stimulant drug effects (Reissig et al., 2009). Hundreds of different brands are marketed, with caffeine content ranging from 50 mg to 500 mg per can or bottle.

It is important for school nurses to be familiar with energy drinks and the potential health consequences associated with their use. Recognizing the features of caffeine intoxication, withdrawal, and dependence may be especially relevant when treating adolescents who may be more likely to consume energy drinks. School nurses are in a unique position to advocate for school policies that ensure that only healthful beverages that contribute to nutrition and energy balance are available to students. Public awareness of health-related issues associated with energy drinks should be increased.

While evaluating adolescent tendencies to consume energy drinks, school nurses should question students about their use of herbal supplements, energy drinks, alcohol, and standard beverages containing methylxanthines, such as tea, coffee, and cocoa. If identified, nurses should encourage students to abstain from the energy drinks. Intervention to reduce soft drink intake among children could be effective in preventing excess energy intake and the prevalence of overweight adolescents. School settings are particularly important, given the widespread prevalence of soft drink vending machines in schools. Identification of heavy consumers could be a first-line screening mechanism for targeting at-risk adolescents, who might benefit from direct intervention efforts.

**REVIEW OF LITERATURE**

In this systematic review of the literature, the objective was to explore the consumption and health effects of energy drinks. The search strategy consisted of using CINAHL and Medline databases. Search dates were limited to 2000–2009. Inclusion criteria consisted of high-quality quantitative and qualitative studies and case reports using a 1 (low quality) to 7 (high quality) scoring system by four authors. Exclusion criteria consisted of poor study design or quality. Search terms and phrases used in the review process consisted of energy drinks, health effects of energy drinks, energy drink consumption, and regulation of energy drinks. The initial search using the term energy drinks resulted in 699 articles. Using combined search terms to provide for specific information in relation to the health effects resulted in 133 articles. After an initial review of the 133 articles using data abstraction and methodological assessment, 23 articles were identified, which provided strong support with an average score above 5 on the scoring scale for the inclusion criteria. Only one study was found that evaluated the impact of an educational approach to informing adolescents about the health effects of energy drinks consumption; however, several studies were identified, which provide support that education and increased awareness is definitely needed to inform adolescents about the potential health
consequences that can occur when these products are consumed.

Findings

Several quantitative and qualitative research articles as well as case studies were found that indicate a need for educating adolescents and young adults about the potential harmful effects of energy drinks. From this literature review, the following health effects were identified in relation to the consumption of energy drinks: arrhythmias, headaches, anxiety, insomnia, dehydration, gastrointestinal upset, nervousness, flushed face, diuresis, seizures, acute mania, strokes, withdrawal symptoms, tooth erosion, psychiatric events, accelerated heart rates, and even death (Candow et al., 2009; Iyadurai & Chung, 2007).

A study conducted by Malinauskas et al. (2007) assessed energy drink consumption among college students. College students \(N = 496\) attending a state university in the Central Atlantic region of the United States were surveyed, and researchers found that 51% of those surveyed were regular consumers of energy drinks. Their study revealed that students were consuming these types of drinks for the following situations: insufficient sleep, to increase energy while studying, driving long periods, drinking alcohol, and to treat a hangover.

Rockett and Putnam (2002) examined the association between self-reported caffeine addiction among high school students and their sociodemographic, health, and welfare characteristics. Their study consisted of 6,867 subjects who were surveyed about their use of caffeine supplementation. Findings indicated that caffeine addiction was associated with health and welfare problems among high school students, although an adverse link to physical health was limited to females. Specific problems identified included an excess risk for being severely stressed, chronic depression, and overall poor health status. Females reported depression and poor health. Males showed an increase risk for being severely stressed and reported more alcohol and drug problems.

Miller (2008a) examined the relationship between energy drink consumption and problem behaviors among adolescents and young adults. This was a cross-sectional, self-report survey of 602 Western New York students. Her study found that the frequency of energy drink consumption was positively associated with marijuana use, sexual risk taking, fighting, seatbelt omission, and taking risks on a dare for the sample as a whole, and associated with smoking, drinking, alcohol problems, and illicit prescription drug use for White students but not Black students. This study suggests that energy drink consumption is closely associated with a problem behavior syndrome, especially among Whites.

Another study conducted by Miller (2008b), examined gender links among sport-related identity, endorsement of conventional masculine norms, risk taking, and energy drink consumption. Miller surveyed 795 undergraduate students enrolled in introductory courses at a public university. Linear regression analyses of energy drink consumption frequencies on sociodemographic characteristics, jock identity, and masculine norms revealed significant relationships of sport-related identity, masculinity, and risk taking on adolescents engaging in health-compromising behaviors such as increased alcohol consumption, violence, and unsafe sex practices.

A study similar to Miller was conducted by Oteri, Salvo, Caputi, and Calapai in 2007. Their study consisted of surveying 450 students at the School of Medicine at the University of Messina. Their study found that 56.9% of those surveyed reported using energy drinks. A total of 48.4% frequently combined energy drinks with alcohol and 35.8% had combined the two in the previous month. This study confirmed an association of energy drinks with alcohol as being very popular among students. Oteri et al. report that the combination of energy drinks and alcohol can reduce adverse symptoms of alcohol intoxication including the depressant effects, thereby not being able to feel the signs of alcohol intoxication. Their study concludes the probability of accidents and/or the possibility of alcohol dependence is increased when the consumption is combined with energy drinks.

Ferreira et al. (2004) conducted a study in 2003 evaluating the effects of different doses of energy drink combined or not combined with alcohol on the physical activity of Swiss mice. They found that the reduction of activity observed after alcohol was antagonized by energy drinks. Further results indicated that the administration of energy
drink enhanced the activity of mice in a dependent way. The administration of energy drink did not significantly alter the effects of alcohol but reduced the depressant effect of alcohol. These data are significant because this combination has quickly become popular among young people as they will consume energy drinks to be able to drink more for longer periods of time.

In 2003, O’Dea reported finding that showed the type of drink supplements consumed by adolescents. Focus interviews were conducted on 78 adolescents. Her study found that adolescents were consuming sports drinks, vitamin and mineral supplements, energy drinks, herbal supplements, guarana, creatine, high-protein milk supplements, and coenzymes. Study participants reported using the supplements for short-term health benefits, prevention of illness, improved immunity, parental supply of supplements, taste, energy boost, better sports performance, and to better their diets. These results suggest that some adolescents consume these products for their perceived physiological benefits and that they may not be aware of any potential risks. Results from the study of O’Dea indicate that an overall increase in energy was related to nearly all of the nutritional supplement use. Participants in this study referred to obtaining an energy boost from supplements. Adolescents clearly articulated that they had experienced the physiologic effect of caffeine and that was the major motivating factor behind their consumption. They also reported that they had deliberately sought a boost and had received it in the form of a caffeine-containing supplement or drink. The results from this study have important implications for the use of health education theory in the planning of nutrition education and health promotion activities.

Blum, Jacobsen, and Donnelly (2005) examined the changes in beverage consumption and associations between beverages consumed and body mass index (BMI) Z scores in 164 children over 2 years. They found that significant decreases in milk and increases in diet sodas were found over 2 years in all subjects and normal weight, whereas overweight had a significant increase in diet soda consumption and a decrease in milk consumption. Change in milk consumption was inversely correlated with sugar-sweetened beverage consumption. Increases in diet soda consumption were significantly greater for overweight and subjects who gained weight as compared to normal weight subjects.

A study by James, Thomas, Cavan, and Kerr (2004) consisted of a five-session, classroom-based educational program that results in changes in BMI, overweight prevalence, and carbonated beverage consumption among 7- to 11-year-old children in six schools. This was the only education-based program found in this review process of the literature. A significant difference between control and intervention groups was observed for change overweight. Total carbonated beverage intake did not significantly change among children in the control classroom, but a significant decrease was observed in the intervention classroom. Significant decrease in the prevalence of overweight among children in intervention classrooms was identified as compared with children in control classrooms and a significant decrease in total carbonated beverage consumption among children in intervention classrooms compared to those in control classrooms. This study contributes to the growing scientific literature that soft drinks and energy drinks are playing a role in the rising epidemic of obesity among children and adolescents.

In 2006, Heatherly, Hancock, and Rogers conducted a double-blind, placebo-controlled study on 9- to 11-year-old children. They found that habitual users of caffeine showed poorer performance on cognitive test compared to nonconsumers. Post hoc comparisons showed that caffeine administration improved the accuracy on cognitive tests but that it had no significant effect on the nonconsumers’ performance. In the consumers, caffeine prevented an increase in headache that occurred after placebo and it increased alertness relative to placebo. These results suggest that children probably derive little or no benefit from habitual caffeine intake, although negative symptoms associated with overnight caffeine withdrawal are avoided or rapidly reversed by subsequent caffeine consumption. Another study was conducted by Hering-Hanit and Gadot in 2003. They evaluated children over a 5-year period of time and found that children and adolescents with high daily caffeine consumption in the form of soft drinks and energy drinks may suffer caffeine-induced headaches. Findings reveal that the gradual withdrawal of these types of products can be achieved without withdrawal.
headache and with complete disappearance of the induced chronic daily headache.

In 2007, R. E. Shapiro presented information in regards to caffeine and headaches in the Journal of Neurosciences. Findings from the article indicate that caffeine has the potential to have an antagonist action on adenosine receptors, which can cause effects similar to that of an analgesic. These effects can lead to the onset or relief of headache, depending on the site of action, the amount consumed, and the timing of caffeine consumption. Shapiro suggests that reducing the risk of developing caffeine-related headaches, clinicians should advise their patients to limit caffeine exposure as they would for any other analgesic.

One study compared 250 ml of a well-known energy drink with a nil sugar nil caffeine, similar tasting control (Anderson & Horne, 2006). In repeated measures, double-blind, balanced design, 10 participants who were sleep restricted ate a lunch, consumed a drink, and 10 min later underwent three 30 min consecutive periods at a reaction time task separated by 3-min breaks when self-ratings of sleepiness were made. The energy drink did not counteract sleepiness and led to slower reaction times and more lapses during the final 30-min session, around 80 min after consumption. From this limited study, there is good evidence that a sugar bolus intake can boost physical energy; however, there is little support that it can have benefit on a sleepy brain. It remains unclear from this study as to whether this leads to subsequent sleepiness.

A comparison study of tooth enamel erosion by energy drinks was conducted to measure the erosive effect of a sports energy drink (Hooper et al., 2004). Their study measured the erosive effect of a sports drink on enamel. This was a single blind randomized crossover design balanced for residual effects involving 18 subjects. They found that very little erosion occurred with the test; however, the positive control produced progression erosion over time and significantly more than the test or negative control at all time points. They concluded that adding calcium with appropriate pH adjustment to energy drinks markedly reduce erosive potential. This study demonstrates that calcium addition can be applied to a range of drink types to reduce erosion of tooth enamel. This modification has been made successfully to soft drinks, carbonated beverages, and now sports drinks. The modification can provide an improvement in the potential dental safety of energy drinks. According to this study, the popularity of energy drinks has the potential to result in an increase in tooth enamel erosion of adolescents and young adults.

A case report was presented involving a 23-year-old female with no medical history that was brought to the hospital for palpitations and chest tightness after consuming an energy drink and another caffeinated beverage (Nagajothi, Khraisat, Velazquez-Cecena, & Arora, 2008). Her blood pressure was 120/55 and her heart rate was 219 beats per minute. Her physical examination and labs were unremarkable. Her electrocardiogram showed a narrow complex tachycardia with a ventricular rate of 219 beats per minute. Carotid sinus massage and Valsalva maneuvers were unsuccessful in stopping the tachycardia. She was given adenosine 6 mg intravenously by rapid push. She then converted to normal sinus rhythm. The effect of the combined energy shot with another caffeinated drink precipitated this health event. From this event, it is important that the public be aware of the potential adverse effects of these energy drinks, alone or in combination with other caffeine-containing products, because fatal and even serious events have been reported.

A Bloomberg, New York, news story in 2009 (Miller, 2009) reported the death of a British student in a nightclub following the consumption of four cans of a popular energy drink and several vodka-based drinks that also contain caffeine. This student had been previously diagnosed with epilepsy in 2001 and was also believed to suffer from a heart condition. Although the coroner ruled out excess drinking and energy drink consumption as a cause of death, the energy drink was considered a partial contributor of the student’s death.

The safety and ethical issues associated with the use of caffeine by children was explored in a report from the Cleveland Clinic (Bramstedt, 2007). The report questioned why cognitive performance enhancement is ethically permissible and sports performance enhancement is not. This report argued that fair play, in both academics and sports is a concept that is challenged by the notion of performance enhancement. Bramstedt’s report does bring an interesting point up regarding whether cognitive enhancement is the concurrent presence or absence of a clinically diagnosed...
cognitive deficit with the use of caffeine supplementation.

A smaller study conducted by Chelben et al. (2008) reported on three patients with known psychiatric illness, who demonstrated deterioration of mental state, psychomotor unease, and intensified affected responses following the use of energy drinks. Their small study shows that while a causal relationship between the use of energy drinks and hospitalization cannot be definitively stated, the association between the two is noted. The researchers conclude that the consumption of energy drinks by individuals with prior psychiatric illness should be used with caution and that the use of energy drinks may be relevant in the patients’ evaluations.

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Another case report discussed new-onset seizures and possible association with the consumption of popular energy drinks (Bramstedt, 2007). The report discussed four patients who had discrete seizures on multiple occasions, following heavy consumption of energy drinks. Once the patients were abstinent from the energy drinks, no recurrent seizures were reported. Iyadurai and Chung (2007) propose that the large consumption of energy drinks rich in caffeine, taurine, and guarana seed could have provoked these seizures. This study is limited by small sample size and may reflect the possibility of a coincidental association. Additional research is needed to examine the central nervous system effects to the ingestion of energy drinks.

DISCUSSION

From this systematic review, there is evidence that more education and increased awareness is needed to inform adolescents and young adults about the potential harmful effects of energy drinks. Some school officials are taking steps to curtail the use of the popular high-octane beverages used by children and adolescents by banning them from school vending machines and not allowing students to bring them to school. These drinks have high levels of caffeine, sugar, and other stimulants. Although the FDA has set a limit on the caffeine content of soft drinks, 68 mg per 12 ounces, energy drinks are not regulated at this point and some contain up to 500 mg of caffeine (Reissig et al., 2009). As the use has skyrocketed, so has concern for the safety of children and teens.

Energy drinks derive their energy-boosting properties chiefly from sugar and caffeine. Caffeine is a pharmacologically active substance, and despite extensive research, its health effects and consequences are the subject of ongoing debate. It is a powerful stimulant of the central nervous system, respiration, and skeletal muscles; other activities include cardiac stimulation, coronary smooth muscle relaxation, and diuresis (Reissig et al., 2009). Guarana has similar stimulatory effect caffeine. Little is known about the health effects of taurine and glucuronolactone, other than the levels in stimulant drinks are several times higher compared to the rest of the diet (Finnegan, 2003).

Over the last decade, energy drinks have catapulted to prominence in the daily routines of adolescents and young adults. Although there is a considerable body of research available on the effects of some of the individual ingredients of energy drinks, very little research has been published in regard to the combined effects of these ingredients in energy drinks themselves. Few empirical studies to date have examined the demographics of energy drink consumption in relation to age, gender, and race. More research is needed on the health implications of the combined effects of energy drinks. Another consideration is the health effects caffeine in children. There are few studies on the subject of caffeine use in children, and there is question as to how ethical it is to test the effects of caffeine on children.

It is important for school nurses to focus attention on this topic when caring for children and adolescents. The results from the studies presented suggest that it is important to warn young people and their parents about the risks and undesirable side effects of energy drinks. The literature review also shows that warnings about the potential dangers may not necessarily deter some
adolescents who may have already weighed the perceived benefits of consumption and decided that the energy boost is desirable. School nurses can take this evidence and educate children and adolescents about alternative ways to increase energy levels such as good nutrition, adequate rest, and regular physical activity.

CONCLUSION

It is clear from the review that there can be health hazards associated with the consumption of energy drinks. School nurses can apply these findings to inform and educate children and adolescents during assessments and examinations, as well as in school and community nutrition education sessions. Interventions to reduce energy drink consumption could be effective in preventing negative health effects in children and adolescents. School settings are particularly important, given the widespread prevalence of vending machines in schools. As school communities begin to address the quality of vending machine offerings that are high calorie, the elimination of energy drinks has the potential to prevent negative health effects in children and adolescents.

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