A survey of the consumption habits and adverse events related to hydration and energy drinks in high school and college students and the general public

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Abstract

Introduction: the best drink for hydrating the body is water; however, there are other options with different ingredients that tend to be used for their flavor and composition, like hydration drinks (e.g., Gatorade) and energy drinks (EDs). Energy drinks are designed to improve psychomotor performance and increase alertness, with caffeine being the main component. Although hydration drinks are not usually associated with short-term adverse effects, prolonged use could have consequences. On the other hand, negative effects of ED consumption have been reported.

Method: a multiple-choice survey was conducted in which participants could choose among several drinks, selecting their preference. They were then asked about the possible adverse effects of their use.

Results: a multiple-choice survey of 430 people was conducted, 96.9% of whom were between the ages of 10 and 25. Out of the total, 52.3% drank hydration beverages or their variations, and 47.7% drank EDs. Adverse effects were found among those who consumed EDs, such as headache (24%), tachycardia (23%), insomnia (20%), jitters (12%) and irritability (8.7%), in higher proportion than among those who consumed hydrating drinks.

Conclusion: the use of EDs is associated with adverse cardiovascular and nervous system effects. Since caffeine is the most relevant common ingredient, these effects are presumed to be related to its pharmacological action. **(Acta Med Colomb 2025; 50. DOI: https://doi.org/10.36104/amc.2025.3308).**

Keywords: *energy drinks, adverse effects, toxicity, tachycardia, insomnia.*

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Introduction

Hydration drinks are isotonic, have a rehydrating component and are made especially for use in sports activities. These products include low doses of sodium (as sodium chloride or sodium bicarbonate), sugar or glucose, and other typical components like fructose, sucrose and maltodextrins. They also generally contain potassium, magnesium, calcium, other minerals and, sometimes, vitamins. These beverages have a similar proportion of fluids, nutrients and minerals as the blood, and therefore their function is not only to hydrate but also to provide energy (1, 2).

They are useful for young athletes who perform extended, vigorous, high-performance exercise, but are unnecessary for most children and adolescents outside of the sports setting (3). A 240 ml serving provides 2-19 g of carbohydrates, 10-70 kilocalories, and electrolytes like sodium (25-200 mg) and potassium (30–90 mg) (3).

The timing of consumption affects their benefits: before exercise, they improve glycogen reserves; during exercise, they maintain hydration and provide energy; and after exercise, they help with muscular and cellular recovery (4). However, one of their disadvantages is that regular consumption can cause insulin resistance, obesity, hypertension and cavities (erosion due to the acids in the drinks, leading to enamel demineralization), especially in sedentary people (5).

In Barcelona, Muñoz and Rovira reported that 46.8% of adolescents used hydration drinks during and after exercise, and only 8.4% used them during leisure activities (3). In a sample of 15,624 students in the USA, Cordrey reported that, in 2015, 59% drank these beverages at least once a week and 13.8% did so daily.

Larson also described adolescents´ sports and energy drink consumption patterns, finding that 37.9% consumed sports and energy drinks at least once a week, associated with physical activity, with greater use among those who played video games or spent more time watching television. In addition, 14.7% consumed energy drinks at least once a week, but not necessarily related to physical activity. Altogether, 10.6% drank both kinds of beverages, 26.8% drank sports but not energy drinks, and 3.6% drank energy but not sports drinks. There was a higher rate of smoking in both groups (6).

In Mexico, the consumption of sugary beverages has increased over the last 20 years, accounting for one fifth of the total daily energy intake. This change in consumption patterns, with a preference for high-calorie drinks with little nutritional value. Mexicans' average energy intake from caloric beverages has increased by 100-300 kcal per day, depending on the age group and sex. Beverage consumption patterns have changed significantly, with a notable increase in the consumption of high-calorie beverages with little nutritional value. This change in beverage consumption has contributed to a rise in the prevalence of overweight, obesity, and type 2 diabetes mellitus, making it a significant public health concern in Mexico (7).

A study in Medellín found a significantly high consumption of sugary sodas, especially among males (62.6%) as compared to females (59.3%), although the study does not specifically detail the consumption of isotonic or sports drinks (4).

On the other hand, energy drinks (EDs) are designed to improve psychomotor performance, increase alertness, reduce fatigue and sleepiness, and improve physical endurance. Their main component is caffeine, although they also include guarana, taurine, glucuronolactone, ginseng, B-group vitamins, yerba mate, and herbal extracts like bitter orange (8, 9). There is no consistent regulation for their composition, advertising, or distribution. Due to its action as an adenosine A1 and A2 receptor antagonist, caffeine modulates dopamine, inhibits phosphodiesterase, and stimulates catecholamine release. It is completely orally absorbed, with a half-life of five hours; its effects depend on the concentration and individual response. Combined ingestion with alcohol prolongs its action (10).

Caffeine toxicity appears with doses of more than 500 mg/day. Excessive caffeine consumption has multiple effects on the cardiovascular system. Its main pharmacodynamic action is in the cell through competitive blocking of adenosine A1 and A2 receptors (11), which increases dopamine, noradrenaline and glutamate release. Adenosine exerts a negative chronotropic effect through these receptors; therefore, its blockage increases the heart rate and blood pressure and facilitates cardiac arrhythmias (12-14).

The lethal dose of caffeine is 200 mg/kg, which, for a 70-kg adult, is equivalent to ingesting 70-100 cups of coffee. An ED contains an average of 83-140 mg of caffeine per 8 oz (226 ml) can, less than the 400 mg/day considered to be safe. However, some cans contain up to 16 oz, and many young consumers may drink two or more cans within a short period of time. Moreover, the effect of these doses on adolescents or children has not been clearly established.

It is important to consider that some ED ingredients, like guarana, increase the total caffeine content. Many also include taurine, a substance that has been related—although controversially—to cardiovascular effects. Another relevant aspect is the concomitant ingestion of EDs and alcohol, which can potentiate caffeine's stimulant effects (15, 16), as alcohol blocks adenosine reuptake, thereby increasing its activity on the receptors.

The adverse effects of EDs are mainly related to their caffeine content. Cases of atrial and ventricular fibrillation have been reported in adolescents and young adults with no prior cardiac history (17-19). Caffeine can increase catecholamine levels and foster calcium overload, triggering atrial or ventricular arrhythmias (17-19).

Energy drinks must be differentiated from sports drinks, which are usually isotonic and made up of water, glucose and electrolytes, with no stimulating substances in their formulas.

Guarana is a plant extract derived from *Paullinia cupana*, a wild plant found in the Brazilian Amazon, and is a common component of EDs. Several effects have been attributed to it, such as weight loss, central nervous system stimulation, memory maintenance, and protection from ethanol-induced gastric lesions. It also contains caffeine, theophylline and theobromine, which increases the total caffeine content of the beverages in which it is found. Theobromine and theophylline may have overlapping effects with caffeine (20).

As far as its cardiovascular effects, guarana is associated with increased blood pressure and cardiac output, with an onset of action two to three hours after ingestion, reaching its peak after approximately eight hours (21).

On the other hand, taurine, an essential amino acid, is also a typical component of EDs. It has neuroprotective properties and acts on the GABA A and B receptors, causing tonic activation that produces neuronal hyperpolarization. It also inhibits antidiuretic hormone (ADH) release from the supraoptic nucleus, exerting a diuretic effect. Its concentration in EDs ranges from 600 to 1,000 mg per unit. Combining it with caffeine potentiates its effects and can contribute to relieving muscle fatigue. However, significant knowledge gaps remain regarding its acute or chronic toxicity, both on its own and combined (22).

Some ED brands can supply up to 15% of the daily recommended calories. In the mid-term, their use can contribute to increased visceral adipose tissue, which is related to overweight and cardiovascular diseases. In 2006, more than 500 new brands of these drinks were launched around the world. They are freely accessible to children, adolescents and young adults. In 2016, global sales reached 25 billion dollars, with a 7% annual growth rate (23, 24).

In Colombia, ED sales went from 5.5-74.9 million liters per year between 2010 and 2019 (25). These drinks especially attract adolescents and young adults due to marketing strategies, peer pressure, and a lack of knowledge regarding the risks associated with their use (23, 24). In Germany, in 2011, 45.7% of students had consumed EDs, and 26% did so regularly (26). In the United States, the number of emergency room visits related to ED consumption increased significantly in a matter of 16 years, going from 3.1 to 6.5 cases per 100,000 visits between 2017 and 2023, respectively (27).

One problem is that consumers, who are usually young, do not differentiate between EDs and soft drinks, which causes confusion and probably abuse. Although isotonic beverages consumption is increasing among youths, the consumption patterns in our young people are not well known. Many prefer to use EDs, confusing them with hydrating beverages or alternating their use, possibly due to very high exposure of these products in audiovisual media.

Therefore, we proposed a survey to identify the consumption patterns of adolescents and young adults in Villavicencio, as well as the related adverse effects. It was especially interesting to compare these effects with the consumption of other beverages such as hydrating beverages, flavored drinks, soft drinks or juices, as many articles have associated the use of EDs with symptoms like headaches, irritability, insomnia, tachycardia, diarrhea and gastroesophageal reflux.

Methods

A survey was designed in which the participants could express their preference for different types of beverages including hydrating drinks, soft drinks, fruit juices, EDs, coffee and alcoholic beverages. They were also asked about the timing, reason, amount and frequency of consumption, as well as the activities during which they are usually ingested, including entertainment patterns such as watching television or playing video games.

Furthermore, they were asked about adverse effects associated with the consumption of any type of beverage, such as headache, insomnia, tremors, tachycardia, gastroesophageal reflux, diarrhea, irritability, and fainting spells. Comparisons were made between the consumption of EDs, hydrating drinks, and other beverages, relative to the onset of these symptoms. They were also asked about the association between the consumption of EDs and other beverages and alcohol ingestion.

Inclusion criteria: adolescents or young adults who agreed to complete the survey after a prior explanation of the questionnaire.

Exclusion criteria: those who did not agree to answer the survey after the explanation, or those whose guardians did not allow it.

Sample size calculation: according to the last census, the total population of Villavicencio is 558,299 people, 67.8% (378,526) of whom are between the ages of 15 and 64 years. The group of 13-24-year-olds accounts for 18% (68,134 people). Applying the formula:

$\mathbf{n = (d^2 \times (N - 1)) + (Z^2 \times p \times (1 - p)) / (N \times Z^2 \times p \times (1 - p))}$, where:

- **n** = the sample size
- **N** = the size of the target population
- **Z** = 1.96 (95% confidence level)
- **p** = 0.5 (estimated proportion of the attribute)
- **d** = 0.05 (5% margin of error)

The result estimated that **382 surveys** were required for the sample.

Statistical analysis

For the age variable, the surveyed individuals were grouped by age ranges, calculating their respective percentages. Percentages were also determined for educational level, classified as high school and college studies.

The differences in the occurrence of adverse effects were compared between ED consumers and those who consumed hydrating or other types of beverages. The adverse effects reported by adolescents and college students were also compared.

The participants were grouped according to hours of sleep, time spent watching television or playing video games, as well as activities during which they consumed beverages, and their respective percentages were determined.

Simple regression analyses were done to evaluate the relationship between consumption habits and the onset of adverse effects like tachycardia, insomnia, tremors, irritability, diarrhea and gastroesophageal reflux.

An Excel spreadsheet was used to process the data and calculate the statistics, and Google Diagrams was used to construct charts.

Results

A total of 430 surveys were applied to high school and college students, 61.7% of whom were females and 38.3% were males. Altogether, 96.9% of the participants were adolescents or college students, and 48% of the total reported consuming EDs.

The age distribution is shown in Figure 1, with a predominance of the 14-17-year-old group, with 38.6%, and the 18-21-year-old group with 38.8%, corresponding to the adolescent and young adult groups, respectively.

An analysis of the educational level of the survey participants found that 52.1% were high school students and 44.4% were college students.

Regarding the frequency of television watching, 69.9% of those surveyed watched one hour or less per day, 26.9%

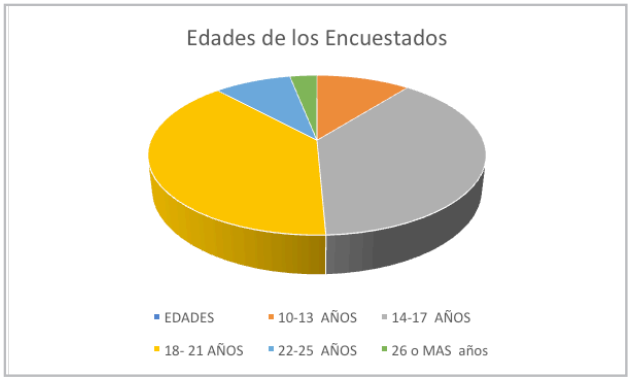

Figure 1. *Age distribution of survey respondents. Source: authors´own.*

never watched television, 3.3% watched three to five hours, and only 0.2% watched more than five hours a day. No correlation was found between the habit of watching television and consumption of hydration or energy drinks (Figure 2).

As far as the daily use of video games, 43.2% of those surveyed did not use them, 26.4% used them for one hour or less, 19.8% used them for one to three hours, 5.7% used them for three to five hours, and 4.2% used them for more than five hours a day. No correlation was found between this habit and the consumption of energy, hydration or other drinks.

The activities during which EDs were consumed were identified. Studying was highlighted, with 118 out of 205 people (57.6%), followed by sports practice with 56 (27%), consumption during parties with 47 (22.9%) and consumption with no particular activity with 68 cases (33.1%).

Figure 3 shows the activities during which those surveyed consumed hydration drinks.

Table 1 presents the adverse effects found with the consumption of EDs, compared to the frequency of adverse effects found with the consumption of hydration drinks. Likewise, Table 2 compares the adverse effects of the use of EDs with the those of the use of hydration drinks in females, finding more adverse effects in participants who consumed EDs. Tables 3 and 4 present the adverse effects of EDs versus the consumption of hydration drinks in high school and college students, respectively.

All the comparisons presented showed more adverse effects in those who consumed EDs, with this finding being more evident in females and college students.

A linear regression analysis was done between the habit of consuming EDs and the adverse effect of tachycardia, with a sample of N = 205, which suggested a positive relationship between ED consumption and tachycardia. The likelihood of this adverse event increased as the frequency of consumption increased (Figure 4).

Another adverse effect commonly related to the consumption of EDs is insomnia. Figure 5 presents a diagram showing the relationship between ED consumption and the onset of insomnia, with a 0.12-0.129 slope, which indicates that the cases of insomnia increase with each additional unit in the number of cases of consumption.

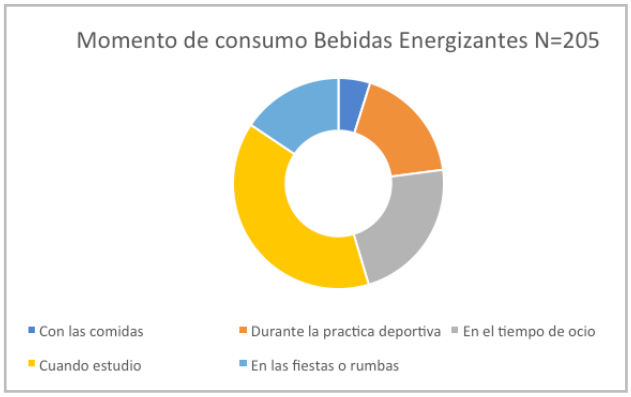

Figure 2. *Activities during which energy drinks are consumed. Source: authors´own n =205*

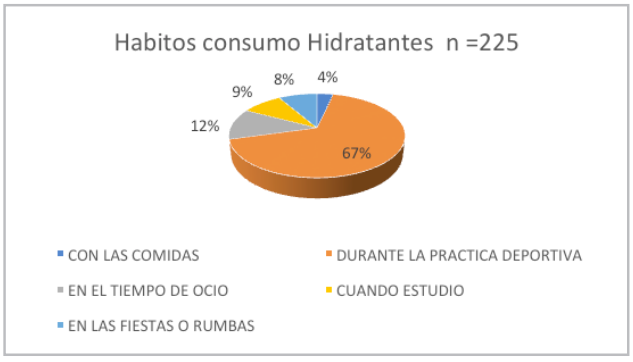

Figure 3. *Hydration drink consumption habits. Source. Authors´own.*

Insomnia was correlated with the frequency of ED consumption. In addition, 35.5% of these young people were found to sleep four to six hours a day, while only 9.1% slept eight to ten hours a day (28, 29).

No linear correlations were found between the use of EDs or hydration drinks and adverse effects like headaches, tremors, irritability, diarrhea, gastroesophageal reflux or headache.

One group of 16 survey responders (7.8% of the sample) reported simultaneous consumption of alcoholic beverages

Table 1. *Comparison between the adverse effects of energy drink and hydration drink consumption n= 430.*

General adverse effect	Use of energy drinks n=205 (47.6%)	Use of hydration drinks n=225 (52.3%)	OR	95% CI	P value =
Tachycardia	50	6	11.77	4.92-28.14	0.001
Headache	49	23	2.75	1.61-4.7	0.001
Insomnia	42	20	2.64	1.49-4.6	0.0002
Tremors	25	6	5.06	2.03-12.6	0.0001
Irritability	18	8	2.6	1.1-6.1	0.082
Gastroesophageal reflux	15	7	2.45	0.9-6.15	0.0183
Diarrhea	5	9	0.6	0.19-1.8	0.66
Source: Authors' own.					

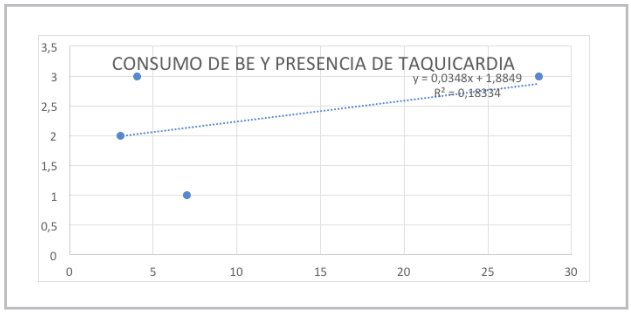

Figure 4. *Relationship between the consumption of energy drinks and the presence of tachycardia. Source: authors' own.*

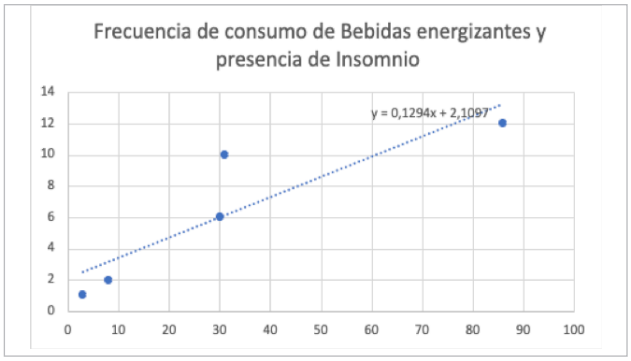

Figure 5. *Relationship between the consumption of energy drinks and the presence of insomnia.*

and EDs, with headache and insomnia as adverse effects.

Discussion

Out of the 430 total surveyed people, 96.9% were adolescents or college students, and 48% consumed EDs. Fajardo also reported 39 to 47% consumption in different groups of adolescents. In his study of 327 college students, Apraez found 46.2% consumption (30). Mansur B reported 55% ED consumption in a group of 375 young people and adolescents (31).

In this survey, 27% consumed EDs while practicing sports. However, when these are consumed during exercise, other liquids are needed to ensure adequate hydration, given the high carbohydrate concentration and lack of mineral salts in EDs.

The literature indicates that moderately active individuals do not obtain anaerobic benefits from ingesting EDs with caffeine (32).

Table 2. *Comparison of adverse effects between the use of energy drinks versus hydration drinks in female survey respondents.*

Adverse effect Females, n =264	Use of energy drinks n= 118 (44.69%)	Use of hydration drinks n=146 (55.3%)	OR	95% CI	P value
Tachycardia	39	1	71.5	9.6-530	0.0001
Headache	38	8	8.19	3.64-18.4	0.0001
Insomnia	30	4	12.1	4.1-35.5	0.0001
Tremors	19	0	57.4	3.42-962	0.0049
Irritability	8	3	3.46	0.89-13.3	0.07
Gastroesophageal reflux	12	0	34.3	2.01-587	0.01
Diarrhea	5	1	6.41	0.73-55	0.0918
Source: Authors´ own.					

Table 3. *Comparison between the adverse effects of the use of energy drinks versus hydration drinks in high school students.*

Adverse effect in high school students n= 223	Use of energy drinks n= 93 (41.7%)	Use of hydration drinks n= 130 (58.29%)	OR	95% CI	P value
Tachycardia	13	1	20.96	2.69-163-209	0.037
Headache	14	6	3.66	1.35-9.92	0.010
Insomnia	20	3	11.59	3.3-40	0.0001
Tremors	9	1	13.82	1.71-111	0.01
Irritability	4	0	13.12	0.69-146	0.08
Gastroesophageal reflux	5	1	7.32	0.84-63	0.07
Diarrhea	0	1	0.46	0.018-11	0.63
Source: Authors' own.					

Table 4. *Comparison between the adverse effects of the use of energy drinks versus hydration drinks in college students.*

Adverse effect in college students n=190	Use of energy drinks n= 101 (53.15%)	Use of hydration or other drinks n= 89 (46.84%)	OR	95% CI	P value
Tachycardia	30	0	76.35	4.5-1270	0.0025
Headache	30	3	12.11	0.8-61	0.06
Insomnia	18	3	6.21	1.76-21	0.0044
Tremors	13	0	27.3	1.59-466	0.022
Irritability	1	3	0.31	0.03-3.05	0.31
Gastroesophageal reflux	8	0	16.27	0.03-3.05	0.31
Diarrhea	3	2	1.45	0.23-8.88	0.68
Source: Authors' own.					

Although no correlation was found between the habit of watching television or playing video games and the consumption of EDs, hydration drinks, or other beverages, previous studies have found increased exposure to EDs through television, online platforms, and streaming services. This highlights the need for future studies to evaluate the impact of this exposure to nutrient-poor and energy-rich products on behavior and health (33).

As far as cardiovascular adverse effects, the most frequent finding was tachycardia, reported in 24% of those surveyed. In a study of 27 health children and adolescents (mean age 14.53 ± 2.40 years; 14 males), Oberhoffer FS showed that, compared to placebo, the mean systolic arterial pressure (SAP) increased up to 5.23 mmHg ($p < 0.0001$), and the mean diastolic arterial pressure (DAP) up to 3.29 mmHg ($p < 0.001$) after ingesting EDs. Furthermore, the prevalence of high blood pressure, stage 1 and stage 2 hypertension, was higher after consuming these drinks (34).

Due to its design, blood pressure was not measured in this survey, and therefore this is a point that could be explored in future studies on the topic.

In a meta-analysis, Nadeem IM reported that EDs with less than 400 mg of caffeine were associated with acute heart rate and systolic blood pressure elevations during dynamic aerobic exercise in healthy adults, highlighting the need to evaluate cardiovascular effects, especially in people predisposed to hypertension. Other studies have also warned of these effects (28).

This survey found other adverse effects related to ED consumption: headache (23.9%), insomnia (20.48%), tremors (12.19%) and irritability (8.7%). Nordt reported headaches in 8% of cases (35). Insomnia was correlated with the frequency of ED consumption and fewer hours of sleep in 35.5% of those surveyed, which could affect academic performance and cause irritability.

A meta-analysis that included 32 studies and 96,549 people reported insomnia in 24.7% of adults (OR 5.02) and nervousness or restlessness in 29.8% (OR 3.52) (28).

As far as gastrointestinal effects, this survey reported gastroesophageal reflux (7.31%) and diarrhea (2.4%). Although they have not been studied much, research in animal models has shown eosinophilic intestinal infiltration induced by ED consumption, which reduces after stopping consumption (36).

Clinical studies have reported gastroesophageal reflux, increased stomach acid, and decreased esophageal sphincter pressure associated with high-caffeine beverages (37). Coffee, for example, can increase rectosigmoid motility within minutes, with comparable effects to those of a 1,000 kcal meal. Nordt also mentioned unspecified gastrointestinal symptoms in up to 11% of cases (37).

In this survey, adverse effects were more frequent in females. Seventy-eight percent of those with tachycardia were females; 77% of those with headaches were also females; and females accounted for 7 and 100% of those with insomnia and tremors, respectively. In their survey, Silva and Ramírez reported that 57.8% of ED consumers were females, with adverse effects like tachycardia, frequent urination and fatigue, without sex stratification (38).

Whether females are more affected by EDs has not been clearly established, and therefore more studies on this possible association are recommended.

A total of 7.8% of consumers mixed EDs with alcohol, which, according to Scalesse, can increase the risk of smoking, the consumption of other substances, aggression and school absenteeism.

Like many authors, we recommend avoiding the frequent use of these beverages in the general population, but especially in adolescents and young adults, due to the frequency of adverse events, and especially avoiding the combination of EDs and alcohol (39).

Although this survey found no short-term adverse effects associated with hydration drinks, their effects are known to be long-term. We recommend that healthcare professionals evaluate their use in adolescents and educate them on their proper use, promoting water as the main source of hydration. Schools should apply policies to limit access to these drinks, prioritizing water, low-fat milk, natural juices and calorie-free beverages. The idea that sports drinks are healthy should also be debunked, and the sale of sugary,

processed, or high-caffeine drinks should be more regulated, especially for children and adolescents.

Limitations. This was an exploratory study of the beverage consumption habits of adolescents and young adults. We evaluated the survey participants' perception of short-term adverse effects. However, the long-term effects of ingesting energy, hydration, sugary, or soft drinks or fruit juices could not be assessed, and therefore further surveys will be needed to study them adequately.

Biases. The interpretation of short-term adverse effects associated with the consumption of hydration and energy drinks could be affected by the fact that many of those surveyed consumed hydration drinks, juices or soft drinks at the same time and alternated their consumption with EDs, and the percentage of participants who did so was not determined.

The results may also be affected by the fact that some participants identified themselves as hydration drink consumers but did not clearly distinguish between these and soft drinks or fruit juices, leading to confusion or combined or alternating consumption of these products.

Conclusion

Energy drink consumption is linked to adverse effects in both the cardiovascular system (like tachycardia [OR 11.77]) and the nervous system (including insomnia [OR 2.64], tremors [OR 5.6] and irritability [OR 2.6]). Since caffeine is the most common component in all EDs, these unwanted effects are believed to be mainly related to this substance.

Controlled consumption of energy and hydration drinks should be promoted, especially among children, adolescents, young adults and their families.

In this regard, Colombia should advance toward a much stricter regulation of the sale of EDs, limiting their sale in shopping centers, bars and other public establishments.

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