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ASSOCIATION BETWEEN ENERGY DRINK CONSUMPTION AND CARDIAC RHYTHM DISTURBANCES IN YOUNG ADULTS

Getsemani Padilla Vargas, Alejandra Durán Aguayo *, Alizon Guadalupe Flores Juárez and Martha Fernanda Rodríguez Muñoz

Students of: Escuela de Medicina, Universidad Autónoma de Durango, Campus Zacatecas, México.
* Corresponding author:* Alejandra Durán Aguayo

ORCID Details
Getsemani Padilla Vargas: https://orcid.org/0009-0003-3303-5576
Alejandra Durán Aguayo: https://orcid.org/0009-0001-6173-3713
Alizon Guadalupe Flores Juárez: https://orcid.org/0009-0001-3535-1121
Martha Fernanda Rodríguez Muñoz: Https://orcid.org/0009-0002-8945-7754

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ABSTRACT

Introduction: Energy drink consumption among adolescents and young adults has increased substantially in recent years, driven by aggressive marketing and their perceived ability to enhance alertness, physical performance, and concentration (Costantino et al., 2023). These beverages combine caffeine with taurine, sugars, B-group vitamins, and other stimulant compounds that, at the doses commonly consumed, can produce electrophysiological changes capable of predisposing susceptible young individuals to cardiac rhythm disturbances (Ciliberti et al., 2024).

Objective: To analyze, through a systematic review of the available scientific evidence, the association between energy drink consumption and cardiac rhythm disturbances in young adults, describing the underlying electrophysiological mechanisms, the clinical spectrum of reported arrhythmic events, and the implications for clinical practice and public health.

Methodology: A documentary, descriptive, and systematic bibliographic review with a qualitative approach was conducted. Searches were performed in PubMed/MEDLINE using English search terms combined with Boolean operators. Original scientific articles, case reports, randomized clinical trials, and narrative reviews addressing the cardiovascular and electrophysiological effects of energy drinks were included.

Results: The reviewed evidence shows that acute high-volume energy drink consumption produces measurable prolongation of the heart rate corrected QT interval (QTc), with average maximal increases of 18 20 milliseconds in healthy volunteers, alongside modest increases in systolic blood pressure of approximately 5 mmHg (Shah et al., 2019). A narrative review of published case reports identified 32 cases of arrhythmic or ischemic events temporally associated with energy drink consumption, 20 of which involved supraventricular or ventricular arrhythmias, with 3 fatal outcomes (Fletcher et al., 2019). Individuals with underlying genetic channelopathies, particularly Long QT Syndrome,

appear to represent a population of particular vulnerability, with documented cases of torsade de pointes and cardiac arrest following energy drink consumption (Sherazi & Kadish, 2019).

Conclusions: Energy drink consumption produces measurable electrophysiological effects chiefly QTc prolongation and sympathetic activation that, while generally modest and transient in healthy individuals, can precipitate serious arrhythmic events in susceptible young adults, particularly those with underlying or undiagnosed cardiac channelopathies. Public education, clearer product labelling, and clinical vigilance regarding energy drink use in young patie nts presenting with palpitations or unexplained arrhythmic events are warranted.

Keywords: Energy Drinks; Caffeine; Cardiac Arrhythmia; QT Interval; Young Adults; Atrial Fibrillation; Sudden Cardiac Death

1 INTRODUCTION

Energy drinks have become one of the most widely consumed beverage categories among adolescents and young adults worldwide over the past two decades, largely because of their perceived ability to enhance alertness, physical performance, and concentration (Costantino et al., 2023). Unlike traditional sports drinks, formulated mainly to replace fluids and electrolytes, energy drinks are stimulant based products whose primary active ingredient is caffeine, generally combined with taurine, sugars, guarana, and B-group vitamins; the two product categories are fundamentally different and should not be used interchangeably (Committee on Nutrition and the Council on Sports Medicine and Fitness, 2011).

The use of caffeine-containing energy drinks has increased dramatically, particularly in the sporting context, owing to their reported ergogenic effects on strength, endurance, and perceived exertion (Salinero et al., 2014; Jiménez et al., 2021). However, the same stimulant load responsible for this popularity underlies a range of adverse effects, some of which extend well beyond the commonly reported insomnia, nervousness, and gastric upset (Salinero et al., 2014) into the cardiovascular domain, where growing clinical evidence has drawn attention to cardiac rhythm disturbances.

1.1 Energy Drinks: Definition and Composition

Energy drinks are non-alcoholic, caffeinated beverages marketed for their stimulating and performance-enhancing properties. Their principal active compound is caffeine (1,3,7-trimethylxanthine), typically present in higher concentrations than in coffee or cola beverages, combined with taurine, guarana, ginseng, B group vitamins, and large amounts of simple sugars (Rath, 2012; Costantino et al., 2023). Because these products are regulated as foodstuffs rather than pharmaceuticals in most countries, labelling of total stimulant content is frequently incomplete, and single servings can contain caffeine equivalents well above those found in a standard cup of coffee (Thomson et al., 2014).

1.2 Caffeine: Pharmacology and Mechanism of Action

Caffeine acts primarily as a non-selective antagonist of adenosine receptors in the central and peripheral nervous system, producing increased alertness, central nervous system stimulation, and heightened sympathetic outflow (Jones, 2008). This sympathomimetic action increases heart rate, myocardial contractility, and systemic vascular tone, and can affect the electrical repolarization of the myocardium, particularly at higher doses or when combined with other stimulant compounds present in energy drinks, such as taurine and guarana (Saunders et al., 2023; Ciliberti et al., 2024).

1.3 Cardiac Arrhythmias in Young Adults

Cardiac arrhythmias comprise a broad spectrum of disturbances in the rate, rhythm, or origin of the heart's electrical activity, ranging from benign palpitations to life-threatening ventricular arrhythmias. In young, apparently healthy individuals, clinically significant arrhythmias are uncommon and frequently signal an underlying, sometimes previously undiagnosed, cardiac condition, such as a genetic ion channelopathy or structural heart disease (Sherazi & Kadish, 2019). Identifying reversible or modifiable triggers among them stimulant substances such as those found in energy drinks is therefore of particular clinical relevance in this population.

1.4 The QT Interval and Long QT Syndrome

The QT interval, corrected for heart rate (QTc), reflects the duration of ventricular depolarization and repolarization on the surface electrocardiogram. Prolongation of the QTc interval is a well recognized risk factor for torsade de pointes, a potentially fatal polymorphic ventricular tachycardia (Fletcher et al., 2019). Long QT Syndrome (LQTS) is a genetic channelopathy that predisposes affected individuals to QTc prolongation and life threatening arrhythmias, often triggered or exacerbated by adrenergic stimulation, physical exertion, or stimulant substances (Sherazi & Kadish, 2019).

1.5 Atrial Fibrillation

Atrial fibrillation (AF) is the most common sustained cardiac arrhythmia worldwide, though it is rare in young adults, affecting less than 1% of patients under 60 years of age (Bhatt et al., 2021). Nonetheless, case reports describe the development of acute, symptomatic AF in otherwise healthy adolescents and young adults following energy drink consumption, often in the context of concurrent physical exertion (Kaur & Connelly, 2018).

1.6 Autonomic and Sympathetic Mechanisms of Arrhythmogenesis

The arrhythmogenic potential of energy drinks is thought to arise from a combination of sympathetic activation, increased circulating catecholamines, and direct electrophysiological effects on myocardial ion channels, producing measurable changes in heart rate variability, blood pressure, and ventricular repolarization even in healthy volunteers (Steinke et al., 2009; Ciliberti et al., 2024). These transient hemodynamic changes are generally well tolerated in healthy young consumers, but rapid ingestion of large volumes, or consumption by individuals with underlying arrhythmogenic substrates, may result in more dangerous electrophysiological disturbances (Sherazi & Kadish, 2019).

1.7 Patterns of Energy Drink Consumption Among Adolescents and Young Adults

Survey data indicate that energy drink consumption is widespread among adolescents and young adults, with estimates suggesting that approximately one in four American teenagers consumes energy drinks regularly, and consumption rates exceeding 40% among some young adult subpopulations, such as military service members (Fletcher et al., 2019). This high prevalence, combined with frequent co-ingestion with alcohol, exercise, or other stimulants, creates a population-level exposure of potential public health significance (Petit, Levy, Lejoyeux, Reynaud, & Karila, 2012).

1.8 Antecedentes: previous studies

Several previous studies constitute the direct scientific basis for the present review. Shah et al. (2019) conducted a randomized, double-masked, placebo-controlled crossover trial in 34 healthy adults aged 18 to 40 years, comparing two commercially available energy drinks against a caffeine-free placebo. Both energy drinks produced an average maximal QTc increase of 18 to 20 milliseconds that persisted for up to four hours after consumption, with a placebo-adjusted increase of 6.1 to 7.7 milliseconds; systolic blood pressure was approximately 5 mmHg higher after energy drink consumption than after placebo. Although no participant developed a QTc interval exceeding 500 milliseconds, two subjects experienced QTc prolongation greater than 50 milliseconds, a range associated with increased arrhythmic risk. The authors concluded that individuals with acquired or congenital Long QT Syndrome, as well as those with hypertension, should exercise particular caution with energy drink consumption.

Sherazi and Kadish (2019), in an editorial accompanying this trial, described two illustrative case reports: a previously healthy 22-year-old woman who experienced cardiac arrest with documented torsade de pointes after consuming six cans of energy drink over four hours, with a QTc of 526 milliseconds on admission that normalized to 419 milliseconds within days, and subsequent genetic testing confirming LQTS type 1; and a 13-year-old girl with chest pain and palpitations after energy drink consumption whose QTc reached 561 milliseconds on admission before normalizing, also with genetic confirmation of LQTS type 1. A separate randomized, placebo-controlled study in patients with familial LQTS found that the QTc interval increased by more than 50 milliseconds after energy drink consumption in 3 of 24 patients studied.

Fletcher et al. (2019), in a narrative review of the published literature, identified 32 case reports and 19 clinical trials describing electrophysiological and ischemic adverse effects of energy drink consumption. Among the case reports, ventricular arrhythmia, supraventricular arrhythmia, and myocardial ischemia were the most frequently described events, with 3 cases resulting in death. Arrhythmia was documented in 20 of the 32 cases (9 supraventricular, 10 ventricular, and 1 combined), and QT/QTc prolongation was evident in 4 cases. Ten of the 32 cases involved co-ingestion of an energy drink with another substance, most commonly alcohol.

Kaur and Connelly (2018) reported two cases of atrial fibrillation in previously healthy adolescent boys following energy drink consumption, one of which occurred after a running race, presenting with an irregularly irregular heart rate of approximately 130 beats per minute; both patients had unremarkable structural cardiac evaluations, suggesting energy drink ingestion as the probable arrhythmic trigger.

Ullah et al. (2018) published a case report describing a life-threatening cardiovascular event myocardial infarction associated with massive overdose of caffeinated energy drinks, underscoring that the well-known minor side effects of these beverages (tachycardia, headache, anxiety, palpitations) can, in extreme consumption patterns, progress to serious, life-threatening cardiac events.

2 RESULTS

The results presented below correspond to the systematic analysis and integration of the selected scientific evidence, organized according to the specific objectives of this review.

2.1 Electrophysiological Effects of Energy Drink Consumption: QTc Interval

The literature analysis identified consistent evidence that acute energy drink consumption produces measurable, dose related prolongation of the QTc interval in healthy young adults, most robustly demonstrated in the randomized crossover trial by Shah et al. (2019), summarized in Table 1.

Table 1: Electrophysiological and hemodynamic effects of acute energy drink consumption in healthy adults

Parameter	Energy Drink	Placebo
Sample	34 healthy adults, 18–40 years	Same cohort (crossover)
Maximum QTc increase	18–20 ms	Small, transient increase
Placebo-adjusted QTc increase	6.1–7.7 ms	—
Subjects with QTc increase >50 ms	2 of 34	0
Subjects with QTc >500 ms	0	0
Systolic blood pressure change	~+5 mmHg	Minimal change

Source: Prepared by the author based on Shah et al. (2019).

2.2 Clinical Spectrum of Arrhythmic Events Associated with Energy Drink Consumption

The narrative review by Fletcher et al. (2019) provided the most comprehensive characterization of the clinical spectrum of reported adverse cardiovascular events, summarized in Table 2.

Table 2: Clinical spectrum of published case reports of adverse cardiovascular events after energy drink consumption

Finding	Frequency
Total case reports analyzed	32
Cases with arrhythmia	20 (9 supraventricular, 10 ventricular, 1 combined)
Cases with ST-segment changes	14
Cases with QT/QTc prolongation	4
Cases with coronary artery occlusion	5
Fatal outcomes	3
Energy drink consumed alone	22
Co-ingestion with another substance (mainly alcohol)	10

Source: Prepared by the author based on Fletcher et al. (2019).

2.3 Vulnerable Populations: Long QT Syndrome and Genetic Channelopathies

Analysis of the available case reports and controlled studies indicates that individuals with underlying genetic channelopathies, particularly Long QT Syndrome, represent a population of disproportionate risk. Documented cases include a 22-year-old woman with cardiac arrest and torsade de pointes (QTc 526 ms) and a 13 year old girl with palpitations (QTc 561 ms), both subsequently confirmed to have LQTS type 1 (Sherazi & Kadish, 2019). In a controlled study of patients with familial LQTS, energy drink consumption produced a QTc increase exceeding 50 milliseconds in 3 of 24 patients, compared with no such effect in healthy controls under similar conditions (Sherazi & Kadish, 2019).

2.4 Atrial Fibrillation in Young, Structurally Normal Hearts

Beyond ventricular arrhythmias, the reviewed evidence also documents the development of atrial fibrillation in young adults without structural heart disease following energy drink consumption. Kaur and Connelly (2018) described two adolescent boys who developed acute atrial fibrillation after energy drink ingestion, one in temporal association with

vigorous physical exercise, both with subsequently normal cardiac structural evaluation, supporting a probable direct arrhythmogenic role of the beverage itself rather than an underlying structural abnormality.

3 DISCUSSION

The results obtained through this systematic review of the available scientific evidence confirm that energy drink consumption produces measurable electrophysiological effects principally QTc interval prolongation and sympathetic activation capable of predisposing young adults to cardiac rhythm disturbances, ranging from atrial fibrillation to potentially fatal ventricular arrhythmias. These findings are consistent with recent scientific literature and reinforce the need for greater clinical awareness of energy drinks as a modifiable arrhythmic trigger in this population.

3.1 On the Electrophysiological Basis of Energy Drink–Induced Arrhythmias

One of the most relevant findings of this review is the confirmation, through a controlled randomized trial, that energy drink consumption produces a measurable and reproducible QTc prolongation in healthy young adults (Shah et al., 2019). Although the magnitude of this effect an average maximal increase of 18 to 20 milliseconds is modest and unlikely to be clinically significant in most healthy consumers, the finding that 2 of 34 participants developed QTc prolongation greater than 50 milliseconds indicates meaningful inter-individual variability in susceptibility, a pattern also observed in the study of patients with familial LQTS (Sherazi & Kadish, 2019). This variability suggests that a subset of young, apparently healthy energy drink consumers may harbor undiagnosed genetic predispositions that amplify the arrhythmic risk associated with these beverages.

3.2 On the Clinical Spectrum of Reported Adverse Events

The results of the narrative review by Fletcher et al. (2019), identifying 32 case reports with a diverse clinical spectrum including 20 cases of arrhythmia and 3 fatal outcomes illustrate that while acute electrophysiological changes may be modest at the population level, the cumulative burden of severe individual cases is not negligible given the scale of global energy drink consumption. This is consistent with the position of Ciliberti et al. (2024), who emphasize the need for greater regulatory transparency regarding energy drink ingredients given their demonstrated potential for serious adverse cardiovascular events.

3.3 On Vulnerable Populations and the Role of Genetic Channelopathies

The evidence reviewed strongly suggests that individuals with Long QT Syndrome and other genetic channelopathies constitute a population of particular vulnerability. The documented cases of torsade de pointes and cardiac arrest in young patients subsequently found to carry LQTS type 1 (Sherazi & Kadish, 2019) raise the possibility that some sudden cardiac events attributed to energy drinks may in fact represent the unmasking of a previously undiagnosed genetic arrhythmia syndrome, rather than a purely toxic effect of the beverage itself. This distinction carries important clinical implications: it suggests that any young patient presenting with a significant arrhythmic event temporally associated with energy drink consumption should be considered for genetic and electrophysiological evaluation, rather than having the episode attributed to the beverage alone.

3.4 On Atrial Fibrillation in Structurally Normal Hearts

The case series reported by Kaur and Connelly (2018) is particularly noteworthy because it documents atrial fibrillation developing in adolescents without any identifiable structural or genetic predisposition, suggesting that the combination of sympathetic activation and, in at least one case, concurrent physical exertion may be sufficient to trigger this arrhythmia even in the absence of an underlying substrate. This finding differs somewhat from the LQTS related cases, in which a genetic predisposition appears to be a necessary co-factor, and points to at least two distinct pathophysiological pathways by which energy drinks may provoke cardiac rhythm disturbances in young people.

3.5 On the Limitations of the Present Investigation

This study presents limitations that must be acknowledged transparently. First, as a systematic bibliographic review with a qualitative-descriptive design, the conclusions depend entirely on the quality and availability of the primary studies included, without generating original data. Second, much of the strongest clinical evidence on arrhythmic events derives from isolated case reports rather than large-scale epidemiological studies, limiting the ability to estimate a precise absolute risk of arrhythmia among the general population of energy drink consumers. Third, several of the sources initially provided for this review addressed the ergogenic and general physiological effects of caffeine and energy drinks in athletic contexts rather than cardiac electrophysiology specifically, requiring supplementation with additional, directly relevant PubMed-indexed studies to adequately characterize the arrhythmia-specific evidence base.

These limitations underscore the need for larger prospective studies, including systematic ambulatory ECG monitoring in young energy drink consumers, to more precisely characterize the incidence and absolute risk of clinically significant arrhythmias attributable to these beverages.

Acronyms and Abbreviations

Acronym	Meaning
AF	Atrial fibrillation
bpm	Beats per minute
ECG	Electrocardiogram
ED(s)	Energy drink(s)
LQTS	Long QT Syndrome
ms	Milliseconds
QTc	Corrected QT interval
SBP	Systolic blood pressure
SCA	Sudden cardiac arrest
TdP	Torsade de pointes

4 CONCLUSION

This study systematically analyzed the association between energy drink consumption and cardiac rhythm disturbances in young adults, providing a solid evidence-based framework to guide clinical awareness and public health considerations regarding this widely consumed beverage category.

Based on the evidence analyzed, it is concluded that energy drink consumption produces measurable electrophysiological effects principally QTc interval prolongation and sympathetic activation with associated increases in heart rate and blood pressure that are generally modest and well tolerated in healthy young adults but that can precipitate clinically significant arrhythmias, including atrial fibrillation, ventricular arrhythmias, and torsade de pointes, in susceptible individuals. Young adults with underlying or previously undiagnosed genetic channelopathies, particularly Long QT Syndrome, appear to represent a population of disproportionate risk, in whom energy drink consumption may act as a trigger unmasking a pre-existing arrhythmic substrate.

From a clinical perspective, it is concluded that any young patient presenting with palpitations, syncope, or a documented arrhythmic event temporally associated with energy drink consumption warrants careful cardiac evaluation, including consideration of underlying channelopathies, rather than attribution of the event to the beverage alone.

From a public health perspective, given the widespread and increasing consumption of energy drinks among adolescents and young adults, and the documented potential for serious, occasionally fatal, cardiovascular events, there is a clear need for clearer product labelling regarding stimulant content, public education on safe consumption limits, and continued pharmacovigilance and case reporting to more precisely characterize the population-level risk of this exposure.

Finally, this study identifies the need for larger, prospective, controlled studies including electrophysiological monitoring across diverse consumption patterns to more precisely quantify the absolute arrhythmic risk associated with energy drink consumption in young adults, and to clarify the relative contributions of direct pharmacological toxicity versus the unmasking of underlying genetic arrhythmia syndromes.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest regarding the publication of this manuscript.

Statement of ethical approval

This article is a systematic review of available literature and secondary data. It does not contain any studies with human participants or animals performed by any of the authors; therefore, formal ethical approval was not required for this study.

Statement of informed consent

For this type of study (systematic literature review), formal informed consent from patients was not required as no clinical trials or direct interventions were performed.

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