

THE RELATIONSHIP BETWEEN ENERGY DRINKS A AND B WITH BLOOD PRESSURE AND PULSE RATE INCREASE AMONG COLLEGE STUDENTS

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ABSTRACT

Energy drinks are popular among various groups of people, such as teenagers and working individuals. These beverages are consumed to provide additional energy and improve focus. This research investigates the relationship between energy drinks and blood pressure and heart rate in students of the Faculty of Medicine at Universitas Airlangga, Surabaya, Indonesia. The study used the open trial – randomized cross-over study method and collected primary data through experiments. The sample consisted of students from the Faculty of Medicine at Universitas Airlangga, aged 19 to 22 years, with a normal body mass index ranging from 18.5 to 24.9. The systolic, diastolic, and heart rate values were measured before and after consuming energy drinks. A total of 38 research samples were used, including 22 males (57.8%) and 16 females (42.1%). Energy drinks such as Kratingdaeng and Extra Joss showed a significant increase in blood pressure. However, no significant changes were observed in heart rate. The results of the Wilcoxon statistical test, comparing systolic and diastolic conditions before and after consuming Extra Joss, showed $p < 0.0001$. A significance level of $p < 0.05$ indicates a significant effect of energy drinks on the students. The Wilcoxon test for Kratingdaeng also yielded a $p < 0.0001$. For the p -value through the Wilcoxon test on diastolic values before and after consuming Extra Joss and Kratingdaeng, the result was $p < 0.05$. However, the Wilcoxon test for heart rate before and after consuming Kratingdaeng and Extra Joss had a $p < 0.05$. In the Mann-Whitney statistical test, a $p < 0.05$ was found only in the post-systolic condition, while other conditions had at $p \geq 0.05$. In conclusion, energy drinks significantly affected blood pressure, but no significant changes were observed in heart rate.

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INTRODUCTION

Around 1.28 billion adults aged 30-79 worldwide suffer from hypertension, with a significant portion residing in low- and middle-income countries. Approximately 46% of those with hypertension are unaware of their condition. Hypertension is a leading cause of premature death globally¹. Basic Health Research of Indonesia reported that the prevalence of hypertension in Indonesia was 34.1% in 2018, up from 25.8% in 2013. Various conditions, such as kidney disease, thyroid disorders, tumors, adrenal gland abnormalities, or vascular issues, can cause hypertension². Unhealthy lifestyles, including energy drink consumption, can also contribute to increased blood pressure³.

There are cases of palpitations in a 16-year-old boy consuming energy drinks thrice daily for two weeks, even though his blood pressure remains normal⁴. A 28-year-old athlete experienced a heart attack linked to excessive caffeine-containing energy drink intake⁵. Deaths and seizures due to excessive energy drink consumption have also been reported⁶.

A previous study on 27 healthy children and adolescents, averaging 14.53 ± 2.4 years old, showed a significant increase in systolic and diastolic blood pressure after consuming energy drinks⁷. However, the study indicated a minimal impact on heart rate⁷. Another study with 44 adults aged 15-30 showed no significant blood pressure changes post-energy drink consumption but a notable decrease in heart rate 30 minutes later⁸.

Indonesia's energy drink consumption fluctuates yearly, as evident in South Jakarta, where it increased from 19% in 2019 to 26% in 2021⁹. Popular brands

like Kratingdaeng, Hemaviton, Extra Joss, Fit-up, and others contain stimulants like caffeine, taurine, and various vitamins¹⁰. Statistics from 2007 show that Extra Joss and Kratingdaeng were favored brands in Indonesia⁹.

Kratingdaeng and Extra Joss have similar compositions, differing mainly in the presence of royal jelly in Extra Joss. Royal jelly has pharmacological effects, including blood pressure reduction and pulse rate through increased nitric oxide production^{11,12}. Caffeine triggers adrenaline production, leading to increased blood pressure by competitively antagonizing adenosine receptors. Adenosine, a neuromodulator, affects central nervous system functions, causing vasoconstriction and elevated peripheral resistance¹³. Exceeding 400 mg of caffeine, equivalent to four to five cups of coffee daily for healthy adults, can have adverse effects on blood pressure and heart rate¹⁴. The effects of caffeine consumption, felt within 5-30 minutes, can last up to 12 hours, with dosage influencing blood pressure changes¹⁵. With the presence of these issues, the researcher intended to investigate the relationship between energy drinks A (Extra Joss) and B (Kratingdaeng) with the increase in blood pressure and pulse rate in students.

MATERIALS AND METHODS

This study employed the open trial – randomized cross-over study method to investigate the relationship between Extra Joss and Kratingdaeng concerning blood pressure and heart rate in university students. The sample consisted of 38 medical students from Universitas Airlangga in Surabaya, aged between 19 and 22 years, with a normal BMI range of

18.5 – 24.9 from July 2022 to March 2023. The inclusion criteria included students aged 19-22 years with a normal BMI of 18.5 – 24.9. The exclusion criteria involved students with a history of hypertension and habitual energy drink consumption. This research received approval from the Ethical Health Research Committee of Faculty Medicine of Universitas Airlangga, Surabaya, Indonesia, with reference number 246/EC/KEPK/FKUA/2022 on 7 December 2022. The data collected in this study were primary data and obtained directly from the examination of the research subjects. Later, the two groups were subjected to randomization process. Each research subject was assigned a number that was randomly generated using a random number generator. Numbers 1 to 20 were assigned to Group A, while numbers 21 to 38 were assigned to Group B. Subsequently, Group A received Extra Joss, while Group B received Kratingdaeng initially. A washout process was conducted for two weeks to eliminate the caffeine effects in the research participants. Afterward, the given drinks were switched, with Group A receiving Kratingdaeng and Group B receiving Extra Joss. The studied caffeine effect was acuted, lasting for 15 minutes. During data collection, the researcher obtained informed consent from the research subjects. Data analysis used the Wilcoxon and Mann-Whitney tests to analyze the correlation between independent and dependent variables due to different treatments given to the same subjects. Data processing and analysis were conducted using SPSS software (IBM SPSS Statistics) version 26.

RESULTS

In total, 38 students from the Faculty of Medicine, Universitas Airlangga, participated in this research and were included in the analysis. Among these 38 samples, none were taking medications or had any specific medical conditions. The energy drinks consumed by the samples were taken appropriately and did not cause any side effects.

Table 1. Participant Characteristics

Characteristics (n=38)	Total
Sex, n (%)	
Male	22 (57.8)
Female	16 (42.1)
Age, mean ± SD	20.02 (0.28)
Habit, n (%)	
Rare	30 (78.9)
Sometimes	8 (21.0)
Systole, mean ± SD	116.39 ± 6.69
Diastole, mean ± SD	70.97 ± 6.28
Pulse rate, mean ± SD	73.39 ± 9.66

The Kolmogorov-Smirnov test indicated a non-normal distribution of parameter values both before and after consuming energy drinks. Therefore, the data were tested using the Mann-Whitney and Wilcoxon tests to substantiate the research hypotheses.

Table 2. Comparison of Cardiovascular Values between Different Drinks

	Extra Joss	Kratingdaeng	p-value
Pre Systole	118 (100–135)	115 (108-130)	p=0.372
Pre Diastole	70 (60 – 90)	70 (60 – 85)	p=0.664
Pre Pulse Rate	70,5 (60 – 107)	72.5 (65 – 95)	p=0.230
Post Systole	121 (108–138)	118 (110-133)	p=0.034*
Post Diastole	72 (60 – 89)	72 (60 – 90)	p=0.941
Post Pulse Rate	73 (60 – 105)	73.5 (64 – 84)	p=0.537

*significant relationship, p-value obtained from the Mann-Whitney test

Table 3. Comparison of Cardiovascular Values between the Same Drinks

	Pre	Post	p-value
Extra Joss			
SBP	118 (100-135)	121 (108 – 138)	p<0.0001
DBP	70 (60 – 90)	72 (60 – 89)	p=0.0002
Pulse Rate	70.5 (60–107)	73 (60 – 105)	p=0.240
Kratingdaeng			
SBP	115 (108-130)	118 (110 – 133)	p<0.0001
DBP	70 (60 – 85)	72 (60 – 90)	p=0.0005
Pulse Rate	72.5 (65 – 95)	73.5 (64 – 84)	p=0.993

p-value is obtained from the Wilcoxon test

DISCUSSION

Influence of Energy Drinks on Blood Pressure and Heart Rate

A previous study revealed an increase in systolic and diastolic values after consuming energy drinks, with a rise of 5 mmHg for systolic and 4 mmHg for diastolic compared to the placebo¹⁶. Another research also showed a significant increase in average systolic and diastolic values compared to the placebo, with average increases of 5.23 mmHg and 3.29 mmHg, respectively⁷. A meta-analysis stated that energy drinks resulted in an average increase of 4.44 mmHg for systolic and 2.73 mmHg for diastolic values¹⁶. This suggests that the cardiovascular system in children reacts more actively when exposed to the contents of energy drinks compared to adults. A study reported an increase in blood pressure by 10 mmHg and a heart rate increase of 5-7 bpm after consuming energy drinks¹⁷. Another study indicated that

energy drink consumption affects heart cycle repolarization, increases blood pressure, and reduces serum blood potassium levels¹⁸. A study found an increased heart rate 30 minutes after consuming energy drinks¹⁹. However, another study found no changes in heart rate and blood pressure²⁰. Similarly, a study also did not observe changes in values after consuming energy drinks²¹. Resting heart rate decreased after 60 minutes of consuming energy drinks²². Previous studies found no changes in blood pressure and heart rate 60 minutes after consuming energy drinks²³. Another study observed an increase in blood pressure and heart rate within 120 minutes after consuming energy drinks²⁴. The study stated that caffeine-containing energy drinks might increase systolic blood pressure in type 1 diabetes patients²⁵. Similarly, a previous study found an increase in diastolic values and heart rate 30 minutes after consuming energy drinks²⁶. A study using 355 mL of energy drinks found an increase in blood pressure

and heart rate within 2 hours after consumption²⁷.

Another study indicated that heart rate did not significantly change after consuming energy drinks but tended to decrease¹⁶. A study found significant decrease in blood pressure 30 minutes after consuming energy drinks ($p=0.004$)¹⁸. Similarly, after measurements at two hours ($p=0.009$) and four hours ($p=0.022$) post-consumption, a decrease in heart rate was observed. However, there were no significant changes in systolic ($p=0.44$) and diastolic ($p=0.26$) values between before and after consuming energy drinks. A study investigating the acute effects of energy drink consumption on heart rhythm and electrocardiographic interval found a significant decrease in heart rate by 2.71 bpm within 60-120 minutes after consuming energy drinks compared to the placebo²⁸. Systolic blood pressure increased by 3 ± 1.6 mmHg and 6.4 ± 1.7 mmHg after 30 and 60 minutes, respectively, and heart rate significantly decreased (-7.1 ± 2 bpm at 30 minutes and -4.6 ± 2 bpm at 60 minutes) after intravenous caffeine administration²⁹. A previous study used a combination of two active substances, caffeine, and taurine. They found a decrease in heart rate 45 minutes after consuming the drink, while there was no significant change in blood pressure³⁰. These findings contradicted results reported by other researchers.

Body Compensation after Consuming Energy Drinks

A study revealed that after consuming an energy drink for 2 hours, there was an impact on the stiffness of the right common carotid artery³¹. The research involved 19 teenage participants, showing a significant increase in artery stiffness compared to a placebo. Based on these

findings, it is assumed that the heightened arterial stiffness is caused by sympathetic stimulation due to the energy drink's caffeine content, leading to increased blood pressure. This, in turn, can result in a decrease in heart rate through baroreceptor stimulation and the parasympathetic system²⁸. The "fight or flight" response triggered by the sympathetic system is essentially a whole-body reaction. Changes in the functions of organs and tissues throughout the body are synchronized, leading to an increased delivery of oxygen-rich blood and nutrients to the skeletal muscles. Both heart rate and myocardial contractility increase, causing the heart to pump more blood per minute. Sympathetic stimulation on vascular smooth muscles induces widespread vasoconstriction, especially in the gastrointestinal and renal organs. Vasoconstriction serves to redirect blood flow from metabolically inactive tissues to contracting muscles, while the parasympathetic system dominates during rest. This aims to conserve energy, store energy, and regulate bodily functions such as digestion and urination. All effects induced by the sympathetic system are later compensated by the parasympathetic system when the body is at rest. The parasympathetic system reduces heart rate, aiding energy conservation during rest³².

The parasympathetic system utilizes acetylcholine as its neurotransmitter for both preganglionic and postganglionic neurons, activating muscarinic receptors. This differs from the sympathetic system, which uses norepinephrine functioning on adrenergic receptors as the main neurotransmitter for most postganglionic neurons. In the heart, parasympathetic stimulation via M2 receptors causes a decrease in heart rate and conduction speed through the AV node.

Meanwhile, in blood vessels, parasympathetic stimulation via M3 receptors causes vasodilation. After being released from cholinergic neurons and interacting with muscarinic receptors, acetylcholine is rapidly deactivated from the neuroeffector junction to allow for new signals. In cholinergic synapses, this action is primarily enzymatically performed by acetylcholinesterase³³.

The Sympathetic Nervous System (SNS) releases hormones (catecholamines - epinephrine and norepinephrine) to accelerate heart rate. The Parasympathetic Nervous System (PNS) releases acetylcholine to slow down heart rate. Factors such as stress, caffeine, and excitement may momentarily increase heart rate, while meditation or slow and deep breathing may help slow it down. Exercise at any time increases heart rate, and it remains high during continued exercise. Initially, the body reduces parasympathetic stimulation during exercise, allowing the heart rate to slowly increase. During intense exercise, the sympathetic system functions to accelerate heart rate. Regular participation in cardiovascular exercise over an extended period can reduce resting heart rate by enhancing heart size, contractile strength, and the time the heart takes to fill with blood. The decrease in heart rate is due to increased parasympathetic nervous system activity and may also result from decreased sympathetic nervous system activity³⁴.

However, the primary cause of the decrease in heart rate needs further investigation²⁸. Arterial stiffness caused by energy drinks is mainly attributed to the caffeine and guarana content. Caffeine induces sympathetic stimulation, which can increase peripheral vascular resistance and affect arterial stiffness³⁵. A study yielded

significant results related to peripheral systolic and diastolic blood pressure values after consuming energy drinks⁷. The findings confirm that increased resistance in peripheral blood vessels can lead to increased arterial stiffness after consuming energy drinks³¹.

Not only caffeine, but taurine is also suspected to have effects on lowering blood pressure and increasing arterial stiffness³⁶. Besides containing caffeine and taurine, energy drinks are high in sugar and calories. Long-term consumption of energy drinks can increase the risk of glucose metabolism disorders, hypertension, and overweight. All these risk factors have been proven to be associated with the process of increasing arterial stiffness³¹. Energy drinks contribute to an increased risk of cardiovascular disorders, especially in underage individuals with risk factors such as hypertension, overweight, diabetes, and congenital heart disease, making the consumption of energy drinks something to prevent. Additionally, a decrease in pulse rate can be caused by acute spikes in systolic and diastolic observed in various studies²⁸.

Caffeine is also considered to increase the contraction of the left ventricular muscle and cause vasoconstriction, leading to increased blood pressure. The blood pressure increase caused by caffeine also activates carotid baroreceptors, affecting the parasympathetic system. Stimulation of the parasympathetic system results in a decrease in pulse rate, cardiac output, and blood pressure⁷. Physiological systems like these can explain the results found in this research. A study reported that an increase in systolic blood pressure was observed one hour after consuming an energy drink. In contrast to heart rate, heart rate values tend

to decrease after consuming energy drinks⁷. After 2 to 4 hours of consuming energy drinks, a decrease in systolic blood pressure values compared to the peak values was found, possibly due to an increase in the parasympathetic system compensating for the caffeine content in energy drinks. To evaluate considerations in the physiological aspects related to the caffeine's effect on the cardiovascular system, further studies monitoring the activation of the parasympathetic system are still needed. Royal jelly has antihypertensive properties and is associated with increased nitric oxide production. Additionally, royal jelly acts as an agonist to muscarinic receptors, inducing vasorelaxation through the NO/cGMP pathway and calcium channels. Therefore, royal jelly has antihypertensive and vasodilatory functions through increased nitric oxide production³⁷. The vasodilatory effect produced by royal jelly can increase blood mass, enhancing blood flow without affecting systemic circulation. Thus, royal jelly might improve peripheral circulation in healthy individuals without considering product differences³⁸.

Dangers of Energy Drinks to Health

Medical associations, including the American Academy of Pediatrics and the American Medical Association, recommend limiting the consumption of energy drinks in children due to potential health risks associated with these beverages³⁹. Although children and adolescents represent one of the largest consumer groups of energy drinks, there is still no research addressing the acute effects of energy drink consumption on the cardiovascular system of children. The European Food Safety Authority (EFSA) suggests a maximum caffeine consumption of 3 mg per kilogram of body weight,

suitable for healthy children and adolescents without specific risk factors. According to a survey conducted by EFSA, two-thirds of teenagers in Europe between the ages of 10 and 18 consume energy drinks. Twelve percent of teenagers consuming energy drinks are categorized as chronic consumers, consuming these beverages at least four to five times per week. Additionally, 12% of teenagers consuming energy drinks consume at least 1,065 liters in one drinking session and are therefore categorized as highly acute consumers⁴⁰. The high prevalence of chronic and excessive energy drink consumption among children and adolescents is highly concerning.

The side effects of consuming energy drinks include an increased risk of hypertension, glucose metabolism disorders, and overweight. Excessive consumption of energy drinks, especially in conjunction with medication, can lead to disturbances in heart rhythm¹⁶. Recent research reveals a significant increase in the number of supraventricular extrasystoles after acute consumption of energy drinks (3 mg of caffeine per kilogram of body weight) in 26 healthy children and adolescents. Additionally, pediatric case reports indicate that excessive consumption of energy drinks can cause acute kidney failure, seizures, and spontaneous coronary artery dissection, especially in children and adolescents with pre-existing health conditions such as arterial hypertension, rhythm anomalies, diabetes mellitus, and overweight, who should avoid consuming energy drinks⁷. Energy drinks containing caffeine have been temporarily withdrawn from sale after the discovery of side effects. A 2 mmHg increase in systolic blood pressure (SBP) is associated with a 7% increased risk of death from ischemic heart

disease and a 10% increased risk of death from stroke. The side effects of energy drinks reported by several studies highlight the importance of monitoring potential side effects associated with energy drink consumption, as this becomes a significant health issue in society³.

CONCLUSION

Consuming energy drinks like Extra Joss and Kratingdaeng led to increased systolic and diastolic values, while pulse rate remained unchanged. Additionally, a notable difference in post-systolic values was observed between Extra Joss and Kratingdaeng.

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CONFLICT OF INTEREST

All Authors have no conflict of interest.

ETHIC CONSIDERATION

This research obtained ethical approval from the Ethical Health Research Committee of Universitas Airlangga School of Medicine Surabaya, Indonesia, with reference number 246/EC/KEPK/FKUA/2022 on 7 December 2022.

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AUTHOR CONTRIBUTION

All authors have contributed to all processes in this research, including preparation, data gathering, and analysis, drafting, and approval for publication of this manuscript.

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