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

Narendra Arya Setiabudi[1], Budi Susetyo Pikir[2], Pudji Lestari[3], Bambang Purwanto[4]

[1]Medical Student, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[2]Department of Internal Medicine, Dr. Soetomo General Academic Hospital, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[3]Department of Public Health-Preventive Medicine, Universitas Airlangga, Surabaya, Indonesia
[4]Department of Medical Physiology and Biochemistry, Universitas Airlangga, Surabaya, Indonesia

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 at $p<0.05$. In the Mann-Whitney statistical test, a $p<0.05$ was found only in the post-systolic condition, while other conditions had at $p\geq0.05$. In conclusion, energy drinks significantly affected blood pressure, but no significant changes were observed in heart rate.

ARTICLE HISTORY

Received: December, 14, 2023
Revision: February, 23, 2023
Accepted: April, 01, 2024
Online: May, 29, 2024

doi:
10.20473/jcmphr.v5i1.52676

KEYWORDS
energy drinks, blood pressure, heart rate, caffeine.

Corresponding author
Budi Susetyo Pikir
✉ bsp49@fk.unair.ac.id
Department of Internal Medicine, Dr. Soetomo General Academic Hospital, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia

How to cite:
Setiabudi, N. A., Pikir, B. S., Lestari, P., Purwanto, B., 2024, The Relationship Between Energy Drinks A and B with Blood Pressure and Pulse Rate Increase Among College Students, Journal of Community Medicine and Public Health Research, 5(1): 60 - 70.

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 globally[1]. 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 hypertension[2]. Unhealthy lifestyles, including energy drink consumption, can also contribute to increased blood pressure[3].

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 normal[4]. A 28-year-old athlete experienced a heart attack linked to excessive caffeine-containing energy drink intake[5]. Deaths and seizures due to excessive energy drink consumption have also been reported[6].

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 drinks[7]. However, the study indicated a minimal impact on heart rate[7]. 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 later[8].

Indonesia's energy drink consumption fluctuates yearly, as evident in South Jakarta, where it increased from 19% in 2019 to 26% in 2021[9]. Popular brands like Kratingdaeng, Hemaviton, Extra Joss, Fit-up, and others contain stimulants like caffeine, taurine, and various vitamins[10]. Statistics from 2007 show that Extra Joss and Kratingdaeng were favored brands in Indonesia[9].

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 resistance[13]. 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 rate[14]. The effects of caffeine consumption, felt within 5-30 minutes, can last up to 12 hours, with dosage influencing blood pressure changes[15]. 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 placebo[16]. 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, respectively[7]. A meta-analysis stated that energy drinks resulted in an average increase of 4.44 mmHg for systolic and 2.73 mmHg for diastolic values[16]. 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 drinks[17]. Another study indicated that energy drink consumption affects heart cycle repolarization, increases blood pressure, and reduces serum blood potassium levels[18]. A study found an increased heart rate 30 minutes after consuming energy drinks[19]. However, another study found no changes in heart rate and blood pressure[20]. Similarly, a study also did not observe changes in values after consuming energy drinks[21]. Resting heart rate decreased after 60 minutes of consuming energy drinks[22]. Previous studies found no changes in blood pressure and heart rate 60 minutes after consuming energy drinks[23]. Another study observed an increase in blood pressure and heart rate within 120 minutes after consuming energy drinks[24]. The study stated that caffeine-containing energy drinks might increase systolic blood pressure in type 1 diabetes patients[25]. Similarly, a previous study found an increase in diastolic values and heart rate 30 minutes after consuming energy drinks[26]. A study using 355 mL of energy drinks found an increase in blood pressure

and heart rate within 2 hours after consumption[27].

Another study indicated that heart rate did not significantly change after consuming energy drinks but tended to decrease[16]. 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 placebo[28]. 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 administration[29]. 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 pressure[30]. 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 artery[31]. 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 system[28]. 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 rest[32].

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 acetylcholinesterase[33].

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 activityx[34].

However, the primary cause of the decrease in heart rate needs further investigation[28]. 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 stiffness[35]. A study yielded significant results related to peripheral systolic and diastolic blood pressure values after consuming energy drinks[7] The findings confirm that increased resistance in peripheral blood vessels can lead to increased arterial stiffness after consuming energy drinks[31].

Not only caffeine, but taurine is also suspected to have effects on lowering blood pressure and increasing arterial stiffness[36]. 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 stiffness[31]. 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 studies[28].

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 pressure[7]. 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 drinks[7]. 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 production[37]. 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 differences[38].

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 beverages[39]. 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 consumers[40]. 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 rhythm[16]. 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 drinks[7]. 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 society[3].

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.

ACKNOWLEDGMENT

The authors would like to thank all the supervisors and all the research participants who willingly attended on the data collection, enabling the successful implementation of this study. Thank you to the ethics committee of the Faculty of Medicine, Universitas Airlangga, for providing ethical approval for this research.

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.

FUNDING

None.

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.

REFERENCES

1. World Health Organization. Hypertension. [online] Who.int. 2021. Available at: https://www.who.int/news-room/fact-sheets/detail/hypertension. Accessed at December 12, 2022.
2. Hegde S, Ahmed I, Aeddula NR. Secondary Hypertension. 2023 Jul 30. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 31335025.
3. Shah SA, Szeto AH, Farewell R, Shek A, Fan D, Quach KN, Bhattacharyya M, Elmiari J, Chan W, O'Dell K, Nguyen N, McGaughey TJ, Nasir JM, Kaul S. Impact of High Volume Energy Drink Consumption on Electrocardiographic and Blood Pressure Parameters: A Randomized Trial. J Am Heart Assoc. 2019 Jun 4;8(11):e011318.
4. Usman A, Jawaid A. Hypertension in a young boy: an energy drink effect. BMC Res Notes. 2012 Oct 29;5:591.
5. Berger, A. J., & Alford, K. Clinical record Cardiac arrest in a young man following excess consumption of caffeinated “energy drinks.” In The Medical Journal of Australia. 2009. (Vol. 190). www.wada-ama.org/rtecontent/document/Monitoring_Program_2008_
6. Clauson KA, Shields KM, McQueen CE, Persad N. Safety issues associated with commercially available energy drinks. J Am Pharm Assoc (2003). 2008 May-Jun;48(3):e55-63; quiz e64-7.
7. Oberhoffer FS, Li P, Jakob A, Dalla-Pozza R, Haas NA, Mandilaras G.

Energy Drinks: Effects on Blood Pressure and Heart Rate in Children and Teenagers. A Randomized Trial. Front Cardiovasc Med. 2022 Mar 21;9:862041.
8. Hajsadeghi S, Mohammadpour F, Manteghi MJ, Kordshakeri K, Tokazebani M, Rahmani E, Hassanzadeh M. Effects of energy drinks on blood pressure, heart rate, and electrocardiographic parameters: An experimental study on healthy young adults. Anatol J Cardiol. 2016 Feb;16(2):94-9.
9. Putriastuti R, Kustiyah L, Anwar F. Persepsi, konsumsi dan preferensi minuman berenergi. Jurnal Gizi dan Pangan. 2007 Nov 13;2(3):13-25.
10. Aditya MF, Kasiyati K, Isdadiyanto S, Tana S, Sunarno S. Efek Minuman Berenergi Terhadap Histopatologi Hepar Tikus Wistar (Rattus norvegicus). Media Bina Ilmiah. 2021 Jan 31;15(7):4849-60.
11. Pasupuleti VR, Sammugam L, Ramesh N, Gan SH. Honey, Propolis, and Royal Jelly: A Comprehensive Review of Their Biological Actions and Health Benefits. Oxid Med Cell Longev. 2017;2017:1259510.
12. Pan Y, Rong Y, You M, Ma Q, Chen M, Hu F. Royal jelly causes hypotension and vasodilation induced by increasing nitric oxide production. Food Sci Nutr. 2019 Feb 17;7(4):1361-1370.
13. Firmansyah MR, Rustam R. Hubungan Merokok dan Konsumsi Kopi dengan Tekanan Darah pada Pasien Hipertensi. Jurnal Kesehatan. 2017 Aug 31;8(2):263-8.
14. FDA. Spilling the Beans: How Much Caffeine is Too Much? [online] U.S. Food and Drug Administration. 2018. Available at: https://www.fda.gov/consumers/consumer-updates/spilling-beans-how-much-caffeine-too-much.
15. Bistara DN, Kartini Y. Hubungan kebiasaan mengkonsumsi kopi dengan tekanan darah pada dewasa muda. Jurnal Kesehatan Vokasional (JKESVO). 2018;3(1):23-8.
16. Cao DX, Maiton K, Nasir JM, Estes NAM, Shah SA. Energy Drink-Associated Electrophysiological and Ischemic Abnormalities: A Narrative Review. Front Cardiovasc Med. 2021 Jul 1;8:679105.
17. Steinke L, Lanfear DE, Dhanapal V, Kalus JS. Effect of "energy drink" consumption on hemodynamic and electrocardiographic parameters in healthy young adults. Ann Pharmacother. 2009 Apr;43(4):596-602.
18. Kozik TM, Shah S, Bhattacharyya M, Franklin TT, Connolly TF, Chien W, Charos GS, Pelter MM. Cardiovascular responses to energy drinks in a healthy population: The C-energy study. Am J Emerg Med. 2016 Jul;34(7):1205-9.
19. Alford C, Cox H, Wescott R. The effects of red bull energy drink on human performance and mood. Amino Acids. 2001;21(2):139-50.
20. Rashti SL, Ratamess NA, Kang J, Faigenbaum AD, Chilakos A, Hoffman JR. Thermogenic effect of meltdown RTD energy drink in young healthy women: a double blind, cross-over design study. Lipids Health Dis. 2009 Dec 17;8:57.
21. Ragsdale FR, Gronli TD, Batool N, Haight N, Mehaffey A, McMahon EC, Nalli TW, Mannello CM, Sell CJ, McCann PJ, Kastello GM, Hooks T, Wilson T. Effect of Red Bull energy drink on cardiovascular and renal function. Amino Acids. 2010 Apr;38(4):1193-200.
22. Nelson, M. T., Biltz, G. R., & Dengel, D. R. *Cardiovascular and ride time-to-exhaustion effects of an energy drink*. 2014. http://www.jissn.com/content/11/1/2
23. An SM, Park JS, Kim SH. Effect of energy drink dose on exercise capacity, heart rate recovery and heart

rate variability after high-intensity exercise. J Exerc Nutrition Biochem. 2014 Mar;18(1):31-9.
24. Grasser EK, Yepuri G, Dulloo AG, Montani JP. Cardio- and cerebrovascular responses to the energy drink Red Bull in young adults: a randomized cross-over study. Eur J Nutr. 2014 Oct;53(7):1561-71.
25. Olateju T, Begley J, Green DJ, Kerr D. Physiological and glycemic responses following acute ingestion of a popular functional drink in patients with type 1 diabetes. Can J Diabetes. 2015 Feb;39(1):78-82.
26. Cavka A, Stupin M, Panduric A, Plazibat A, Cosic A, Rasic L, Debeljak Z, Martinovic G, Drenjancevic I. Adrenergic System Activation Mediates Changes in Cardiovascular and Psychomotoric Reactions in Young Individuals after Red Bull (©) Energy Drink Consumption. Int J Endocrinol. 2015;2015:751530.
27. Elitok A, Öz F, Panc C, Sarıkaya R, Sezikli S, Pala Y, Bugan ÖS, Ateş M, Parıldar H, Ayaz MB, Atıcı A, Oflaz H. Acute effects of Red Bull energy drink on ventricular repolarization in healthy young volunteers: a prospective study. Anatol J Cardiol. 2015 Nov;15(11):919-22.
28. Mandilaras G, Li P, Dalla-Pozza R, Haas NA, Oberhoffer FS. Energy Drinks and Their Acute Effects on Heart Rhythm and Electrocardiographic Time Intervals in Healthy Children and Teenagers: A Randomized Trial. Cells. 2022 Jan 31;11(3):498.
29. Corti R, Binggeli C, Sudano I, Spieker L, Hänseler E, Ruschitzka F, Chaplin WF, Lüscher TF, Noll G. Coffee acutely increases sympathetic nerve activity and blood pressure independently of caffeine content: role of habitual versus nonhabitual drinking. Circulation. 2002 Dec 3;106(23):2935-40.
30. Bichler A, Swenson A, Harris MA. A combination of caffeine and taurine has no effect on short term memory but induces changes in heart rate and mean arterial blood pressure. Amino Acids. 2006 Nov;31(4):471-6.
31. Li P, Mandilaras G, Jakob A, Dalla-Pozza R, Haas NA, Oberhoffer FS. Energy Drinks and Their Acute Effects on Arterial Stiffness in Healthy Children and Teenagers: A Randomized Trial. J Clin Med. 2022 Apr 7;11(8):2087.
32. McCorry, L.K. (2007). Physiology of the Autonomic Nervous System. American Journal of Pharmaceutical Education, [online] 71(4), p.78. doi:https://doi.org/10.5688/aj71047.
33. Tindle J, Tadi P. Neuroanatomy, Parasympathetic Nervous System. 2022 Oct 31. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan–. PMID: 31985934.
34. *Heart Rate | Sports Medicine | UC Davis Health*. (n.d.). Retrieved October 28, 2023, from https://health.ucdavis.edu/sports-medicine/resources/heart-rate
35. Mahmud A, Feely J. Acute effect of caffeine on arterial stiffness and aortic pressure waveform. Hypertension. 2001 Aug;38(2):227-31.
36. Azuma, J., Schaffer, S. W., & Ito, T. (Eds.). (2009). *Taurine 7* (Vol. 643). Springer New York. https://doi.org/10.1007/978-0-387-75681-3
37. Pan Y, Rong Y, You M, Ma Q, Chen M, Hu F. Royal jelly causes hypotension and vasodilation induced by increasing nitric oxide production. Food Sci Nutr. 2019 Feb 17;7(4):1361-1370.
38. Liang Y, Kagota S, Maruyama K, Oonishi Y, Miyauchi-Wakuda S, Ito Y, Yamada S, Shinozuka K. Royal

jelly increases peripheral circulation by inducing vasorelaxation through nitric oxide production under healthy conditions. Biomed Pharmacother. 2018 Oct;106:1210-1219.

39. Committee on Nutrition and the Council on Sports Medicine and Fitness. Sports drinks and energy drinks for children and adolescents: are they appropriate? Pediatrics. 2011 Jun;127(6):1182-9.
40. Zucconi, S., Volpato, C., Adinolfi, F., Gandini, E., Gentile, E., Loi, A., & Fioriti, L. Gathering consumption data on specific consumer groups of energy drinks. 2017. *EFSA Supporting Publications*, *10*(3). https://doi.org/10.2903/sp.efsa.2013.en-394