ORIGINAL ARTICLE

EFFECT OF ENERGY DRINK ON REACTION TIME, HAEMODYNAMIC AND ELECTROCARDIOGRAPHIC PARAMETERS

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Objectives: To evaluate the cardiovascular effects and reaction time associated with energy drink in healthy medical students. **Methods:** In this randomized control design, a total of 30 healthy volunteers, 19–21 years of age of either sex were divided at random into three groups namely A, B and C. At the time of study, subjects were fasting overnight and were abstaining from caffeine for 48 hours. Baseline pulse and blood pressure were taken whereas heart rate, QTc interval and mean reaction time of each of three groups were measured by using power laboratory. The subjects of group A had consumed nothing while those belonging to group B and C were asked to consume 250 ml (1 can) and 500 ml (2 cans) of energy drink respectively and measurements were retaken after 1 and 2 hours interval. Statistical analysis was done using SPSS-19, and $p \leq 0.05$ was considered significant. **Results:** The pulse rate, heart rate, blood pressure and QTc interval increased significantly in group C at 2 hour as compare to group A and B. In group C, at 2 hours, pulse rate increased by 16.1% (p=0.001), systolic blood pressure increased by 9.5% (p=<0.001), diastolic blood pressure increased by 10.1% (p=0.002), heart rate significantly increased by 17.3% (p=0.015) and QTc interval prolonged by 12.4% (p=0.002). A decrease in mean reaction time was noticed by 20.0% (p=<0.001). **Conclusion:** Energy drink consumption increases the HR, BP, QT interval as well as performance. The more the energy drink consumed, the higher the changes are likely to be.

Keywords: Energy drink, heart rate, blood pressure, performance

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INTRODUCTION

Energy drinks are non-alcoholic drinks marketed for boosting energy levels and mental concentration. Since the beginning of Red Bull® in 1987, the current worldwide leader of energy drinks, they have become very popular particularly among young adults, athletes and college students. Most of these unique energy blends like Red Bull®, Rock Star® and Monster® consist mainly of caffeine and taurine at varying concentrations along with amino acid derivative (camitine), sugar, herbal extracts (guarana, ginseng) and nutritional supplements.[1,2] Caffeine, as a main ingredient can range from 80 mg to over 200 mg per serving. This compares to 34 mg in Coke® and 55 mg in Mountain Dew®.[3,4] Being the most widely consumed drug by the young adults, pharmacological effects of caffeine are thus of potentially great importance.[5] The purpose of this study was to study the potential cardiovascular, haemodynamic, electrocardiographic (ECG) effects and reaction time of Red Bull® energy drink in healthy young medical students.

METHODOLOGY

This randomized control study was conducted at CMH, Medical College Lahore with the approval of the concerned Ethical Review Committee. After written informed consent, 30 healthy, non-smoking, normotensive young medical students of either sex (15 males and 15 females), aged 19–21 years, taking no medications were divided at random into 3 groups namely A, B and C. Exclusion criteria were a medical history of cardiovascular disease, taking any medication affecting the cardiovascular system (such as anti-hypertensive and anti-arrhythmic), history of drug abuse, or taking central nervous system stimulants, a history of migraine or epilepsy/seizures. All participants were requested to avoid caffeine (tea, coffee, soft drinks) for at least 48 hours prior to the test. On the study day, subjects presented to the study centre at 8:00 AM, after a fast of at least 12 hours. Upon their arrival, baseline pulse and blood pressure (BP) were taken whereas heart rate (HR), QTc interval and mean reaction time (MRT) of each of the three groups were measured by using PowerLab® (ADInstruments Australia). The subjects belonging to group A, have consumed nothing whereas participants of group B and C were asked to consume 250 ml (1 can) and 500 ml (2 cans) of an energy drink (Red Bull®), each dose containing 80 mg of caffeine and 1,000 mg of taurine in 250 ml) over a 30 minutes period respectively and all measurements were retaken after 1 and 2 hours interval. Participants abstained from eating or drinking anything except the assigned energy drinks over that time period. The data was arranged and analysed using SPSS-20. Comparison of the percentage change in the quantitative variables between three groups was done using ANOVA. Detailed analysis of ANOVA for pair-wise comparison

between three groups was done by Tukey's Test (Post-hoc analysis), and $p \leq 0.05$ was considered statistically significant.

RESULTS

Thirty (30) medical students were enrolled in this study and all participants completed the study course. Group C showed the highest increase in pulse rate (16.1%) after 1 hour of consumption of energy drink and was significantly different from group A (3.5%, $p<0.001$) and B (6.5%, $p<0.008$). After 2 hours the change in group C was significantly different form group A and B ($p=0.001$ and <0.001 respectively). The difference of change in group B and C between 1 and 2 hours was also significant (9.27%, $p<0.012$) (Table-1).

The systolic blood pressure (SBP) and diastolic blood pressure (DBP) increased maximally in group C to 10.0/8.4% after 1 hour ($p<0.001$ and 0.002 respectively), and 9.5/10.1% after 2 hours ($p<0.001$ respectively). The increase in group B was less than group C but was significant as compare to group A to 7.4/7.7% ($p<0.011$ and 0.004) after 1 hour, and 6.0/7.1% ($p<0.007$ and 0.005) after 2 hours respectively. The change in pulse pressure (PP) was though highest in group C, i.e., 17.3% at 1 hour and 8.4% at 2 hours but was not significantly different as compare to group A ($p=0.192$) and group B ($p=0.395$) (Table-2).

The change in heart rate (HR) for group B was 7.3% ($p=0.015$) at 1 hour and 1.4% ($p<0.001$) at 2 hours; whereas in group C, it was 17.3% ($p<0.001$) after 1 hour and 16.4% ($p<0.001$) after 2 hours. Increase in heart rate in group C at 1 hour and 2 hour was significantly different form group A ($p<0.001$ at 1 hour, and $p<0.001$ at 2 hours respectively). The change in QTc interval was observed highest (12.4%) in group C after 2 hours, and was significantly higher than group A (0.6%), ($p=0.002$) and group B (3.7%), ($p=0.038$). The differences between groups after 1 hour and between 1 and 2 hours were all insignificant ($p=0.063$) (Table-3).

The mean reaction time (MRT) was decreased by 8.8% and 20.0% for groups Band C respectively after 1 hour and the net decrease after 2 hours was 14.2% and 26.0% respectively. After 1 hour, the decrease in group C was significantly different from group A ($p=0.001$) but not different from group B ($p=0.07$). After 2 hours, decrease in MRT both in groups B and C was statistically significant compared to group A ($p=0.039$ and <0.001 respectively) (Table-4).

Mean percent change in haemodynamic parameters for three groups after 1 hour, 2 hours, and between 1–2 hours are tabulated in Table-5.

Table-1: Tukey's Test for pair-wise comparison of pulse rate for three groups at 1 hour, 2 hours and between 1 to 2 hours

Variable	Groups	Mean Difference	SE	*p*
Pulse 1 hr	**A vs B**	-2.92	2.94	0.588
	A vs C	-12.59066	2.94	0.001*
	B vs C	-9.67104	2.94	0.008*
Pulse 2 hr	**A vs B**	2.41	3.33	0.752
	A vs C	-14.45597	3.33	0.001*
	B vs C	-16.86695	3.33	0.000*
Pulse 1–2 hr	**A vs B**	4.84	2.98	0.253
	A vs C	-4.43	2.98	0.313
	B vs C	-9.27392	2.98	0.012*

*Significant

Table-2: Tukey's Test for pair-wise comparison of SBP, DBP, and PP for three groups at 1 hour, 2 hours and between 1 to 2 hours

Variables		Groups	Mean Difference	SE	*p*
SBP	**1 hr**	**A vs B**	-6.5396	2.08	0.011*
		A vs C	-9.07576	2.08	0.000*
		B vs C	-2.54	2.08	0.452
	2 hrs	**A vs B**	-6.36208	1.93	0.007*
		A vs C	-9.88903	1.93	0.000*
		B vs C	-3.53	1.93	0.179
	1–2 hrs	**A vs B**	-0.54	1.67	0.945
		A vs C	-1.77	1.67	0.549
		B vs C	-1.23	1.67	0.744
DBP	**1 hr**	**A vs B**	-8.94923	2.50	0.004*
		A vs C	-9.60084	2.50	0.002*
		B vs C	-0.65	2.50	0.963
	2 hrs	**A vs B**	-8.26295	2.40	0.005*
		A vs C	-11.28892	2.40	0.000*
		B vs C	-3.03	2.40	0.429
	1–2 hrs	**A vs B**	-0.04	2.66	1.000
		A vs C	-2.62	2.66	0.593
		B vs C	-2.58	2.66	0.602
PP 1 hr		**A vs B**	-2.00	6.95	0.955
		A vs C	-12.14	6.95	0.207
		B vs C	-10.14	6.95	0.326

*Significant

Table-3: Tukey's Test for pair-wise comparison of heart rate (HR) and QTc interval for three groups at 1 hour, 2 hours and between 1to 2 hours

Variables	Groups	Mean Difference	SE	*p*
HR 1 hr	**A vs B**	-6.25	2.77	0.080
	A vs C	-14.59323	2.77	0.000*
	B vs C	-8.33854	2.77	0.015*
HR 2 hrs	**A vs B**	-0.37	3.33	0.993
	A vs C	-15.20301	3.33	0.000*
	B vs C	-14.82996	3.33	0.000*
HR 1–2 hrs	**A vs B**	5.07	2.86	0.199
	A vs C	-3.03	2.86	0.548
	B vs C	-8.09080	2.86	0.023*
QT 1 hr	**A vs B**	-5.47	5.20	0.551
	A vs C	-11.82	5.20	0.077
	B vs C	-6.35	5.20	0.451
QT 2 hrs	**A vs B**	-4.35	3.32	0.402
	A vs C	-13.01612	3.32	0.002*
	B vs C	-8.66422	3.32	0.038*
QT 1–2 hrs	**A vs B**	0.57	2.02	0.957
	A vs C	-4.01	2.02	0.134
	B vs C	-4.58	2.02	0.078

*Significant

Table-4: Tukey's Test for pair-wise comparison of MRT for three groups after 1 hour, 2 hours and between 1to 2 hours

Variable	Groups	Mean Difference	SE	*p*
MRT 1 hr	A vs B	8.44	4.84	0.208
	A vs C	19.65776	4.84	0.001*
	B vs C	11.22	4.84	0.070
MRT 2 hrs	A vs B	17.21504	6.65	0.039*
	A vs C	28.99481	6.65	0.000*
	B vs C	11.78	6.65	0.198
MRT 1–2 hrs	A vs B	6.72	3.34	0.129
	A vs C	1.18	3.34	0.934
	B vs C	-5.54	3.34	0.240

*Significant

Table-5: Mean percent change in haemodynamic parameters for three groups after 1 hour, 2 hours and between 1–2 hours

Para-meter	Time	Percent change (Mean±SD)			*p*
		Group A	Group B	Group C	
Pulse	1st hr	3.5±2.4	6.5±6.0	16.1± 9.4	0.001
	2nd hr	2.9±2.6	0.5±9.0	17.4± 8.9	<0.001
	1–2 hr	-0.5±2.9	-5.3±6.4	4.0±9.2	0.016
SBP	1st hr	0.9±2.7	7.4±6.3	10.0±4.3	0.001
	2nd hr	-0.4±3.6	6.0±5.0	9.5±4.2	<0.001
	1–2 hr	-1.2±3.5	-0.7±4.0	0.5±3.8	0.563
DBP	1st hr	-1.2±2.6	7.7±5.9	8.4±7.2	0.001
	2nd hr	-1.2±6.2	7.1±4.7	10.1±5.1	<0.001
	1–2 hr	0.1±4.5	0.2±4.0	2.8±8.3	0.537
PP	1st hr	5.2±8.9	7.2±16.2	17.3±19.6	0.192
	2nd hr	1.3±10.3	2.9±12.8	8.4±13.1	0.395
	1–2 hr	-3.0±11.4	-1.7±11.6	-4.2±16.3	0.920
HR	1st hr	1.1±1.9	7.3±7.2	15.6±7.8	<0.001
	2nd hr	1.0±2.6	1.4±8.9	16.2±9.0	<0.001
	1–2 hr	0.0±2.4	-5.0±6.0	3.1±9.0	0.028
QTc	1st hr	-0.6±2.0	4.9±6.7	11.2±18.9	0.093
	2nd hr	-0.6±2.0	3.7±7.5	12.4±10.3	0.002
	1–2 hr	0.0±2.0	-0.6±6.7	4.0±3.5	0.063
MRT	1st hr	-0.4±4.6	-8.8±11.4	-20.0±14.1	0.002
	2nd hr	3.0±8.9	-14.2±16.1	-26.0±18.0	0.001
	1–2 hr	3.6±7.7	-3.1±8.7	2.4±5.8	0.119

*Significant

DISCUSSION

We observed increase in blood pressure, heart rate, and QT interval, and decrease in mean reaction time after consumption of energy drink. Caffeine-based energy drinks are marketed and claimed for their beneficial effects as natural alternatives to increase energy, to reduce stress, and to improve physical and cognitive performance such as concentration, and alertness.[6] Lately, many adverse effects of these drinks have been noticed with deep concern. It is a common practice among many younger adults, especially in medical students to consume 1 to 2 cans of energy drink daily to reduce sleep hours and to boost up the energy level for study and completing projects.[7] Most common brand consumed was Red Bull®.[8]

This study observed the significantly increased pulse rate, heart rate, blood pressure and QTc interval within 2 hours after consumption of two cans (500 ml) of energy drink as compared to those who consumed one can (250 ml) or nothing. Although the available energy drinks are multi-component products, it is impossible to identify the specific component responsible for the increases observed but caffeine and taurine are the two main ingredients found in all types of energy drinks. Regarding cardiovascular effects, previous studies[9,10] suggested that caffeine has more effect on haemodynamic parameters. Findings of our study corroborate those studies[11,12] in which it was found that energy drink consumption caused increase in blood pressure and heart rate. Similarly, Steinke *et al*[13] also observed a significant increase in BP, HR and QTc interval after consumption of 500 ml of non-specific energy drink at 2 and 4 hours.

Our study is consistent with Lemery *et al*[14] who studied the effects of caffeine alone and found a significant increase in resting systolic and diastolic BP after its consumption. Studies conducted in Pakistan[11] and Saudi Arabia[15] through questionnaire observed the increased post-consumption HR as well as SBP and DBP.

Another study randomized nine subjects to receive either Red Bull® (80 mg caffeine and 1,000 mg taurine in 250 ml) or control (80 mg caffeine solution in 250 ml water) and observed significantly higher recordings of mean 24-h SBP, DBP, and mean arterial pressure (MAP) in those who consumed Red Bull®.[16] Elitok A *et al*[17] found increased heart rate and blood pressure 2 hours after consumption of 355 ml of Red Bull®. Doerner JM[18] suggested that increase in cardiovascular and haemodynamic parameters were due to combined effects of caffeine and taurine.

Alford *et al*[19] observed the effect of the Red Bull® (250 ml) on exercise performance and reported no change in resting BP 30 min after its consumption. Ragsdale *et al*[20] noticed no change in blood pressure within 2 hours test period after consuming one can of Red Bull®. On the contrary, Sang Min An *et al*[21] noticed no significant change in HR and BP after consumption of 2.5 mg/Kg body weight energy drink. The possible reason for the inconsistency of our results with the former studies could also be credited to different amounts or different types of energy drinks used during research projects. Furthermore, the duration of post-consumption HR and BP recording were not similar mostly among all studies ranging from as early as 30 minutes to even 24 hours.

We observed a significant decrease in mean reaction time (MRT) which was found to be consistent with previous studies. Goel V *et al*[22] from India found a significant decrease in MRT after giving Red Bull®. Likewise, Charlotte B Monke[23] observed a 19% decrease in MRT after Red Bull® consumption. Glade[24] reviewed more than 100 research papers and concluded that MRT quickened after energy drink consumption. These improvements in MRT are attributed to the

combined effects of ingredients found in energy drinks. We found a decrease (20%) in MRT in a group who consumed 500 ml of Red Bull®, while in another study[25] a decreased MRT after 30 minutes of consumption of Red Bull® was observed in a group who consumed lower doses of energy drinks.

Some limitations of this study include small sample size and limitation to young healthy subjects only. It requires generalization for other age groups as well. We have investigated the acute cardiovascular and haemodynamic changes only for two hours after energy drink consumption whereas these parameters should be evaluated for a longer periods of time to notice the peak effects after consumption of energy drinks.

CONCLUSION

Energy drink consumption affects the cardiovascular parameters by increasing HR, BP, and QT interval as well as performance. The more the energy drink is consumed, the higher the changes are likely to be.

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