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ACUTE EFFECT OF ENERGY DRINK CONSUMPTION ON RESTING HEART RATE, BLOOD PRESSURE, AND HEART RATE VARIABILITY

by

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ACUTE EFFECT OF ENERGY DRINK CONSUMPTION ON RESTING HEART RATE, BLOOD PRESSURE, AND HEART RATE VARIABILITY

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ABSTRACT

Introduction: Caffeine is a widely consumed substance that is present in foods and medicinal products (Souza, 2014). Energy drinks are some of the most popular dietary supplements in the young adult population (Nelson, 2014).There are many articles that research caffeine from a performance standpoint. Surprisingly, there is very little research that investigates their effect on the cardiovascular system while at rest without exercise (Miles-Chan, 2015). Grasser et al. (2014) found that the consumption of Red Bull increased resting heart rate and blood pressure. Nelson et al. (2014) found an increase in resting heart rate but no change in heart rate variability while supplementing Red Bull. There are not any studies that investigate Monster Energy drink on resting measures alone. Also, there are not any studies that investigate resting measures that combine beat-to-beat blood pressure analysis and heart rate variability. **Purpose:** The purpose of this study was to identify the effect of caffeine supplementation on resting heart rate, blood pressure, and heart rate variability. **Subjects:** Participants consisted of healthy males and females, aged 19 - 29 (n = 14). **Methods:** Each participant attended two separate sessions (each session separated by at least 48hr). All testing was performed in a quiet, climate controlled laboratory and started between 6:00 a.m. and 10:00 a.m. Baseline cardiovascular measures were analyzed for 10 minutes prior to ingestion of a drink. Participants were instructed to relax and avoid any movement. The participants rested in the supine position for 10 minutes. After baseline measures were recorded, participants ingested either a caffeinated Monster Energy® drink (MED) or a

caffeine-free placebo (P). Both beverages were served in a dark, opaque cup and consumed 30 minutes prior to testing. Participants consumed the beverage within a 15-minute period from the time it was received. The amount of beverage consumed (473 mL) was the same for both visits and each participant. However, the amount of caffeine differed. The participants who received the ED had a caffeine content of 140 mg and those who received the P were caffeine free. Post drink cardiovascular monitoring continued for 10 minutes in the same manner that baseline measures were recorded (i.e. supine). Participants returned at least 48 hours after initial visit to repeat baseline and resting cardiovascular measures with either an ED or a P. **Results:** Under resting conditions, paired t-test between MED and P indicate a difference in DBP, p-value = 0.02. However, there were no differences in HRV and hemodynamic parameters (MHR, lnHRV, RMSSD, LF_nu, HF_nu, Total_nu, LF/HF, SBP, MBP, and RPP) before and after MED or P consumption. These results support that 473 mL of MED does not influence HRV or hemodynamic parameters. Intraclass correlation coefficients (ICC) show strong reliability between baseline measures (MHR, DBP, and MBP) and moderate reliability within SBP. **Conclusions:** The results show that consumption of energy drinks contribute to a decrease in DBP. However, HRV and other hemodynamic parameters are not significantly affected by the consumption of energy drinks. Further research is necessary in order to determine the effects of energy drinks on such measurements.

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CHAPTER 1

ACUTE EFFECT OF ENERGY DRINK CONSUMPTION ON RESTING HEART RATE, BLOOD PRESSURE, AND HEART RATE VARIABILITY

INTRODUCTION

The popularity of energy drinks (ED) has drastically increased amongst young adults in recent years (31). Most prefer to consume EDs due to the increased feeling of energy it provides (2). Research reports ED usually containing relatively high levels of caffeine and 51% of college students consume at least one ED on a monthly basis (19). EDs provide stimulating effects such as an increase in heart rate (HR) and blood pressure (BP) as well as improve sleep deprivation (20,30). Increase in vascular resistance instead of stroke volume results in a rise in BP provided there are insignificant changes in HR (32,37). Previous researchers proposed that the rise in BP was due to heightened stimulation of the sympathetic nervous system (26,29).

While popularity and consumption continue to increase, there are very few studies investigating the impact EDs have on the cardiovascular system (15,22). Research investigating ER's effects on HR are equivocal. Many discrepancies noted from previous studies range from an increase, decrease, or no effect on HR (13,24,31). Blood pressure has been reported to be increased, using continuous beat-to-beat BP monitoring, after consuming the ED *Red Bull*® (12). Few studies have considered the acute effects of other

EDs on hemodynamic changes utilizing similar non-invasive techniques. Even with caffeine's popularity, the effect of energy drink consumption on HR variability (HRV) needs further investigation. While certain HRV parameters have been investigated, the results are varied (24,27,35). Individual risk assessment and clinical investigation could benefit from both HRV and hemodynamic measurements (22,27).

Some of the disagreements in research could be contributed to the inability to control diet and lifestyle of the participants, fitness conditioning (trained vs. untrained), body posture during the experiment, or differences in ED composition (i.e. caffeine and taurine). (10). Another potential issues is the discontinuous hemodynamic measurements during the post-consumption drink period (1,3,21,26). The purpose of this study was to investigate the acute impact *Monster® Zero Ultra* energy drink (MED) has on the cardiovascular system using HRV and continuous beat-to-beat BP measurements compared to a similar tasting, non-caffeinated, calorie-free, soft drink of equal volume.

METHODS

Subjects

Fourteen healthy young adults (7 males and 7 females) were recruited from the surrounding community on a voluntary basis. The participants averaged (mean ± SD) 25 ± 3 yrs, with a height of 1.74 ± 0.12 m, a weight of 75.6 ± 20.8 kg, had a body mass index of 24.6 ± 5.0 $kg \cdot m^2$, and average 17.5 ± 7.6% body fat (Table 1).

Each participant was screened and free from any known medical history of cardiovascular, pulmonary, or metabolic problems. All participants reported for two visits. Each visit took place the morning after an overnight (≥8 hr) fast, and participants were asked to avoid vigorous physical activity, caffeine, and alcohol consumption 24 hrs prior to testing (22). Written informed consent was obtained from each participant prior to participating and the study was approved by the AUM Institutional Review Board.

Descriptive Measures

Prior to testing, height and weight were assessed using wall-mounted stadiometer (Seca 216, Birmingham, UK) and a digital weight scale respectively (Tanita BWB-800S, Arlington Heights, IL, USA). Body mass index was calculated as body weight (kg) divided by height squared (m^2). A 7-site skinfold measurement (Harpenden Skinfold Caliper, Baty International, West Sussex, UK) was used to estimate body fat percentages (16).

Experimental Design

This is a single-blind, placebo controlled, counter-balanced crossover design in which participants were assigned one of two orders (1 = Monster Energy® Drink, 2 = Sprite Zero, placebo). Each participant attended two separate sessions (each session separated by at least 48hr). All supine testing was performed in a quiet, dimly lit, climate controlled room and started between 6:00 a.m. and 10:00 a.m. (12). Participants were instructed to relax and avoid any movement. The participants rested in the supine

position for 10 minutes and baseline cardiovascular measures were recorded prior to ingestion of a drink. After baseline measures were recorded, participants ingested either a caffeinated Monster Energy® drink (MED) or a caffeine-free placebo (P). Both beverages were served cold, in a dark, opaque cup and instructed to consume the beverage within a 15-minute period from the time it was received (24). The amount of beverage consumed (473 mL) was the same for both visits and each participant. However, the amount of caffeine differed. The participants who received the ED had a caffeine content of 140 mg and those who received the P were caffeine free (Tables 5 & 6). Post drink cardiovascular monitoring started 30 mins after the participant finished the drink and continued for 10 minutes in the same manner that baseline measures were recorded (i.e. supine). Participants returned for a second visit separated by at least 48 hours after initial visit to repeat baseline and resting cardiovascular measures consuming the alternate drink.

Cardiovascular Recordings

Cardiovascular, EKG recordings were performed using a modified Lead II arrangement and an Electrocardiogram Amplifier (ECG100C) (*BioPac* Systems, Inc., Aero Camino Goleta, CA, USA) with data sampled at a rate of 1,000 Hz (12). Continuous, beat-to-beat, BP was monitored using a *CNAP* ® *Monitor 500* (CNSystems, Medizintechnik, Graz, Austria). BP measurements were taken using the Penaz principle from either the index or middle finger of the left hand (12). A standard cuff was placed on the participant's upper arm on the ipsilateral side for calibration purposes (22). Both

HR and BP signals were recorded using AcqK*nowledge* 4.2 software (*BioPac* Systems, Inc., Aero Camino Goleta, CA, USA). HRV was analyzed using Nevrokard aHRV software (aHRV 13.3.0, Nevrokard, Izola, Slovenia).

Statistical Analysis

All data means and SD were calculated for pre and post-MED and P. Changes were calculated in the pre and post cardiovascular and hemodynamic response to analyze differences in response to drink consumption. The changes between measures were analyzed utilizing a paired-samples t-test. Intraclass correlation coefficient (ICC) was used to test reliability of baseline resting measures (MHR, SBP, DBP, MBP). For all statistical tests, the level of significance was set at $p \leq 0.05$. All data was analyzed using Microsoft Excel 2013 and SPSS 21.0 (IBM Corp., Armonk NY, USA).

RESULTS

Under resting conditions, statistical analysis revealed a difference in DBP, (MED = 5 ± 11, P = -3 ± 6, $p = 0.02$) (Table 3). However, there were no statistical differences in HRV and hemodynamic parameters (MHR, lnHRV, RMSSD, LF nu, HF nu, Total nu, LF/HF, SBP, MBP, and RPP) before and after MED or P consumption (Table 3). These results support that 473 mL of MED does not influence resting HRV measures, SBP, or MAP. Intraclass correlation coefficients (ICC) showed strong reliability between baseline measures (MHR, DBP, and MBP) and moderate reliability within SBP (Table 2).

DISCUSSION

The aim of this present study was to determine if the (MED) had an acute impact on the cardiovascular system using HRV and continuous beat-to-beat BP measurements. Results from this current study did not find any changes in hemodynamic parameters such as BP and HR. The results were consistent with the findings Willoughby. HR and HRV were not affected after consuming an ED in compared to P. Willoughby et al. (2009) found in a study of 50 young adults that HR was unaffected one hour after consuming an 8 oz. can of an ED.

Other research has shown findings different than the current study. One study revealed an increase in HR two hours after consuming 355 mL of an ED (9). Similarly Grasser et al. (2014) found HR levels peaked at 90 minutes after consumption of the same amount of the same ED. Steinke et al. (2009) also showed an increase in HR within two to four hours after ED consumption. However, this study further concluded that the increase in HR could have been influenced by another ingredient in the ED. In this case, a comparison could be done on the ingredients of the ED in this study along with the drinks consumed in the current study.

Contrary to previous findings, other studies found a reduction in HR after the consumption of an ED (5,13,26). These studies further speculate that other ingredients in the ED in combination with caffeine could have contributed to a reduction in HR. In this current study, there was no differences of changes in heat rate.

There were no differences from the current study on heart rate variability (HRV). Nelson et al. (2014) initially studied 15 young adults and found no change in HRV after consuming an ED prior to a cycle ergometer test. On the other hand, changes in HRV could be related to the dosage (240 mg) of caffeine contained in the ED (32). Another study also implied that the majority of the effects on the body systems (e.g. increased HR) are likely to be linked to the amount of caffeine concentration in the EDs (2).

I was until recently studies began to assess the impact of an ED with beat-to-beat measurements (11). If was discovered that after consuming one can of an ED, there was an increased workload on the heart muscle evidenced by increase in HR, BP and cardiac output(20). Additional research discovered that there were significant changes in BP, HR, and HRV in EDs with higher dosages (3 mg/kg) of caffeine. A limitation to the current study could be the amount of caffeine consumed. The caffeine amount in the MED used in the current study was 140 mg (6).

Several studies also examined the effects of EDs on BP. They discovered a higher systolic rate lasting up to four and a half hours after consuming an ED (3). EDs have also been found increase BPs within two hours after consumption (8). The extension of post caffeine consumption was also noted in two other studies recording an increase in BPs up to 24 hours (10,13). Our study indicated a significant change in DBP post MED consumption. This agrees with a previous study that have recorded higher BP readings on two separate days (29). However, in their study the consumption of EDs was

two cans daily for one week, which could have altered the results and did not report acute changes. Worthley et al. (2010) found an increase in BP readings after subjects consumed 250 mL of an ED. The amount consumed in the current study was either 473 mL of MED or 473 mL of the P. Some discrepancies from other studies are similar to the findings of the current study. After consumption of the ED, no changes were demonstrated in BP measurements (1,26).

Limitations

A limitation to this study could be the amount of caffeine consumed. The caffeine amount in the MED used in the current study was 140 mg. EDs with higher doses of caffeine content of 3 mg/kg produced significant increases in BP, HR, and HRV (7).

It has also been reported that EDs with higher doses of caffeine (i.e. 240 mg) could account for the hemodynamic changes (32). Although the results of Hartley and his colleagues (2004) study concur with previous studies about caffeine raising the HR, they speculated that the reasons could be from the amount ingested. The subjects in this current study consumed 473 mL prior to exercising. Not being able to monitor if the participants did not consume any caffeine products prior to testing would be consider another limitation to this study (13). It should be noted that individuals who consume caffeine on a regular basis can build a tolerance, taking larger amounts to effect the individual.

CHAPTER 2

REVIEW OF THE LITERATURE

Energy Drinks and Caffeine

The market for energy drinks has rapidly expanded since their first introduction in the 1960s. EDs have gained popularity around the world for their claim to elevate mental alertness and improve consciousness (25). The largest user of EDs in the world is the United States (14). There are several brands of EDs, however, one of the more popular EDs is *Red Bull*® with yearly worldwide sales in the billions of dollars (4,14,16,23,25). EDs generally describe certain type of beverages that include different amounts of caffeine along with other ingredients such as "taurine, B-group vitamins, sugar, and herbal supplements" (12).

Over the recent years, because of their effective marketing techniques, EDs have gained increased acceptance from the young adult population, especially men (5,25,28). The advertisement of EDs appeals to young adults who want to spark their energy levels and/or enhance their mental awareness (5,28). For example, the *Red Bull*® ED company credits its success by advertising their product will "give you wings" indicating it gives a person more zeal (4,23).

Surprisingly, another survey identified that approximately 51% of college students had ingested at least more than one ED per month (16). Reasons for the

prominence among college students, several studies found that the practice of consuming EDs is viewed as a "natural alternative" for various circumstances: recouping lost hours of sleep, boosting energy levels, improving concentration during study hours prior to exams, maintaining wakefulness while driving for long periods at a time, combining with alcoholic beverages to improve the taste and helping to deal with a hangover (3,16,22).

Health risks identified from ingesting EDs have been linked to the high concentrations of caffeine, typically the main ingredient found in most EDs (5,10). Caffeine is classified as a central nervous system stimulant and it has been suggested to be responsible for an increase in BP particularly during exercise (23). Also classified as a physical performance enhancer, caffeine can raise HR (14). The amount of caffeine in these EDs varies in content from 50 mg to 505 mg per can or bottle; compared to a 6 oz. cup of coffee, the amount of caffeine content is 77 to 150 mg and to caffeinated beverages, the caffeine content is 50-100 mg (14,25).

However, regardless of the increase in worldwide approval of EDs, there has been limited research investigating on the acute or long-term effects these drinks might have on the cardiovascular system (19). It is significant to point out that the vitalizing features of EDs, that make it marketable, can produce negative health effects such as elevated HR and BP as well as dehydration and insomnia (17). Regardless of the negative effects, the results of one study of 439 college students concluded that 60% of the participants used these drinks while attending college. Most of the participants reported that they choose

EDs to feel "energetic", to be able to focus more while studying, and/or to prevent sleepiness. This study also implied that the majority of the effects on the body systems (e.g. insomnia, increased HR) are likely to be linked to the amount of caffeine concentration in the EDs (2).

Heart Rate

There have been several studies that examine the effects of ED consumption on HR. In a study involving 50 young adults, Willoughby et al. (2009) discovered that HR was unaffected one hour after ingesting a 250ml (8 oz.) can of sugar-free *Red Bull®*, which is equivalent to approximately 80 mg of caffeine. Yet, even though there was no change in HR during the exercise phase of the study, one study did find a higher resting HR during the consumption of MEDs (21).

While some studies have identified that HR was not affected by caffeine, others have recorded a minimal and temporary increase or decrease in HR after consuming caffeine. After consuming caffeine both men and women had an increase in HR (13). It was suggested that the inconsistencies in these studies related to the effects of caffeine on increasing or decreasing HR could possibly be due to the methodology performed by the study or the amount of caffeine ingested (26).

Results from a study with college-aged individuals found a tendency for a reduction in HR in men and women (rags). However, two studies found similar results of a substantial drop in HR after studying the effects of caffeine and another ingredient

found in EDs, taurine (4,12). Taurine is an amino acid believed to inhibit stimulation of the sympathetic nervous system (23). Further evidence of HR reduction was demonstrated within 30 minutes after the participants had ingested 75 mg of caffeine (28). Within the first hours of ingesting an ED, the results of a study by showed a significant decrease in HR (haj).

On the contrary, a number of studies have determined that the effects of caffeine in EDs cause an increase in HR. In one study 50 young, healthy adults around 25 yrs of age were noted having an average uptrend in HR from 78 beats per minute at baseline to 84 beats per minute ($p = 0.005$) two hours after consuming 355mL of the *Red Bull®* (8). Similarly, among 25 healthy subjects, one study found a substantial increase in HR after the subjects ingested 355mL of the ED *Red Bull®*. Peak values resulted after 90 minutes (4 ± 1 beats per minute) (11).

In 15 healthy young adults ranging in age 18-40 yrs research demonstrated that within two to four hours of ingesting an ED, their HRs increased by 7% ($p = 0.009$) on day one and 11% ($p < 0.001$) on day seven. It was concluded that the increase in HR occurring later after consumption might have been due to another ingredient in the ED other than caffeine (28).

Heart Rate Variability

HRV is defined as changes in HR from beat-to-beat (31). Changes in the HR from beat-to-beat can provide a tool to examine the risks of the cardiac effects from

caffeine, a main ingredient found in EDs (24). Two studies speculated that one of the issues might be that the subjects had an increased sensitivity to the EDs which could trigger a sympathetic response from the central nervous system resulting in changes in the heartbeat (7,20).

An initial study of 15 subjects (8 male and 7 female) was completed to research the effects of MED on HRV after ingesting an ED prior to exercising. The results showed no change in HRV (21). Another study by concluded that the differences in their results could be from a higher dose of caffeine, 240 mg (32). A second contrast in these two studies was the time frame in which the HRV was measured. One study measured HRV at 30 minutes as opposed to being performed at a 60-minute time point (22,32).

Hemodynamic Parameters

A review of literature present evidence that hemodynamic parameters (i.e. systolic and diastolic BPs, and cardiac output) are also affected by caffeine intake. Evidence further discovered that both men and women have corresponding increases in BP related to caffeine consumption affecting hemodynamic parameters. However, the mechanism by which caffeine raises BP produces different cardiovascular responses. In men, the increase in BP triggers an increase in vascular resistance whereas in women, an increase in BP stimulates an increase in cardiac output (13).

The purpose of a study done with 25 young health adults was to examine cardiovascular changes as a result of consuming the ED *Red Bull*. This study was the

first to determine the impact of an energy drink measured with beat-to-beat hemodynamics. The findings revealed that consuming one can of *Red Bull®* resulted in an escalated workload to the heart muscle as evidenced in an increase in HR, increase in systolic blood pressure (SBP) of 5.2mmHg and diastolic blood pressure (DBP) of 6.1mmHg and increased cardiac output (11). Another study also employed the use of beat-to beat measurements on eight healthy young men to monitor the comparison of cardiovascular parameters after the consumption of the ED, *Red Bull®*. The findings showed a consistent increase in BP (19)

Another study discovered that consumption of ED containing 1 mg/kg of caffeine raised mean BP by 5 ± 3 mmHg and the HR increased 2 ± 3 beats per minute. EDs with higher doses of caffeine content of 3 mg/kg produced a significant increase in BP by 8 ± 2 mmHg and increased the HR by 4 ± 3 beats per minute. In addition, the higher dose of caffeine could be related to heart palpitations and decreases in HRV (6).

Numerous studies on the effects of caffeine and EDs have presented data that would indicate increases in cardiovascular health hazards that might go undetected during a routine physical examination (30). A study in young adults between the ages of 21-26 yrs reported a higher HR afterload post caffeine consumption lasting up to four and a half hours (3). In addition, extension of post caffeine consumption occurred in BP monitoring from as early as 15 minutes and lasting up to 24 hours or more (12).

Similar increases in BP recordings have been shown in women and men who have chronic effects from frequent use of caffeine (13). In a study of 15 healthy adults between the ages of 18 and 40 yrs, a variation in BP was found after ingesting two cans of an ED daily for one week. The caffeine content of each can was 200 mg. Day 1 recorded an increase in SBP by 7.9% (p =0.006) and DBP by 7% (p =0.046). Day 7 recorded an increase in SBP by 9.6% (p <0.001) and DBP 7.8% (p =0.063) (28).

A study measured BP two hours after ingesting an ED and found an increased systolic pressure (112 to 121) mmHg (p =0.006) and an increased diastolic pressure (73 to 76 mmHg) (p =0.008) (8). Another study with nine subjects with a mean age of 28, received either an ED with 80 mg caffeine or a solution of 80 mg of caffeine diluted in water every three to four hours during a day of testing. After 24 hours, the results demonstrated an increase in SBP from 117.4 to 123.2 mmHg and increase in DBP from 68.2 to 73.6 mmHg from the group consuming the ED (9). Worthley et al. (2010) also found BP increased from the group who consumed 250 mL of an ED as opposed to the group drinking carbonated water.

Some discrepancies from other studies reported no change in BP measurements after consuming 250 mL of the ED *Red Bull*® within 30 minutes (1) and throughout the two-hour testing period (23)

More research is needed to inform the public about the potential adverse effects from consuming too many EDs (29). It appears that many studies do show that EDs

containing caffeine in a low dose may produce minor side effects that are unremarkable to the individual. However, if the consumption of EDs increases, this may elevate the caffeine levels to a dosage where symptoms begin to become more noticeable to the individual.

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TABLES AND FIGURES

Table 1. – Table to represent descriptive measures for participants in this study (n = 14, female = 7, male = 7).

	Age (yrs)	**Ht (m)**	**Wt (kg)**	**BMI ($kg \cdot m^{-2}$)**	**SkF (BF%)**
Males (n = 7)	26 ± 2	1.85 ± 0.05	90.2 ± 20.9	26.7 ± 6.3	13.0 ± 7.8
Females (n = 7)	24 ± 3	1.64 ± 0.08	61.1 ± 8.5	22.6 ± 2.8	22.1 ± 5.3
$\bar{X}$ ± SD	25 ± 3	1.74 ± 0.12	75.6 ± 20.8	24.6 ± 5.0	17.5 ± 7.6

Table 2. – Table to represent the reliability of baseline resting measures for each trial utilizing intraclass correlation coefficients (ICC). Variables include mean HR (MHR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean blood pressure (MBP). MHR, DBP, and MBP were highly reliable while SBP was acceptable.

	MHR	**SBP**	**DBP**	**MBP**
ICC (r =)	0.85	0.69	0.85	0.88

Table 3. This table represents collective descriptive measures of pre and post MED and pre and post P and changes in all dependent variables from pre to post drink. All descriptive measures include mean and SD. Paired T-Test analysis was performed to compare differences between Monster energy drink (MED) and placebo (P). Diastolic blood pressure (DBP) was statistically different while all other variables were not.

	Pre_MED	**Post_MED**	**Pre_P**	**Post_P**	**MED Δ**	**P Δ**	**p-value**
MHR (BPM)	59 ± 8	57 ± 6	61 ± 10	58 ± 9	-3 ± 5	-4 ± 3	0.64
lnHRV	2.64 ± 1.14	2.85 ± 1.32	2.78 ± .80	2.72 ± 0.84	0.27 ± 0.61	-0.14 ± 0.77	0.11
RMSSD	4.08 ± 1.81	4.68 ± 3.30	4.11 ± 1.99	3.84 ± 1.52	0.71 ± 2.34	-0.29 ± 1.27	0.22
LF_nu	43.26 ± 19.27	44.79 ± 16.85	46.13 ± 14.17	41.00 ± 15.63	1.43 ± 13.10	-5.14 ± 17.49	0.34
HF_nu	52.95 ± 18.98	50.70 ± 16.39	49.29 ± 14.17	54.69 ± 15.96	-2.36 ± 14.22	5.36 ± 16.66	0.24
Total_nu	138.26 ± 41.59	141.06 ± 39.95	135.03 ± 22.08	134.85 ± 21.46	2.79 ± 36.43	-0.29 ± 28.63	0.82
LF_HF	1.03 ± 0.67	1.10 ± 0.79	1.08 ± 0.55	0.93 ± 0.72	0.071 ± 0.73	-0.14 ± 0.77	0.55
SBP (mmHg)**	122 ± 8	131 ± 10	120 ± 8	124 ± 17	9 ± 11	5 ± 14	0.43
DBP (mmHg)**	71 ± 11	76 ± 8	74 ± 7	71 ± 10	5 ± 11	-3 ± 6	0.02*
MBP (mmHg)**	88 ± 9	95 ± 7	89 ± 7	89 ± 11	7 ± 10	-1 ± 7	0.06
RPP (HR * SBP)/100**	72 ± 15	72 ± 10	72 ± 16	71 ± 18	-1 ± 9	-1 ± 10	0.84

*Indicates significance $\alpha \leq 0.05$. **Indicates a sample size of n = 11

Table 4: The table represents collective descriptive measures of pre and post MED and pre and post P in male participants. All descriptive measures include mean and SD.

	Pre_MED	**Post_MED**	**Pre_P**	**Post_P**
MHR (BPM)	59 ± 12	55 ± 8	58 ± 12	55 ± 10
lnHRV	2.45 ± 1.29	2.67 ± 1.67	2.88 ± 0.88	2.77 ± 0.83
RMSSD	3.39 ± 1.56	4.45 ± 4.14	4.15 ± 2.32	3.79 ± 1.67
LF_nu	54.01 ± 9.99	51.02 ± 15.25	49.02 ± 11.88	43.07 ± 15.68
HF_nu	42.41 ± 8.86	45.49 ±	46.57 ± 10.81	52.94 ± 17.04
Total_nu	156.67 ± 49.06	158.60 ± 49.94	139.23 ± 20.41	140.03 ± 16.03
LF_HF	1.36 ± 0.49	1.35 ± 0.89	1.17 ± 0.60	1.06 ± .90
SBP (mmHg)	121 ± 8	132 ± 9	119 ± 9	123 ± 17
DBP (mmHg)	67 ± 12	75 ± 9	72 ± 7	69 ± 9
MBP (mmHg)	85 ± 10	95 ± 8	88 ± 8	87 ± 10
RPP (HR * SBP)/100	72 ± 18	72 ± 13	70 ± 18	69 ± 21

Table 5: The table represents collective descriptive measures of pre and post MED and pre and post P in female participants. All descriptive measures include mean and SD.

	Pre_MED	**Post_MED**	**Pre_P**	**Post_P**
MHR (BPM)	60 ± 4	58 ± 4	64 ± 9	60 ± 7
lnHRV	2.83 ± 1.02	3.03 ± 0.93	2.67 ± 0.78	2.67 ± 0.91
RMSSD	4.77 ± 1.89	4.90 ± 2.51	4.07 ± 1.77	3.89 ± 1.48
LF_nu	32.52 ± 20.86	38.55 ± 17.09	43.24 ± 16.56	38.93 ± 16.54
HF_nu	63.48 ± 21.05	55.91 ± 17.86	52.01 ± 17.34	56.44 ± 15.95
Total_nu	119.85 ± 23.45	123.52 ± 15.69	130.83 ± 24.47	129.68 ± 26.05
LF_HF	0.71 ± 0.70	0.85 ± 0.63	0.98 ± 0.53046	0.81 ± 0.52693
SBP (mmHg)*	124 ± 8	127 ± 13	121 ± 7	127 ± 19
DBP (mmHg)*	78 ± 3	78 ± 6	78 ± 4	75 ± 11
MBP (mmHg)*	93 ± 4	92 ± 6	94 ± 5	92 ± 14
RPP (HR * SBP)/100*	73 ± 8	71 ± 4	77 ± 13	76 ± 12

*sample size of n = 11

Table 6. This table represents the contents within Monster Energy® Drink. MED was the experimental beverage.

Nutrition Facts

Serving Size 8.0 fl. oz. (240mL)	
Serving Per Container 2	
Amount Per Serving	%DV*
Calories 0	
Total Fat 0g	0%
Sodium 180mg	8%
Total Carb 2g	1%
Sugars 0g	
Erythritol 1g	
Protein 0g	
Niacin (Vit. B3)	100%
Vitamin B6	100%
Vitamin B12	100%
Pantothenic Acid (Vit. B5)	100%

Table 7. This table represents the contents within the placebo, Sprite Zero. This was the control beverage.

Nutrition Facts

Serving Size 1 Can (355mL)	
Amount Per Serving	
Calories 0	
Total Fat 0g	0%
Sodium 35mg	1%
Total Carb 0g	0%
Protein 0g	