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ORIGINAL ARTICLE

The Effects Of Energy Drinks On Choice Reaction Time Tasks Among Mmmc Medical Students - A Randomized-Controlled Trial.

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ABSTRACT

Consumption of energy drinks is on the rise among all age groups, especially young adults. These drinks contain taurine and caffeine as their main ingredients. Thus, the objective of this study is to investigate the effects of energy drinks on choice reaction time in comparison to mineral water among healthy young adults. A randomized controlled trial was done in a private medical college in Malaysia in October 2016. Participants were divided into 2 intervention groups; energy drink (n=18) and placebo (n=16) and were given the intervention drink (250ml). Their choice reaction time was assessed using Deary-Liewald Reaction Time and cardiology parameters (systolic and diastolic blood pressure and heart rate) were recorded before and after the intervention. After a 7-day washout period, the test was repeated with a crossover of the groups. The change in response and parameters were analyzed using independent T-test. There was a significant decrease in the choice reaction time after consumption of energy drink along with slight increase in blood pressure and heart rate as compared with placebo. Energy drink can improve the choice reaction time with slight changes in systolic and diastolic blood pressure and heart rate as compared to placebo.

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INTRODUCTION

Reaction time is the time interval between a stimulus and the initiation of the response to that stimulus [1,2]. There are 2 types, simple reaction time and choice reaction time. Simple reaction time is only one stimulus and one response. Choice reaction time is multiple stimuli and multiple responses [3,4,5]. Factors that affect reaction times include age, gender, physical fitness, fatigue, distraction, alcohol, personality type, whether the stimulus is auditory or visual and psychoactive ingredients such as caffeine or glucose [2,6].

Energy drinks are products that increase alertness and enhance physical and mental performance with energetic arousal concentration [7,8]. Caffeine (1,3,7-trimethylxanthine) is one of the most famous contents of energy drinks other than taurine, glucuronolactone, sugars, and other B vitamins and herbal extracts [6,9]. The stimulating effects of caffeine are predominantly caused by an antagonistic action on adenosine receptors. Hence, caffeine increases the levels of several neurotransmitters such as dopamine, acetylcholine and serotonin [10]. Males between the ages of 18 and 34 years consume the most energy drinks, and almost one-third of teens between 12 and 17 years drink them regularly [7]. The common reasons people consume energy drink are counteracting sleepiness and increasing energy, maintaining alertness while studying and driving [11,12,13]. Also, it is known to enhance cognitive performance, specifically the reaction time [6,14].

The only previous study to examine the effects of energy drink ingredients, alone and together with other ingredients, showed that a whole energy drink containing caffeine, glucose, ginseng and ginkgo biloba improved memory and attention, but each ingredient alone had no effect on mood or cognition [6,11]. A study on cognitive and mood improvements of caffeine in habitual consumers and habitual non-consumers of caffeine also show significant simple reaction time difference along with digit vigilance reaction time, numeric working memory reaction time and sentence verification accuracy [15]. On the contrary, the specific addition of caffeine with L-theanine is known to increase focus attention during demanding cognitive tasks but not reaction time specifically [16].

Thus, the present study was conducted to determine the effect of energy drink on reaction time among MBBS students of batch 33.

METHODOLOGY

A randomized, single-blinded, balanced crossover study was carried out to figure out the effects of energy drinks on the choice reaction time task among medical students of Melaka Manipal Medical College which is located in the city of Muar (a city bordering the states of Johor and Malacca in Malaysia). Melaka Manipal Medical College (MMMC) is a renowned private medical institution with a hallmark of academic excellence and an enviable track record in providing quality medical education [17]. Sample size was calculated using the formula,

$$Sample\ size = \frac{2C}{\delta^2} + 1$$

Where C = (Zα + Z)^2

= 1.96

$$\delta = \frac{\bar{x}_1 - \bar{x}_2}{SD}$$

$\bar{x}_1$= mean of intervention
$\bar{x}_2$ = mean of control
SD = standard deviation

A minimum of 32 students was required as the sample size, as each arm needed 16 people. A total of 34 students took part in the study on 20th October 2016, out of which 18 of them were given 250ml of intervention (energy drink) [11,18] and the rest were given placebo of the same amount (mineral water). After a 7-day washout period [11, 18], crossover was done on 27th October 2016 with an attrition of 2 people.

SAMPLING METHOD

Method used was consecutive sampling (with simple randomization) using Microsoft Excel software after exclusion criteria elimination. Out of 205 medical students of Batch 33 MMMC, 113 students were excluded via exclusion criteria questionnaire. The sample was chosen from the remaining 92 students via simple randomization.

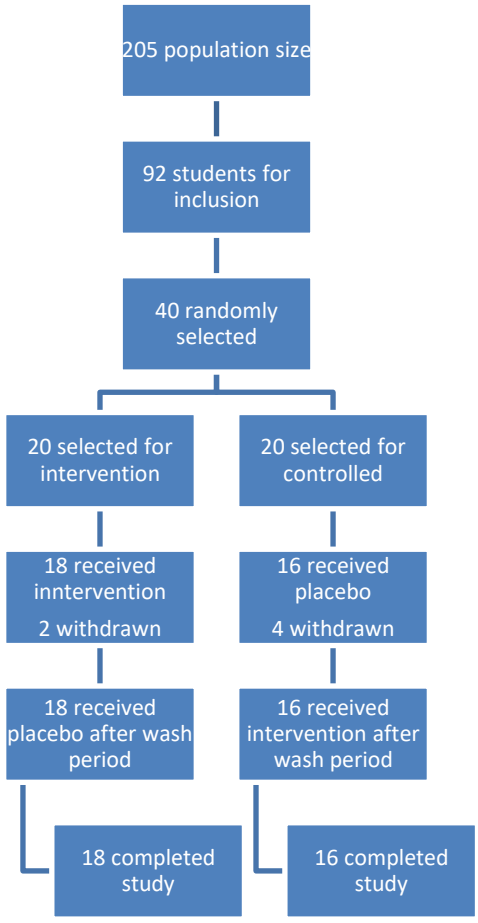
As for the procedure, sampling frame was batch 33 MBBS students of MMMC. All individuals in sampling frame were given a questionnaire on amount of caffeine consumption daily to exclude individual with exclusion criteria of more than 1 cup daily of caffeine consumption. Identified individuals after elimination are given identification number. A computerized program (Microsoft excel) was run to generate a random sample of individuals included in this experiment which is then divided in 2 groups of control (mineral water) and intervention (livita energy drink) by random. Separate treatments given in 1 week interval to both groups. There were no caffeine consumption restrictions on study days. Subjects were tested as a group, with BP and Heart rate assessments made both before drinks were consumed (pre-treatment) and 15 minutes after consumption (post-treatment), to allow for absorption, then the single and multiple choice reaction time test.

As far as the eligibility criteria is concern, the inclusion criteria were healthy young adults aged 20-28 years old as well as Batch 33 medical student of MMMC whereas the exclusion criteria were coffee consumption more than once daily, pregnancy, breastfeeding, allergy to any content of energy drink (caffeine, taurine) and pre-existing medical conditions or otherwise to avoid energy drink recommendations.

DATA COLLECTION

Variables included in our study were demographic profile which includes age, gender, ethnicity, birth order and monthly allowance; blood pressure (before and after consumption); heart rate (before and after consumption); single and multiple reaction control time with error. Methods used were questionnaires [18], reaction control time using a software called Deary-liewald Reaction time task in where the end result will be given in miliseconds [4]. The software includes two types of task which are simple response time task (SRT) and choice response time task (CRT). SRT is basically where there is just one stimulus, and when the stimulus appears, subject has need to respond with the one response there is in this type of experiment. For instance, every time subject sees a light go on, subject needs to press the space bar of the computer keyboard. On the other hand, CRT includes multiple stimuli, and each stimulus requires a different response. For example, subject will see one of 10 letters presented and each time a subject sees the letter, subject needs to press the corresponding letter key of the keyboard [19,20]. This software is validated and used in a few studies. One of the study which used this software was binge-watching behaviour and its association with low mood. The purpose of this study is to investigate the phenomenon of binge-watching and the implications of such a phenomenon on the mental well being of binge-watchers [21].

Tools involved were Livita® 250ml, mineral water 250ml, electronic BP monitor, laptops for choice reaction tests, opaque cups & lids and straws.



DATA PROCESSING & ANALYSIS

Software used was Epi info for calculation of the statistics related. Descriptive statistics involved are frequency (%) and mean (SD). As for the inferential statistics, paired t-test and simple linear regression used. Paired t-test is used since our dependent variables include before and after column. Test of association used is relative risk since our study is randomized control trial. As for the Level of significance, the cut off point for p value is fixed as 0.05.

Confirmatory statistical analysis of a crossover trial
Choice Reaction Time

Sequence group A-B

ID (i)	X_{1i}	X_{2i}	$C_i(X)$	$D_i(X)$
A1	536	477	1013	59
A2	435	328	763	107
A3	663	611	1274	52
A4	333	345	678	-12
A5	338	371	709	-33
A6	391	381	772	10
A7	437	511	948	-74
A8	475	431	906	44
A9	391	324	715	67
A11	420	414	834	6
A12	406	362	768	44
A13	444	435	879	9
A14	500	379	879	121
A15	417	383	800	34
A16	415	404	819	11
A17	674	510	1184	164
A18	478	548	1026	-70
A19	619	610	1229	9

Arithmetic means and sums of squared deviations required for tests:
Cx= 899.78, Dx=30.44; SQCx= 554123.11, SQDx= 64032.44.

Figure 1: Flowchart of subjects' disposition at 2 weeks

Sequence group B-A

ID (j)	X_{1j}	X_{2j}	$C_j(X)$	$D_j(X)$
B1	502	467	969	35
B2	404	447	851	-43
B3	429	412	841	17
B4	512	591	1103	-79
B5	625	526	1151	99
B6	425	451	876	-26
B7	439	427	866	12
B8	405	364	769	41
B10	438	528	966	-90
B11	375	308	683	67
B13	464	438	902	26
B14	425	422	847	3
B15	548	600	1148	-52
B16	448	425	873	23
B17	751	453	1204	298
B18	547	461	1008	86

Arithmetic means and sums of squared deviations required for tests:
Cy= 941.06, Dy=26.06; SQCy= 327338.94, SQDy= 123744.94.

*The following formulas are obtained and cited from Wellek et al [45].
*The p-value were determined through calculations via Graphpad [46].

Pre-test to check assumption of negligible carryover effects:

Test statistics: $T = \sqrt{\frac{mn}{N}}\left(\frac{C\bar{x}-C\bar{y}}{\sqrt{\frac{SQC\bar{x}+SQC\bar{y}}{N-2}}}\right)$

$$= \sqrt{\frac{(18)(16)}{34}}\left(\frac{899.78-941.06}{\sqrt{\frac{554123.11+327338.94}{32}}}\right)$$

$$= 0.7447$$

p value: p = 0.4619

*m= no of intervention sample
*n = no of control sample

*N = total number of sample
*Cx = mean of intervention (choice reaction time)
*Cy = mean of control (choice reaction time)
*SQCx = summation square of Cx
*SQCy = summation square of Cy

Test for differences between treatment effects:

Test statistic : $T = \sqrt{\frac{mn}{N}}\left(\frac{D\bar{x}-D\bar{y}}{\sqrt{\frac{SQD\bar{x}+SQD\bar{y}}{N-2}}}\right)$

$= \sqrt{\frac{(18)(16)}{34}}\left(\frac{30.44-26.06}{\sqrt{\frac{64032.44+123744.94}{32}}}\right)$

$= 0.1664$

p value: p = 0.8689

Significance decision: Significant improvement in choice reaction time with energy drink (A) compared with mineral water (B); No evidence of relevant carryover effects.

*m= no of intervention sample
*n = no of control sample
*N = total number of sample
*Dx = deviation of intervention (choice reaction time)
*Dy = deviation of control (choice reaction time)
*SQDx = summation square of Dx
*SQCy = summation square of Dy

Simple reaction time
Sequence group A-B

ID (i)	X_{1i}	X_{2i}	$C_i(X)$	$D_i(X)$
A1	335	464	799	-129
A2	324	276	600	48
A3	449	333	782	116
A4	361	287	648	74
A5	359	286	645	73
A6	258	278	536	-20
A7	359	311	670	48
A8	315	278	593	37

A9	272	263	535	9
A11	301	443	744	-142
A12	267	318	585	-51
A13	278	356	634	-78
A14	282	306	588	-24
A15	297	289	586	8
A16	274	284	558	-10
A17	354	339	693	15
A18	332	448	780	-116
A19	302	325	627	-23

Arithmetic means and sums of squared deviations required for tests:
Cx= 644.61, Dx= -9.167; SQCx=120500, SQDx= 89646.5

Sequence group B-A

ID (j)	X_{1j}	X_{2j}	$C_j(X)$	$D_j(X)$
B1	295	529	824	-234
B2	269	497	766	-228
B3	264	364	628	-100
B4	275	350	625	-75
B5	312	526	838	-214
B6	322	297	619	25
B7	289	331	620	-42
B8	279	276	555	3
B10	265	331	596	-66
B11	273	312	585	-39
B13	258	310	568	-52
B14	256	291	547	-35
B15	448	433	881	15
B16	319	347	666	-28
B17	295	458	753	-163
B18	314	560	874	-246

Arithmetic means and sums of squared deviations required for tests:
Cy= 684.06, Dy= -92.44; SQCy= 211383, SQDy= 131744

Pre-test to check assumption of negligible carryover effects:

Test statistics: $T = \sqrt{\frac{mn}{N}}\left(\frac{C\bar{x}-C\bar{y}}{\sqrt{\frac{SQC\bar{x}+SQC\bar{y}}{N-2}}}\right)$

$$= \sqrt{\frac{(18)(16)}{34}}\left(\frac{644.61-684.06}{\sqrt{\frac{120500+211383}{32}}}\right)$$

$$= 1.127$$

p value: p = 0.2681

*m= no of intervention sample
*n = no of control sample
*N = total number of sample
*Cx = mean of intervention (choice reaction time)
*Cy = mean of control (choice reaction time)
*SQCx = summation square of Cx
*SQCy = summation square of Cy

Test for differences between treatment effects:

Test statistic : $T = \sqrt{\frac{mn}{N}}\left(\frac{D\bar{x}-D\bar{y}}{\sqrt{\frac{SQD\bar{x}+SQD\bar{y}}{N-2}}}\right)$

$$= \sqrt{\frac{(18)(16)}{34}}\left(\frac{-9.167-(-92.44)}{\sqrt{\frac{89646.5+131744}{32}}}\right)$$

$$= 2.913$$

p value: p = 0.0065

Significance decision: Significant improvement in choice reaction time with energy drink (A) compared with mineral water (B); No evidence of relevant carryover effects.

*m= no of intervention sample
*n = no of control sample
*N = total number of sample
*Dx = deviation of intervention (choice reaction time)
*Dy = deviation of control (choice reaction time)
*SQDx = summation square of Dx
*SQCy = summation square of Dy

RESULTS

Table I
Characteristics of independent variables via quantitative analysis amongst Intervention and Placebo

Independent Variables	Intervention Mean (SD)	Placebo Mean (SD)	P value
Age (years)	22.94 (0.42)	22.75 (0.45)	0.116

Table II
Characteristics of independent variables via qualitative analysis amongst Intervention and Placebo

Independent Variables	Intervention (n=18) No.(%)	Placebo (n=16) No.(%)	P value
Gender			0.013
Male	7 (38.9%)	6 (37.5%)	
Female	11 (61.1%)	10 (62.5%)	
Ethnicity			0.66
Malay	11 (61.1%)	7 (43.8%)	
Chinese	4 (22.2%)	2 (12.5%)	
Indian	2 (11.1%)	3 (18.8%)	
Others	1 (5.6%)	4 (25.0%)	
Monthly allowance			0.0239
<RM500	2 (11.1%)	0 (0%)	
RM501-RM1000	15 (83.3%)	15 (93.8%)	
>RM1000	1 (5.6%)	1 (6.3%)	

Table III
Characteristics of outcome variables amongst Intervention and Placebo

Independent variables	Intervention before Mean (SD)	Intervention after Mean (SD)	T test	P value
Simple reaction time (ms)	317.72 (47.48)	326.89 (62.66)	0.60	0.553
Error (%)	0.00	0.28 (1.18)	0.33	0.743
Four-choice reaction time(ms)	465.11 (100.02)	434.67 (90.42)	0.05	0.960
Error (%)	6.67 (6.64)	5.00 (4.20)	0.34	0.733
Cardiovascular changes	79.17 (16.49)	72.89 (10.98)	0.05	0.964
Heart rate(bpm)	123.22 (14.03)	121.33 (12.70)	0.42	0.680
Systolic BP(mmHg)	74.83 (6.21)	72.78 (8.57)	0.18	0.856
Diastolic BP(mmHg)	35.06 (11.22)	27.33 (8.12)	0.008	0.993
Perception				

Independent variables	Placebo before Mean (SD)	Placebo after Mean (SD)	T test	P value
Simple reaction time (ms)	295.81 (46.16)	388.25 (96.47)	0.0013	0.999
Error (%)	0.00 (0)	1.25 (3.87)	0.22	0.83
Four-choice reaction time(ms)	483.56 (96.85)	457.50 (75.21)	0.27	0.790
Error (%)	5.31 (3.40)	2.19 (2.56)	0.007	0.994
Cardiovascular changes	76.06 (10.93)	73.86 (8.46)	0.44	0.666
Heart rate(bpm)	117.06 (12.70)	124.75 (14.72)	0.05	0.959
Systolic BP(mmHg)	72.75 (9.29)	73.19 (8.57)	0.80	0.428
Diastolic BP(mmHg)	33.44 (4.88)	36.31 (8.15)	0.16	0.87
Perception				

According to Figure 1, 40 students were randomized and divided into intervention and controlled groups respectively. A total of 18 completed the study for the intervention while only 16 completed the study in controlled group with both groups undergoing a cross-over after a wash-period of 7 days. Table 1 shows the mean ± SD age of both intervention and controlled groups of 22.94± 0.42 years and 22.75 ±0.45 years respectively with a p-value of 0.116.

Table II shows the characteristics of independent variables via qualitative analysis amongst Intervention and Placebo. There was no significant difference between the two groups in terms of baseline characteristics. For gender, intervention group consisted of 7 males (38.9%) with 11 females (61.1%) while placebo group deviated slightly in both genders with 6 males (37.5%) and 10 females (62.5%). The P value was 0.013.

In terms of ethnicity, Malays were a majority in both intervention and controlled groups with 11 (61.1%) for the interventions and 7 (43.8%) for the latter. The second highest number were Chinese in intervention group with 4 (22.2%) with others being the second highest in controlled group, also with 4 (25.0%). Indians ranked third in both groups with 2 (11.1%) in intervention group and 3 (18.8%) in the other. There was only 1 Others in intervention group (5.6%) while 2 Chinese (12.5%) in the controlled group. P-value is 0.66.

The majority of subjects reside in the RM501-RM1,000 group with 15 (83.8%) in intervention group and also 15 (93.8%) in controlled group. 2 subjects (11.1%) reside within <RM500 in the intervention with nil in the controlled group. Only 1 subject in both groups with a monthly allowance of >RM1,000 with 5.6% in intervention group and 6.3% in controlled group. P-value is 0.0239.

Table III portrays the results of the dependent variables measured according to the crossover sessions which were measured following the intake of intervention and placebo with respects to the groups. Each subjects underwent blood pressure and heart rate measuring with a sphygmomanometer along with simple and choice reaction time including the percentage errors using the reaction time software [4]. The primary outcome measured in the experiment was the choice reaction time. With respects to the intervention group's line of study, the simple reaction time with intervention had an average of 317.72 ± 47.48 seconds with 0.00% error. The simple reaction time done after the washing period with the consumption of the placebo showed 326.89 ± 62.66 seconds with a mean of 0.28% error, signifying an increase in choice reaction time with the placebo consumption. P-value was 0.553. This is the opposite for choice reaction time whereby it is 465.11 ± 100.02 and error of 6.67% with the intervention but 434.67 ± 90.42 and error of 5% with the placebo. The p-value was 0.960. The heart rate shows an average of 79.17 ± 16.49 beats per minute (bpm) for intervention while 72.89 ± 10.98 bpm for placebo with p-value of 0.964. Systolic and diastolic blood pressure showed an average of 123.22/74.83 mmHg ±14.03/6.21 for intervention while 121.33/72.78 mmHg ±12.7/8.57 for placebo.

For the controlled group, the simple reaction time during placebo intake was 295.81 ± 46.16 sec with 0.00% error. After the wash period of seven days, the simple reaction time with intervention was 388.25 ± 96.47 sec and error of 1.25% ±3.87. P-value was 0.999. The choice reaction time during controlled conditions was 483.56± 96.85 sec with error of 5.31% ± 3.4 while during the intervention, it was 457.5 ± 75.21 sec and error of 2.19 ± 2.56. P-value was 0.790. The heart rate was 76.06 ± 10.93 bpm during control and 73.86 ± 8.46 for intervention, showing a p-value of 0.666. The blood pressure for the control was 117.06/72.75 mmHg ± 12.70/9.29 with 124.75/73.19 mmHg ± 14.72/8.57 for intervention. Its p-value was 0.05.

Table IV
Outcome of Statistical Analysis

Independent variables	**Pretest Assumption**	**Test For Difference**
Simple reaction time (ms)	T-test value: 1.127 P-value: 0.268	T-test value: 2.913 P-value: **0.006**
Choice reaction time(ms)	T-test value: 0.745 P-value: 0.461	T-test value: 0.166 P-value: 0.869
Cardiovascular changes		
Systolic BP(mmHg)	T-test value: 0.3373 P-value: 0.7381	T-test value: 1.3836 P-value: 0.1761
Diastolic BP(mmHg)	T-test value: 0.3240 P-value: 0.748	T-test value: 0.7163 P-value: 0.4790
Heart Rate(bpm)	T-test value: 0.8151 P-value: 0.4210	T-test value: 1.189 P-value: 0.2432

Table IV portrays the statistical analysis of the study which was confirmed with accordance to Wellek et al.[45] regarding a randomized controlled trial with single-blinded and crossover variant through a paired t-test upon which the p value was determined using calculations via Graphpad.[46] All variables such as the simple reaction time, choice reaction time, systolic blood pressure(BP), diastolic BP and heart rate were determined and recorded accordingly with the pretest being executed to check the assumption of negligible carryover effects. As shown in table IV, all pretests were not significant, as seen from the respective p values, signifying that the assumption to reject the null hypothesis is negligible thus promoting which leads to the test for difference after treatment. The simple reaction time has proven to be significant with the p value of 0.006, while it is the opposite for the remaining variables.

DISCUSSION

The study conducted has shown significant value (p = 0.006) as seen in Table IV for simple reaction time task with consumption of energy drink. Previous studies have shown that a content of the energy drink, caffeine has reduced reaction time on the choice reaction time and simple reaction time task [12]. Those studies demonstrated that the consumption of glucose, taurine and caffeine containing 'energy drink' can improve cognitive performance without significant changes in ones' mood [9]. In comparison to placebo (mineral water), significant improvement was observed on the 'speed of attention' for the choice reaction time factor derived from the comprehensive selection of task from the Deary-Liewald reaction time task software [9]. Mental performance, including psychomotor factors like alertness, ones' ability to focus and eye-hand coordination improved. The physical (cognitive) and mental benefits of the combined ingredients in this energy drink has proven to give consistent improvements. In this study, caffeine being one of the core ingredient, may affect the choice reaction time task by increasing subjective alertness in the subject [19]. In our opinion, taurine and glucose also may have enhanced the effect of glucose to give a significant reduction in choice reaction time as compared to the placebo effect (mineral water), although some studies doubt that taurine would affect one's cognitive performance [19].

Our study showed that there was no significant result in the choice reaction time among those who had consumed energy drinks prior to undergoing the test. Similar results were also seen in previous studies that showed energy drink consumption improved choice reaction time compared to placebo consumption. The constituents of energy drink would have increased the activity of the Anterior Cingulate Cortex (ACC), an area of the brain responsible in processing, learning and memory. Subjects with short reaction times showed significantly more ACC activation (Brodmann Area 24) and an increased error rate[23]. The error percentage in simple reaction time was close to zero in both the intervention and control group. This was due to presence of outliers that were present in the study. This finding suggests that increased ACC activity is associated with a gain in

reaction speed at the expense of correctness [23]. These outliers could also be due to a technicality error resulting from a laptop lag.

Based on other works done, variable findings on heart rate shown with either little effect [24], a decrease [25-30] or more rarely an increase[31] being reported. Our study showed significant difference after intervention with energy drink done, which is an increase in heart rate. This is consistent with previous reports of heart rate acceleration associated with consumption of caffeine. This effect appears to rely on shifting the equilibrium between two caffeine sensitive systems. The first is adenosine blockade at sympathetic nerve terminals which increases noradrenaline release resulting in heart rate acceleration. The other is the activation of medullary vagal nuclei (directly or via the baroreceptor reflex) which results in heart rate deceleration [31]. Acceleration of heart rate in our present finding seems to be tilting more to the former causing an increase in heart rate.

Based on the results we found that readings for systolic and diastolic BP (p=0.959 and p=0.428, respectively) showed no significant changes post-consumption. Regarding the blood pressure, there was some literature review indicating no change in blood pressure even after consuming the energy drinks. For example, Alford et al. investigated the impact of the energy drink Red Bull (250 mL) on exercise performance of 36 volunteers and reported no change in resting BP 30 min after consumption. [19, 33] Similarly, Ragsdale et al. in a randomized control trial study, reported no change in BP throughout a 2-hour test period after taking 250 ml of energy drink [32, 33]. This results mostly due to the duration of post-consumption BP monitoring variations among these studies from as early as 15 to 30 min (which mostly indicated no BP change) to even 24 h or more (that mostly demonstrated a rise in BP). Taking these points into consideration, it can be hypothesized that energy drinks will only increase BP when they are used in sufficiently high amounts and when BP is monitored at sufficiently late time points post-consumption. Thus, it would have been possible to observe a significant elevation in BP in this study if we had used higher amounts of the same energy drink [33]. In other study, (Fujita et al. 1987) found that energy drink containing taurine has been shown to decrease both systolic and diastolic blood pressure, as a result of taurine neutralizing the effects of caffeine in raising the blood pressure [34]. It is possible that the combination of caffeine and taurine in the caffeinated energy drink counteracted each other's effects and lead to the lack of any significant changes in blood pressure [34,35]. In addition, this result maybe because of the failure to account for confounding variables, including baseline BP, gender, dietary intake, stress and body mass index (BMI)[36,37]. The combination of psychological (e.g., type A behavior pattern) and environmental (eg, job strain) factors may also substantially influence blood pressure [38].

For the perception score, one of the study shows caffeine has significant effect (p value= 0.007) on perception [9]. According to articles, Energy drinks improve concentration and alertness as well as help both mental and physical performance. They pump up, vitalize body and mind and also fuels brain therefore providing focus, energy, and determination. [19,40,41] Our experiment shows no significant difference for perception (p value = 0.99)

probably because caffeine shows its maximal effect in the morning according to an article[42] but our experiment was carried out in the evening. Our subjects could have been tired after long day of clinical postings at the hospital since our experiment was done on a working day. Therefore, the caffeine didn't have significant effect on their perception. Also other factors such as selective bias could have influenced our perception score result. Bias in the sense that they could have been a regular caffeine consumer but could have given false information regarding caffeine consumption. Or else subject could have consumed caffeine earlier in the morning regardless of informing them not to.

LIMITATIONS

Despite the large number of sample size included in the study when compared to previous studies, the reliability of this experiment would be more accurate if done on a larger sample size to reduce bias results. Better results would be obtained 30 minutes after consuming the energy drink instead of 15 minutes. This is because 30 minutes is the peak of effect after consumption [43]. However, this might not be convenient to the subjects due to the fact of excess time usage of the subjects as they had other matters to attend to and to avoid attrition. The study period of only 2 weeks limited this study from collecting more samples and results. The tests done on subjects were conducted on the evening after class on which some students are retiring from their daily routine whilst some travelled from afar to conduct the experiment. This would affect the subjects' true and undisturbed performances and could also downgrade their cognitive performances. With reference to the usage of mineral water as placebo, this caused an inappropriate psychological effect on the subjects and due to that, their assumption upon disagreeable drink would disinterest on furthering with the experiment. Study does not address on how each component on energy drinks or the combination of ingredients in different brands have effect on consumers.

RECOMMENDATIONS

As proven to some extent that energy drinks may enhance a person's cognitive performances and concentration, those who need an increased burst of energy are recommended to consume a considerable amount of the aforementioned beverage which contains caffeine provided within suitable doses served. Also, the energy drink would act to counteract fatigue and sleep deprivation as it would alleviate a person's mood and concentration. To achieve the physiological and psychological effects of caffeine, one would consider consuming energy drinks instead of other caffeine-serving beverages because of the preferable taste due to the associated glucose and taurine contents which would enhance the taste.

ETHICS

Our research topic was approved by the research ethics committee of Faculty of Medicine of Melaka Manipal Medical College(MMMC) which was given prior to the study.

It was not a voluntary participation as it was a randomized study. Written informed consent was obtained before the experiment was conducted. Confidentiality of all participants was maintained. Questionnaires as well as the reaction control time software used in our studies are validated and used in other studies done related to our research topic [4,18].

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