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The Acute Effects of Green Tea Consumption on Alertness and Blood Pressure Among Undergraduate Medical Students: A Randomized Control Study

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Abstract

The objective of this randomized controlled trial was to evaluate the acute effects of green tea consumption on alertness and blood pressure among medical students in MMMC. After filling up a pre-intervention questionnaire, blood pressure and pulse rate were measured. Each intervention group participant was given 200 ml of high dose green tea (1.5g green tea brewed in 200ml boiled water). Each control group participant was given 200 ml of low dose green tea (1.5g green tea brewed in 2000ml boiled water). Blood pressure, pulse rate and reaction time were measured after 15 minutes, and post-intervention questionnaire were filled up. For high dose green tea, the mean difference of SBP between pre and post consumption was 0.60, 95% CI (-2.82 to 4.02), p value (0.723), whereas mean difference of DBP between pre and post consumption was -1.27, 95% CI (-5.34 to 2.80), p value (0.529). For low dose green tea, the mean difference of SBP was 6.43, 95% CI (1.92 to 10.95), p value (0.007) whereas the mean difference of DBP was 4.63, 95% CI (2.90 to 6.37), p value (<0.0001). The mean difference of reaction time between the two groups was -1.8ms, 95% CI (-54.4 to 50.9), p value (0.947). Based on the study done, it can be concluded that green tea in low doses does have immediate effect on the individual's blood pressure (lowers blood pressure) but not alertness and pulse rate. However, high dose green tea does not have significant immediate effects on the individual's blood pressure, alertness and pulse rate.

Keywords

Green Tea, Medical Students, Blood Pressure, Reaction Time, Randomized Trial

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1. Introduction

World Health Organisation (WHO) states that cerebrovascular disease is the cause of one third of global deaths and is a leading and increasing contributor to the global disease burden. Hypertension is one of the main risk factors for the occurrence of cerebrovascular disease throughout the world. [1] According to the National Health and Morbidity Survey, the prevalence of hypertension varies among countries, between countries in the same region, and among subgroups in a country. For the Malaysian population of ≥18 years, there was a 1% increase in prevalence of hypertension in a duration of over 6 years. [2] Hypertension is classified as a preventable disease by WHO and therefore, its incidence can be reduced by various interventions such as lifestyle changes, dietary changes and medications. Findings have stated that the population needs to be made aware of the current magnitude of hypertension in Malaysia [2] According to the Framingham data, even people who are free of

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hypertension at the age of 55 have a ninety percent risk of developing hypertension anytime in their life. [3] In this study, the correlation between green tea and its immediate effects on systolic and diastolic blood pressure will be discussed.

Regarding alertness, it is defined as the activated states of cerebral cortex affecting the ability to process information which can be intrinsic or phasic and may be relatively global or more localized. These states are also described as arousal, vigilance, and attention. [4] Intrinsic alertness represents the cognitive control of wakefulness and arousal, typically assessed by simple reaction time tasks without a preceding warning stimulus whereas phasic alertness, is called for in reaction time tasks in which a warning stimulus precedes the target, and it represents the ability to increase response readiness subsequent to external cueing. [5] There are many researches done to date on various factors which may improve alertness, including L-Theanine and Caffeine, [6, 7] energy drinks, [8, 9] light exposure, [10] matcha green tea [11] and drugs like sertraline. [12] These researches are very crucial to the population which requires to have long hours of attention especially students and shift workers, particularly healthcare workers.

Green tea is definitely the nature's treasure to the mankind. After water, green tea is the most consumed beverage in the world. [13] Effects of tea consumption on mental performance, especially attention, and mood have been investigated. The studies reviewed are mainly focused on the relatively acute effects of green tea and its ingredients, which occur immediately after consumption or during the course of a day, in healthy adult populations. [14] Green tea which contains bioactive compounds is traditionally known to induce mental clarity, cognitive function, physical activation and relaxation. [15] Green tea which is derived from the plant *Camellia sinensis* is a very popular beverage worldwide. [16] The health-promoting effects of green tea are mainly attributed to catechins, which belong to a family of compounds known as flavonoid-like polyphenols or flavanols. Green tea is mainly composed of catechins (8–20%), caffeine (2–4%), and amino acids (1–8%). Epigallocatechin gallate (EGCG) is the most abundant catechin, followed by epigallocatechin (EGC). Theanine (l-theanine, *N*-ethyl-l-glutamine) is the most common amino acid, but other amino acids such as arginine (Arg) and glutamic acid (Glu) are also found in tea leaves. [17] A 2013 Cochrane review evaluated the benefit of green teas for primary prevention of cardiovascular disease (CVD). Green tea has statistically produced significant reductions in blood pressure (systolic blood pressure [SBP] and diastolic blood pressure [DBP]). [18] According to the American journal of clinical nutrition, Caffeine in green tea is the most consumed psychoactive ingredient worldwide. [19] Its attention effects have been studied extensively. [20, 21] Numerous studies have indicated that even in low doses such as 50 mg caffeine improves performance on attention tasks and subjective alertness. Whereas effects on simple attention tasks have been well established, recent studies have also indicated beneficial effects of caffeine on more complex, multifaceted attention tasks. [22-24]. Studies have proven, L-Theanine in green tea also can improve attention and shorter response time in attention-switching task. [25-28] Generally, previous studies focused more on long-term and less of the immediate effects of green tea, especially that of blood pressure.

Our objective was to evaluate the acute effects of green tea consumption on alertness and blood pressure.

2. Methodology

2.1. Study Design, Place and Time

This study was designed as a Randomized Control Trial where the acute effect of green tea on alertness and blood pressure among medical students in Melaka Manipal Medical College (MMMC) was hoped to be established. This study consists of 6th and 7th semester MBBS students of MMMC. Both semester students were situated at the Muar Campus of MMMC during the entire duration of the study. The participants of this study comprised of medical students from the 3 main ethnic groups in Malaysia which are Malay, Chinese and Indian and other ethnic groups. This study also included international students from various countries, such as Sri Lanka and South Africa. This study was conducted from December 2018 until January 2019.

2.2. Sample Size

A previous study entitled 'An intervention study on the effect of matcha tea, in drink and snack bar formats, on mood and cognitive performance' [11], as a reference for the sample size of this study. According to the data given, the mean of the control group (μ1) was 10.7 with a standard deviation (σ 1) of 26.81 whereas the mean of the intervention group (μ 2) was -11.8 and the standard deviation (σ 2) was 19.23. Formula of comparing two means to calculate sample size was used. The formula used for the calculation was:

$$n \geq \frac{\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right) 2\,(\sigma_1^2 + \sigma_2^2\,/r)}{(\mu_1 - \mu_2)2}$$

Where,

1. Mean in control group, (μ1) = 10.7
2. Mean in intervention group, (μ2) = 26.81
3. Standard deviation in control group, (σ1) = 19.23

4. Standard deviation in intervention group, (σ2) = -11.8

5. Sample size ratio, r = 1

6. Type 1 Error rate, α = 0.05

7. Type 2 Error rate, β= 0.20

The calculated minimum sample size, $n_{calculated}$ for our study was 17 in each each arm. Using the formula below, the final adjusted sample size, n_{final} was calculated. 18.8~ 19 in each arm.

Where,

1. $n_{calculated}$ = 17

2. Non-response percentage = 10%

The final adjusted sample size, n_{final} obtained was 18.8~ 19 in each arm. However, the sample size selected for this study was a total of 60 samples, 30 from each arm.

$$nfinal = \frac{\text{ncalculated}}{1 - \text{non response\%}}$$

2.3. Sampling and Randomization

The study population comprise of Medical students of MMMC, approximately 800 in number (N=800). Sample was taken from students of Semester 6 which comprised of 150 students and Semester 7 which has 130 students. A total of 60 students was selected as the study sample (n) from 280 students of MMMC, Muar Campus for this research. Convenience (non-probability) sampling method which was by voluntary participation by MMMC, Muar Campus students was used in this study to select the subset from the total population.

Enquiries were made to identify students who were willing to participate in the study. Those who were willing to volunteer in this study which only consists of healthy medical students of MMMC, Muar Campus and have signed the written informed consent form were the inclusion criteria of this study. The exclusion criteria for this study was those who were suffering from any systemic disease, on medication, current smokers, consuming cognitive enhancers, consuming alcohol within the past 24 hours and those consuming caffeinated beverages for the past 8 hours before the study was conducted.

The students were then divided into 2 groups, the intervention group (group A) and the control group (group B) by block randomization using the website www.randomizer.org.

The randomization sequence was only known to 1 of the researchers (The researcher who allocated the drinks to the participants, CP) to ensure allocation concealment. The index number of subjects (1 to 60) were written on the pre-intervention questionnaire and distributed randomly to the participants (By 3 other researchers, who did not know of the randomization sequence) who have already signed the written informed consent form and cleared our screening questionnaire. Group A (intervention) received a concentrated (High dose) green tea, whereas group B (control) received diluted (low dose) green tea.

2.4. Procedure, Intervention and Follow-up

All the participants were given an informed consent form to be filled in before participating in the study. The proper consent was obtained, and the participants were informed that the participation in the study was voluntary. A screening questionnaire was given to the research participants to determine their eligibility in the study. Healthy volunteers with written informed consent were eligible to join the study. Exclusion criteria includes participants with systemic disease like hypertension, diabetes mellitus and SLE. Also, those who are currently smoking are excluded from the study. Volunteers who are consuming medications like cognitive enhancers, cough syrups, and antidepressants, antiepileptic were excluded from the study. Added to that, volunteers who had consumed alcohol for the past 24 hours or caffeinated beverages for past 8 hours were also excluded. After taking into consideration of our study's inclusion and exclusion criteria, (based on the screening questionnaire) participants will be chosen to take part in our study. Before the intervention was introduced, the participants' systolic and diastolic blood pressure and pulse rate were measured after 5 minutes of rest, using electronic blood pressure monitor. 3 researches, LM, AE, and BG were assigned to take the blood pressure and pulse rate of the participants in sitting position. The blood pressure and pulse rate were measured for one time. After that, the participants were given a pre-intervention questionnaire. The questionnaire consists of socio demographic questions and also questions to assess their green tea and coffee consumption frequency. Their frequency of exercising and meditation, with the duration of their exercise were also assessed.

After that, for the intervention group, the participants were given 200 ml of concentrated (high dose) green tea which was prepared by brewing 1 sachet (1.5g) of green tea in boiled water. For the control group, 200 ml of diluted (low dose) green tea (prepared by mixing 2000 ml of boiled water with 1 sachet (1.5g) of green tea) was given. They were required to finish drinking the drinks given within 5 minutes and remain seated for another 15 minutes after finishing the drink, all the participants were called back to measure their systolic and diastolic blood pressure and pulse rate using electronic blood pressure monitor. 3 researches, LM, AE, and BG were assigned to take the blood pressure and pulse rate of

the participants in sitting position. The blood pressure and pulse rate were measured for one time. Apart from that, the alertness of the participants were also measured, using human benchmark test (Reaction Time Test). [29] The average reaction time result out of 5 trials was recorded for every participant at the end of the test. At the end of all reaction time test, blood pressure and pulse rate measurement, the values were recorded in a table on the pre-intervention questionnaire.

Lastly, post-interventional questionnaire was given which required them to rate their self-perceived alertness level using a 1 to 10 scale (with 1 showed the least alertness and 10 with the most alert). In addition to that, self-perceived performance in the reaction time test and also self-perceived feeling of being relaxed was also included in the post-intervention questionnaire, also rated using a 1-10 scale. Other than this, the side effects of green tea were also accessed. The participants were asked if they had felt any adverse effects such as palpitation, headaches, sweating and increased heart rate which are commonly seen in green tea drinkers.

2.5. Data Collection, Data Processing & Data Analysis

The data collected was analyzed using Epi Info V 7.2.2.6 software and Microsoft Excel 2013. The data was recorded in Microsoft Excel. The independent variable was green tea while the dependent variables such as systolic blood pressure, diastolic blood pressure, pulse rate, performance, alertness, and adverse effects were recorded. The mean, standard deviation, level of significance, unpaired t-test, and chi-square test was calculated using Epi Info software. GraphPad V8.0.0 Software was also used to calculate paired t-test.

2.6. Ethical Consideration

The study was conducted with voluntary participation where the students had choice to participate or withdraw at any point of time in this study. The students were given a brief description about the study before experiment was carried out. A written informed consent was distributed to the voluntary students prior to the experiment as to respect their rights to participate in this study. Confidentiality of the participants was maintained as they had the option of remaining anonymous and any of the information gathered was only used for the purpose of this study. This study had received the approval of the Ethics Committee of Melaka Manipal Medical College (MMMC). At the end of this study, the results obtained was informed to the respective participants.

3. Results

In Table 1, the total number of samples were 60 participants with response rate of 100%. The mean age of participants in the intervention group was 22.60 and mean in the control group was 22.63. The standard deviation of age in the intervention group was 1.07 and the standard deviation in the control group was 1.25. As for gender, in the intervention group, there were 60% females and 40% males whereas in the control group, there were 56.67% females and 43.33% males. In the intervention group, respondents comprised of 30% Indians, 26.67% Chinese, 16.67% Malays, and 26.67% others. In the control group, there were 50% Indians, 33.33% Chinese, 6.67% Malays and 10% others. All participants were asked about their exercise habit. In the intervention group, 16.67% of respondents exercise daily and 83.33% of respondents do not exercise daily. As for the duration of exercise of participants, from the 16.67% who exercise daily in the intervention group, 60% of them exercised for 30-60 minutes daily, 20% exercised <30 minutes and 20% exercised for more than 60 minutes daily. In the control group, 70% of participants do not exercise daily. In this group, 44.44% of those who exercised daily exercised between 30 to 60 minutes daily followed by 33.33% who exercised more than 60 minutes and 22.22% who exercised less than 30 minutes daily. In the intervention group, 50% of respondents have never meditated before. 16.67% meditated at least once in 2 weeks, 13.33% meditated at least once monthly, 10% meditate at least once a week and another 10% who meditate daily. In the control group, 76.67% have said that they do not meditate. 16.67% meditate at least once in 2 weeks, 3.33% at least once monthly and 3.33% at least once in a week. 0% have said that they meditate daily.

Table 1. Participant Demographic Profile.

Variables	High Dose Green Tea (n=30) n (%) Mean (SD)	Low Dose Green Tea (n=30) n (%) Mean (SD)	Total n (%)
Age (years)	22.60 (1.07)	22.63 (1.25)	
Gender			
M	12 (40.00)	13 (43.33)	25 (41.46)
F	18 (60.00)	17 (56.67)	35 (58.33)
Race			
Chinese	8 (26.67)	10 (33.33)	18 (30)
Indian	9 (30.00)	15 (50.00)	24 (40)

Variables	High Dose Green Tea (n=30) n (%) Mean (SD)	Low Dose Green Tea (n=30) n (%) Mean (SD)	Total n (%)
Malay	5 (16.67)	2 (6.67)	7 (11.67)
Others	8 (26.67)	3 (10.00)	11 (36.67)
Daily Exercise			
Yes	5 (16.67)	9 (30.00)	14 (23.33)
No	25 (83.33)	21 (70.00)	46 (76.67)
Duration of daily exercise			
<30 minutes	1 (20.00)	2 (22.22)	3 (5)
30-60 minutes	3 (60.00)	4 (44.44)	7 (11.67)
>60 minutes	1 (20.00)	3 (33.33)	4 (6.67)
Meditation			
Never	15 (50.00)	23 (76.67)	38 (63.33)
At least once monthly	4 (13.33)	1 (3.33)	5 (8.33)
At least once in 2 weeks	5 (16.67)	5 (16.67)	10 (16.67)
At least once in a week	3 (10.00)	1 (3.33)	4 (6.67)
Daily	3 (10.00)	0	3 (5.0)

Table 2. Patient Demographic Profile (Status of Daily Coffee and Green Tea Consumption of intervention and control group).

Variables	High Dose Green Tea (n=30) n (%)	Low Dose Green Tea (n=30) n (%)	Total n (%)
Daily Green Tea Consumer			
Yes	2 (6.67)	1 (3.33)	3 (5.00)
No	28 (93.33)	29 (96.67)	57 (95.00)
Daily Coffee Consumer			
Yes	4 (13.33)	6 (20.00)	10 (16.67)
No	26 (86.67)	24 (80.00)	50 (83.33)

In Table 2, the total number of samples were 60 participants with 100% response rate. Participants were asked, in the pre-intervention questionnaire, on their daily green tea intake. In the intervention group, 6.67% of respondents have answered yes for consuming green tea daily and the remaining 93.33% have responded no. As for the control group, 3.33% have responded yes and 96.67% have responded no. When asked about coffee consumption daily, in the intervention group, 13.33% have responded yes and the remaining 86.67% have responded no. However, in the control group, 20% have answered yes and 80% have answered no.

Table 3. Effects of High Dose and Low Dose Green Tea on Blood Pressure, Pulse Rate and Reaction Time.

Variable	Mean (SD)		Mean Difference (95%CI)	t-statistic (df)	P-value
	High Dose Green Tea (n=30)	Low Dose Green Tea (n=30)			
Before SBP (mmhg)	119.7 (13.86)	124.0 (13.92)	4.4 (-2.8 to 11.5)	1.22 (58)	0.228
After SBP (mmhg)	119.1 (13.49)	117.6 (15.78)	-1.5 (-9.1 to 6.1)	-0.39 (58)	0.700
Before DBP (mmhg)	77.6 (6.44)	79.9 (9.42)	2.4 (-1.8 to 6.5)	1.14 (58)	0.261
After DBP (mmhg)	78.8 (11.21)	75.3 (11.08)	-3.5 (-9.3 to 2.2)	-1.23 (58)	0.224
Before PR (bpm)	77.1 (10.67)	78.2 (11.76)	1.2 (-4.6 to 67.0)	0.40 (58)	0.689
After PR (bpm)	79.6 (11.19)	78.7 (11.13)	-0.9 (-6.6 to 4.9)	-0.30 (58)	0.765
Reaction Time (ms)	405.3 (101.85)	403.6 (101.78)	-1.8 (-54.4 to 50.9)	-0.07 (58)	0.947

Table 3 shows the pre-interventional systolic blood pressure (SBP), post interventional SBP, pre-interventional diastolic blood pressure (DBP), post-interventional DBP, pre-interventional pulse rate (PR), post-interventional PR and also reaction time of two groups which are the high dose green tea and low dose green tea. The mean value of pre-interventional SBP of high dose green tea group was 119.7 mmHg with a standard deviation of 13.86 mmHg whereas in the low dose green tea group, the mean value was 124.0 mmHg with a standard deviation of 13.92. The mean difference of pre-interventional SBP between the two groups was 4.4 mmHg, with 95% CI being -2.8 to 11.5 mmHg. The p value was 0.228, which was not significant. The mean value of post-interventional SBP of high dose green tea group was 119.1mmHg with a standard deviation of 13.49 mmHg whereas in the low dose green tea group, the mean value was 117.6 mmHg with a standard deviation of 15.78. The mean difference of post-interventional SBP between the two groups was -1.5 mmHg, with 95% CI being -9.1 to 6.1 mmHg. The p value was 0.700, which was not significant. The mean value of pre-interventional DBP of high dose green tea group was 77.6 mmHg with a standard deviation of 6.44 mmHg whereas in the low dose green tea group, the mean value was 79.9 mmHg with a standard deviation of 9.42. The mean difference of pre-interventional diastolic blood pressure between the two groups was 2.4 mmHg, with

95% CI being -1.8 to 6.5 mmHg. The p value was 0.261, which was not significant. The mean value of post-interventional DBP of high dose green tea group was 78.8 mmHg with a standard deviation of 11.21 mmHg whereas in the low dose green tea group, the mean value was 75.3 mmHg with a standard deviation of 11.08. The mean difference of post-interventional DBP between the two groups was -3.5 mmHg, with 95% being -9.3 to 2.2 mmHg. The p value was 0.224, which was not significant. The mean value of pre-interventional PR of high dose green tea group was 77.1 bpm with a standard deviation of 10.67 bpm whereas in the low dose green tea group, the mean value was 78.2 bpm with a standard deviation of 11.76. The mean difference of pre-interventional PR between the two groups was 1.2 bpm, with 95% CI being -4.6 to 67 bpm. The p value is 0.689, which was not significant. The mean value of post-interventional PR of high dose green tea group was 79.6 bpm with a standard deviation of 11.19 bpm whereas in the low dose green tea group, the mean value was 78.7 bpm with a standard deviation of 11.13. The mean difference of post-interventional PR between the two groups was -0.9 bpm, with 95% CI being -6.6 to 4.9 bpm. The p value was 0.765, which was not significant. The mean value of reaction time of high dose green tea group was 405.3 ms with a standard deviation of 101.85 ms whereas in the low dose green tea group, the mean value was 403.6 ms with a standard deviation of 101.78 ms. The mean difference of reaction time between the two groups was -1.8 ms with 95% CI being from -54.4 to 50.9 ms. The p value was 0.947, which was not significant.

Table 4. Effects of High Dose and Low Dose Green Tea on self-perceived alertness, relaxation and performance.

Variable	Mean (SD)		Mean Difference (95% CI)	T-statistic (df)	P-value
	High Dose (n=30)	Low Dose (n=30)			
Alertness	6.8 (1.48)	5.8 (2.46)	-1.0 (-2.0 to 0.9)	-1.85 (58)	0.070
Relaxation	5.6 (1.83)	5.1 (1.98)	-0.6 (-1.6 to 0.4)	-1.15 (58)	0.254
Performance	6.8 (1.44)	6.0 (1.77)	-0.8 (-1.6 to 0.1)	-1.89 (57)	0.064

Table 4 shows the mean value with standard deviation, Mean difference with 95% CI, t value with degree of freedom (df) and P value for self-perceived alertness, relaxation and performance for the high dose green tea and low dose green tea groups. The mean score for alertness for high dose green tea group was 6.8 with SD of 1.48 whereas for low dose green tea group was 5.8 with SD of 2.46. The mean difference for alertness was -1.0 with 95% CI from -2.0 to 0.9 whereas the p value was 0.070, which was not significant. The mean score for relaxation for high dose green tea group was 5.6 with SD of 1.83 whereas for low dose green tea group was 5.1 with SD of 1.98. The mean difference for relaxation was -0.6 with 95% CI from -1.6 to 0.4 whereas the p value was 0.254, which was not significant. The mean score for performance for high dose green tea group was 6.8 with SD of 1.44 whereas for low dose green tea group was 6.0 with SD of 1.77. The mean difference for performance was -0.8 with 95% CI from -1.6 to 0.1 whereas the p value was 0.064, which was not significant.

Table 5. Comparison of pre and post systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate (PR) in intervention group (high dose green tea).

Statistical test: paired t-test

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Pre (n=30)	Post (n=30)			
SBP (mmHg)	119.67 (13.86)	119.07 (13.49)	0.60 (-2.82 to 4.02)	0.36 (29)	0.723
DBP (mmHg)	77.57 (6.44)	78.83 (11.21)	-1.27 (-5.34 to 2.80)	0.64 (29)	0.529
PR (bpm)	77.07 (10.7)	79.57 (11.2)	-2.50 (-6.18 to 1.18)	1.39 (29)	0.176

Table 5 shows the comparison of pre and post interventional systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate (PR) in interventional group of which high dose green tea was given. The sample size (n) was 30. The mean of pre-interventional SBP was 119.67mmHg with standard deviation of 13.86 whereas the mean of post-interventional SBP was 119.07mmHg with standard deviation of 13.49. The mean difference of SBP between pre and post high dose green tea was 0.60, with 95% CI being -2.82 to 4.02. The p value was 0.723. There was no significant difference of SBP pre and post high dose green tea. The mean of pre-interventional DBP was 77.57mmHg with standard deviation of 6.44 whereas the mean of post-interventional DBP was 78.83mmHg with standard deviation of 11.21. The mean difference of DBP between pre and post high dose green tea was -1.27, with 95% CI being -5.34 to 2.80. The p value was 0.529. There was no significant difference of DBP pre and post high dose green tea. The mean of pre-interventional PR was 77.07bpm with standard deviation of 10.7 whereas the mean of post-interventional PR was 79.57bpm with standard deviation of 11.2. The mean difference of PR between pre and post high dose green tea

was -2.50, with 95% CI being -6.18 to 1.18. The p value was 0.176. There was no significant difference of PR pre and post intervention (High dose green tea)

Table 6. Comparison of pre and post systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate (PR) in control group (low dose green tea). Statistical test: paired t-test

Variables	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	P-value
	Pre (n=30)	Post (n=30)			
SBP (mmHg)	124.03 (13.92)	117.79 (15.78)	6.43 (1.92 to 10.95)	2.91 (29)	0.007
DBP (mmHg)	79.93 (9.42)	75.30 (11.08)	4.63 (2.90 to 6.37)	5.46 (29)	<0.001
PR (bpm)	78.23 (11.76)	78.70 (11.13)	-0.47 (-3.92 to 2.99)	0.28 (29)	0.784

Table 6 shows the comparison of pre and post interventional systolic blood pressure (SBP), diastolic blood pressure (DBP), and pulse rate (PR) in control group of which low dose green tea was given. The sample size (n)=30. The mean of SBP pre-intervention was 124.03mmHg with standard deviation of 13.92 whereas mean of SBP post-intervention was 117.79mmHg with standard deviation of 15.78. The mean difference between pre and post-intervention was 6.43, with 95% CI being 1.92 to 10.95. The p value was 0.007. There was significant difference of SBP pre and post low dose green tea. The mean of DBP pre-intervention was 79.93mmHg with standard deviation of 9.42 whereas the mean of DBP post-intervention was 75.30mmHg with standard deviation of 11.08. The mean difference between pre and post intervention was 4.63, with 95% CI being 2.90 to 6.37, The p value was <0.001. There was significant difference of DBP pre and post intervention (Low dose green tea). The mean of PR pre-intervention was 78.23bpm with standard deviation of 11.76 whereas the mean of PR post-intervention was 78.70bpm with standard deviation of 11.13. The mean difference between pre and post low dose green tea PR was -0.47, with 95% CI being -3.92 to 2.99. The p value was 0.784. There was no significant difference of PR pre and post low dose green tea.

Table 7. Comparison between high dose green tea and low dose green tea and its adverse effects.

Variable	High Dose Green Tea n (%)	Low Dose Green Tea n (%)	Chi Square (df)	P value
Confusion				
Present	1 (3.3%)	0 (0%)	1.02 (1)	0.313
Absent	29 (96.7%)	30 (100%)		
Nausea				
Present	1 (3.3%)	1 (3.3%)	0.00 (1)	0.999
Absent	29 (96.7%)	29 (96.7%)		
Vomiting				
Present	1 (3.3%)	0 (0%)	1.02 (1)	0.313
Absent	29 (96.7%)	30 (100%)		
Dizziness				
Present	1 (3.3%)	1 (3.3%)	0.00 (1)	0.999
Absent	29 (96.7%)	29 (96.7%)		
Diarrhoea				
Present	1 (3.3%)	0 (0%)	1.02 (1)	0.313
Absent	29 (96.7%)	30 (100%)		
Irritability				
Present	2 (6.7%)	0 (0%)	2.07 (1)	0.150
Absent	28 (93.3%)	30 (100%)		
Tremor				
Present	2 (6.7%)	0 (0%)	2.07 (1)	0.150
Absent	28 (93.3%)	30 (100%)		
Heartburn				
Present	2 (6.7%)	0 (0%)	2.07 (1)	0.150
Absent	28 (93.3%)	30 (100%)		
Palpitation				
Present	4 (13.3%)	1 (3.3%)	1.96 (1)	0.161
Absent	26 (86.7%)	29 (96.7%)		
Headache				
Present	2 (6.7%)	0 (0%)	2.07 (1)	0.150
Absent	28 (93.3%)	30 (100%)		

Table 7, the total number of participants of our research were 60 participants with response rate of 100%. A total of 6.7% of participants experienced headache after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced headache. The chi square value was 2.07 and P value was 0.150 which was not significant. 13.3% of participants experienced palpitation after consumption of high dose green tea whereas 3.3% of the participants who consumed low dose green tea experienced headache. The chi square value was 1.96 and P value was 0.161 which was not significant. 6.7% of participants experienced heartburn after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced heartburn. The chi square value was 2.07 and P value was 0.150 which was not significant. 6.7% of participants experienced tremor after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced tremor. The chi square value was 2.07 and P value was 0.150 which was not significant. 6.7% of participants experienced irritability after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced irritability. The chi square value was 2.07 and P value was 0.150 which was not significant. 3.3% of participants experienced diarrhea after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced diarrhea. The chi square value was 1.02 and P value was 0.313 which was not significant. 3.3% of participants experienced dizziness after consumption of high dose green tea whereas 3.3% of the participants who consumed low dose green tea experienced dizziness. The chi square value was 0.00 and P value was 0.999 which was not significant. 3.3% of participants experienced vomiting after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced vomiting. The chi square value was 1.02 and P value was 0.313 which was not significant. 3.3% of participants experienced nausea after consumption of high dose green tea whereas 3.3% of the participants who consumed low dose green tea experienced nausea. The chi square value was 0.00 and P value was 0.999 which was not significant. 3.3% of participants experienced confusion after consumption of high dose green tea whereas none of the participants who consumed low dose green tea experienced confusion. The chi square value was 1.02 and P value was 0.313 which was not significant.

4. Discussion

In this research, our main objective was to find out the acute effects of green tea consumption on alertness, blood pressure and pulse rate among MBBS students of Melaka Manipal Medical College which was a randomized control study.

For the analysis of our result, for high dose green tea, the mean difference of SBP between pre and post intervention was 0.60mmHg, 95% CI (-2.82 to 4.02), p value (0.723). The mean difference of DBP between pre and post intervention was -1.27mmHg, 95% CI (-5.34 to 2.80), p value (0.529). For low dose green tea, the mean difference of SBP between pre and post intervention was 6.43mmHg, 95% CI (1.92 to 10.95), p value (0.007). The mean difference of DBP between pre and post intervention was 4.63mmHg, 95% CI (2.90 to 6.37), p value (<0.001). The mean difference of reaction time between the high dose and low dose green tea groups was -1.8ms, 95% CI (-54.4 to 50.9), p value was 0.947.

It showed that, there was no significant influence of consumption of high dose green tea on the blood pressure and pulse rate in the high dose green tea group. This differs from our hypothesis that there will be a decrease in the blood pressure and pulse rate of the participants 15 minutes after the consumption of high dose green tea. However, in the control group, a significant reduction was seen in the systolic and diastolic blood pressure of participants after consuming the low dose green tea, but no significant difference was seen in pulse rate after consuming the low dose green tea. As for the alertness level (mean reaction time), there was no significant difference seen between the high dose green tea and low dose green tea group. This result also contradicts our hypothesis that the alertness level in people who consumed high dose green tea will be higher than those who consumed low dose green tea.

As for self-perceived alertness, relaxation and performance in the reaction time test, it was found that there was no significant difference between intervention and control group. In addition, the adverse effects experienced by the participants from both the groups were also not significant.

In a previously conducted study on the effect of matcha green tea, in drink and snack bar formats, on mood and cognitive performance, [11] within the drink formats (matcha green tea versus placebo tea), reaction time in the matcha green tea group were significantly faster compared to the placebo group. Various other studies have also proven that green tea promotes alertness levels. [20, 21, 25-28] This was contrary to our study results where the reaction time of intervention group was not significantly faster compared to the control group. Other than that, in a meta-analysis of 13 randomized controlled trials on the effect of green tea consumption on blood pressure, [29] a significant reduction in SBP and DBP was observed in subjects supplemented with green tea when

compared with control subjects. Another study also proved that green tea lowers blood pressure. [18] These 2 studies also contradicted our study result. Regarding pulse rate (PR), our study did not reveal any significant changes after the consumption of green tea which, was contrary to a previous study which concluded that green tea has a strong effect on heart rate (i.e., it decreases the heart rate in normotensive female individuals and increases heart rate in the normotensive male individuals). [30]

This study had various limitations which needs to be acknowledged, such as the setting of the study itself. The study was conducted in a lecture hall and the alertness could have been affected due to the common distraction in the lecture hall, such as noise and interruption from other peers. Another major limitation of this study was the number of participants. The number of participants should be increased to obtain a significant finding. This was not achievable because it was difficult to get volunteers to participate in this study. Many were reluctant to spend time on this study while others deemed green tea unpalatable. Medical students from Melaka campus could not be included as they were having examinations. Due to all these shortcomings, this study had been limited to only 60 participants and this may have contributed to not achieving any significant result difference between the low dose green tea group and high dose green tea group. Furthermore, there was no exact previous research done on the same settings and variables tested which lead to no validated questionnaire and medico-related tests available to be used in this study. Our study focused on immediate effects of green tea, whereas previous studies generally focused on long-term but not the immediate effects of green tea.

For future studies, it is recommended that the research is held for a longer period of time with multiple sessions of assessment to get a more accurate result. Besides, it is also recommended to include more participants in this study. This may contribute to the effectiveness of the study conducted along with the variables tested. It is also advised to take average of several readings of blood pressure and pulse rate instead of taking a single reading. Other variables can also be included and tested in the future such as the effects of green tea on alertness (other than the reaction time), sleep quality, etc.

5. Conclusion

Based on the study done, it can be concluded that green tea in low doses does have some immediate effect on the individual's blood pressure and alertness (lowers blood pressure and increases alertness), but not pulse rate. However, high doses of green tea do not have significant immediate effects on the individual's blood pressure, alertness and pulse rate. The results may have been influenced by other factors like systematic errors and confounding factors such as caffeine levels difference between high dose green tea and low dose green tea preparations. However, it is best advised to conduct further studies for more accurate results.

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Conflict of Interest

All the authors do not have any possible conflicts of interest.

References

[1] https://www.who.int/cardiovascular_diseases/guidelines/hypertension_guidelines.pdf?ua=1

[2] Naing, C., Yeoh, P. N., Wai, V. N., Win, N. N., Kuan, L. P., & Aung, K. (2016). Hypertension in Malaysia. Medicine, 95 (2), e2417. doi: 10.1097/md.0000000000002417.

[3] Vasan, R. S. et al. Residual lifetime risk for developing hypertension in middle-aged women and men: The Framingham Heart Study. JAMA. 287, 1003–1010 (2002).

[4] Vigilance, alertness, or sustained attention: physiological basis and measurement B. S. Oken, M. C. Salinsky, S. M. Elsas Clin Neurophysiol. Author manuscript; available in PMC 2010 May 6. Published in final edited form as: Clin Neurophysiol. 2006 Sep; 117 (9): 1885–1901. Published online 2006 Apr 3. doi: 10.1016/j.clinph.2006.01.017 PMCID: PMC2865224.

[5] On the functional neuroanatomy of intrinsic and phasic alertness. Sturm W, Willmes K. Neuroimage. 2001 Jul; 14 (1 Pt 2): S76-84.

[6] PSYCHOTROPIC EFFECTS OF CAFFEINE IN MAN. II. ALERTNESS, PSYCHOMOTOR COORDINATION, AND MOOD Avram Goldstein, Sophia Kaizer and Richard Warren Journal of Pharmacology and Experimental Therapeutics October 1965, 150 (1) 146-151.

[7] van Duinen, H., Lorist, M. M., & Zijdewind, I. (2005). The effect of caffeine on cognitive task performance and motor fatigue. Psychopharmacology, 180 (3), 539-547. DOI: 10.1007/s00213-005-2191-9.

[8] 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. PubMed PMID: 11665810.

[9] Beneficial effects of an "energy drink" given to sleepy drivers. Horne JA, Reyner LA. Amino Acids. 2001; 20 (1): 83-9. PMID: 11310933.

[10] Chellappa, S. L., Steiner, R., Blattner, P., Oelhafen, P., Götz, T., & Cajochen, C. (2011). Non-visual effects of light on melatonin, alertness and cognitive performance: can blue-enriched light keep us alert? PloS one, 6 (1), e16429. doi: 10.1371/journal.pone.0016429.

[11] Christina Dietz, Matthijs Dekker, Betina Piqueras-Fiszman, An intervention study on the effect of matcha tea, in drink and snack bar formats, on mood and cognitive performance, Food Research International (2017), doi: 10.1016/j.foodres.2017.05.002.

[12] Meythaler JM, Depalma L, Devivo MJ, Guin-Renfroe S, Novack TA. Sertraline to improve arousal and alertness in severe traumatic brain injury secondary to motor vehicle crashes. Brain Inj. 2001 Apr; 15 (4): 321-31. PubMed PMID: 11299133.

[13] Rai, Nishant & Anand, Jigisha & Kumar, Navin & Gautam, Pankaj. (2013). green tea paper.

[14] Dietz, Christina & Dekker, Matthijs. (2017). Effect of Green Tea Phytochemicals on Mood and Cognition. Current pharmaceutical design. 23. 10.2174/1381612823666170105151800.

[15] Pateriya, Pradeep. (2018). Green tea -A short review.

[16] Suzanne J Einöther, Vanessa E Martens; Acute effects of tea consumption on attention and mood, The American Journal of Clinical Nutrition, Volume 98, Issue 6, 1 December 2013, Pages 1700S–1708S, https://doi.org/10.3945/ajcn.113.058248.

[17] Unno, K., Noda, S., Kawasaki, Y., Yamada, H., Morita, A., Iguchi, K., & Nakamura, Y. (2017). Reduced Stress and Improved Sleep Quality Caused by Green Tea Are Associated with a Reduced Caffeine Content. Nutrients, 9 (7), 777. Doi: 10.3390/nu9070777.

[18] Hartley L, Flowers N, Holmes J, et al. Green and black tea for the primary prevention of cardiovascular disease. Cochrane Database Syst Rev. 2013; 6: CD009934.23780706.

[19] Ferré S. An update on the mechanisms of the psychostimulant effects of caffeine. J Neurochem 2008; 105: 1067–79.

[20] Einöther SJ, Giesbrecht T. Caffeine as an attention enhancer: reviewing existing assumptions. Psychopharmocology (Berl) 2013; 225: 251–74.

[21] Rogers PJ. Caffeine, mood and mental performance in everyday life. Nutr Bull 2007; 32: 84–9.

[22] Brunyé TT, Mahoney CR, Lieberman HR, Taylor HA. Caffeine modulates attention network function. Brain Cogn 2010; 72: 181–8.

[23] Brunyé TT, Mahoney CR, Lieberman HR, Giles GE, Taylor HA. Acute caffeine consumption enhances the executive control of visual attention in habitual consumers. Brain Cogn 2010; 74: 186–92.

[24] Tieges Z, Snel J, Kok A, Wijnen JG, Lorist MM, Richard RK. Caffeine improves anticipatory processes in task switching. Biol Psychol 2006; 73: 101–13.

[25] Giesbrecht, T., Rycroft, J. A., Rowson, M. J., De Bruin, E. A., 2010. The combination of Ltheanine and caffeine improves cognitive performance and increases subjective alertness. Nutr. Neurosci. 13, 283–290.

[26] Einöther, S. J., Martens, V. E., Rycroft, J. A., De Bruin, E. A., 2010. L-theanine and caffeine improve task switching but not intersensory attention or subjective alertness. Appetite 54, 406–409.

[27] Owen, G. N., Parnell, H., De Bruin, E. A., Rycroft, J. A., 2008. The combined effects of Ltheanine and caffeine on cognitive performance and mood. Nutr. Neurosci. 11, 193–198.

[28] Bryan J. Psychological effects of dietary components of tea: caffeine and L-theanine. Nutr Rev 2008; 66: 82–90.

[29] Peng, X., Zhou, R., Wang, B., Yu, X., Yang, X., Liu, K., & Mi, M. (2014). Effect of green tea consumption on blood pressure: A meta-analysis of 13 randomized controlled trials. Scientific Reports, 4 (1). doi: 10.1038/srep06251.

[30] Ullah, Naveed & Khan, Mir & Asif, Afzal & Ali Shah, Afrasiab & Anwar, Sadaf & Wahid, Hazrat & Nazir, Aamir. (2011). Effect of Green tea on Heart Rate of Male and Female. Asian Journal of Medical Sciences. 3. 180-182.