Effects of Black and Green Tea Consumption on Blood Pressure and Liver Enzymes: A Randomized Controlled Trial

Iman A Hakim[1,2*], Linda Garland[2], Robin Harris[1,2] and H-H Sherry Chow[2]

[1]Mel and Enid Zuckerman College of Public Health, USA
[2]University of Arizona Cancer Center, The University of Arizona, Tucson, Arizona, USA

Abstract

Background: The effect on tea consumption on blood pressure and liver enzymes are controversial. The beneficial effects of long-term ingestion of black and green tea on systolic and diastolic blood pressure have been suggested by several studies.

Objectives: The overall goal of this study was to determine the effects of high tea consumption on blood pressure and liver enzymes

Design: We completed a 6-month randomized, controlled, double-blinded trial in a group of former and current smokers who were randomized to receive black or green tea preparations or a matching placebo.

Results: A total of 146 participants (80 females and 66 males) were enrolled in the study. At the end of the 6-month intervention, women in the black tea group showed a 4 mmHg decrease (*p* = 0.01) in systolic blood pressure while female in the green tea group showed a 30.1% decrease (*p* = 0.035) in Alanine transaminase (ALT). No significant changes were observed in men.

Conclusion: Our data confirm previous findings related to the beneficial effect of black tea on blood pressure and of green tea on serum liver enzymes especially among females. In addition, our study showed that long-term regular consumption of black tea and green is safe.

Keywords: Tea; Gender; Blood pressure; Liver enzymes; Clinical trial; Smokers

Abbreviations: AST: Aspartate Transaminase; ALT: Alanine Transaminase; BP**:** Blood Pressure**;** CVD: Cardiovascular Disease**;** DBP: Diastolic Blood Pressure; SBP: Systolic Blood Pressure.

Introduction

Smoking has been linked to uncontrolled blood pressure (BP). It is well known that BP levels change with age. Systolic blood pressure (SBP) increases from adolescence until old age, while diastolic blood pressure (DBP) increases until age 50 years and then decreases [1]. The risk of cardiovascular disease (CVD) mortality increases gradually throughout the range of BP starting at pre-hypertensive ranges of SBP (120–139 mmHg) and DBP (80–89 mmHg) [2]. Therefore, small changes in BP through dietary interventions may have a significant impact on reducing the risk especially among former and current smokers.

A large number of animal and epidemiologic studies as well as small-size clinical trials have investigated the relationship between tea consumption and BP, with inconsistent outcomes [3-7]. Despite of these conflicting results, green tea extracts (GTE) have been increasingly used by the general population as an ingredient in different dietary supplements. Some concerns have been raised about the safety of the intake of high doses of GTE. A systematic review revealed that in most cases, there were multiple agents involved and the committee recommended taking GTE with meals [8]. However, drinking green tea has not been associated with liver injury or serum aminotransferase elevations [9].

Therefore, we examined in the context of a randomized, controlled, doubled blinded trial the efficacy of regular black and green tea drinking in reducing BP among current and former smokers. We also examined the impact of black and green tea consumption on liver enzymes in this population of middle-aged and elderly former and current smokers.

Subjects and Methods

Study population

We recruited current and former smokers between 40 and 80 years of age. Subjects were screened to exclude regular tea drinkers, pregnant women, history of cancer, current drug or alcohol abusers, individuals with an abnormal liver function blood test or those currently being treated with antidepressants. The study was approved by the Institutional Review Board of the University of Arizona, and all of the subjects provided informed consent before enrollment.

Study protocol

The study protocol and data collection procedures were described in details elsewhere [10]. In brief, the study was a 3-arm double-blinded randomized placebo-controlled tea intervention trial. Each subject was randomly assigned to drink 4 cups (12 oz. each) of black tea, green tea, or placebo tea daily for 6 months. Study participants were asked to maintain the beverage consumption pattern (4 cups/day) for 6 months, returning to the clinic at monthly intervals. Blood and urine samples were collected at baseline, mid study (month 3) and end of the study (month 6). SBP (in mmHg) and DBP (in mmHg) were measured at

least 3 times with a minimum 5-minute interval, by using Omrom MX3 plus automated oscillometric Blood Pressure Monitor (O-HEM-742-E; Matsusaka, Japan), according to standard operating procedures, by a well-trained research specialist. BP measurements were performed after participants had been seated for at least 5 minutes. Levels of serum glucose, ALT, and AST were determined at the central laboratory affiliated with the University of Arizona.

Statistical methods

Descriptive analyses were conducted by gender. Primary end points were changes in SBP, DBP, glucose, and liver enzymes (AST and ALT) from baseline to 6 months after commencement of intervention. Tests for significance of the change (pre-intervention versus post-intervention values) in SBP, DBP, AST and ALT were performed by gender. Results were expressed as mean ± standard deviation (SD). Multiple linear regression models were used to estimate the main effects of black and green tea intake on SBP, DBP, glucose, AST and ALT with or without adjustment for potential confounders. Data presented are adjusted for smoking status and years of smoking. Statistical tests were two-sided with a significant level of 0.05. All statistical analyses were conducted using Stata Statistical Software (Stata 12).

Results

Of the 154 randomized participants, 146 (80 females and 66 males) current and former smokers completed the 6-month intervention. There were no statistically significant differences by gender, smoking variables, or treatment group between those who completed the study and those who did not. Among those who completed the study, compliance to the tea intervention was >95%.

Overall characteristics of the study population by gender are shown in Table 1. Our data showed that women have significantly lower SBP (p=0.03) and DBP (p=0.005) as well as lower blood glucose (p=0.001) and ALT (p=0.002) levels compared to men. There were no significant differences in baseline characteristics between the three intervention groups (data not shown).

Unadjusted means of baseline and 6-month (end of intervention) clinical data per group are shown in Table 2 for females and Table 3 for males.

The adjusted mean changes in SBP, DBP, glucose, AST and ALT by tea group compared to placebo are shown in Table 4. Our data showed a significant decrease in SBP (4 mmHg) among females after 6 months of drinking black tea (p=0.01). Green tea consumption was associated with a significant decrease (p=0.035) in serum ALT among females.

	Females Mean ± SD	Males Mean ± SD	p value Males *vs.* Females
Age (year)	59.6 ± 9	61.0 ± 8	0.36
BMI (kg/m²)	28.3 ± 6.8	29.1 ± 6.9	0.47
Former/current smoker	34/46	27/39	0.85
Systolic blood pressure (mm Hg)	123.1 ± 17.0	129.0 ± 15.4	0.03
Diastolic blood pressure (mm Hg)	68.7 ± 10.6	73.4 ± 9.0	0.005
Blood glucose	94.8 ± 14.1	108.7 ± 34.9	0.001
Aspartate transaminase (AST)	22.6 ± 17.5	24.6 ± 10.7	0.43
Alanine transaminase (ALT)	20.2 ± 11.9	27.9 ± 17.6	0.002

Table 1: Overall characteristics of the study population by gender.

	Green Tea Mean ± SD	Black Tea Mean ± SD	Control *Mean ± SD*
Systolic blood pressure			
Baseline	119.3 ± 17.6	127.0 ± 17.8	122.9 ± 15.7
Month 6	118.9 ± 13.6	122.9 ± 14.6*	123.3 ± 16.2
Diastolic blood pressure			
Baseline	69.1 ± 10.6	69.8 ± 12.4	67.4 ± 9.2
Month 6	71.4 ± 12.6	69.5 ± 16.4	65.3 ± 10.9
Blood glucose			
Baseline	95.0 ± 19.9	95.2 ± 10.5	94.2 ± 11.4
Month 6	86.0 ± 26.7	98.0 ± 17.9	91.0 ± 9.7
Aspartate transaminase (AST)			
Baseline	27.8 ± 30.5	21.2 ± 6.5	19.7 ± 5.5
Month 6	18.1 ± 5.8	29.8 ± 29.5	18.9 ± 4.2
Alanine transaminase (ALT)			
Baseline	23.5 ± 18.6	18.3 ± 7.4	19.3 ± 7.3
Month 6	16.3 ± 6.7*	18.7 ± 6.3	18.4 ± 7.0

Table 2: Females clinical outcomes at baseline and month 6 by intervention group. *P < 0.05

	Green Tea Mean ± SD	Black Tea Mean ± SD	Control Mean ± SD
Systolic blood pressure			
Baseline	129.5 ± 14.7	129.9 ± 16.8	127.8 ± 15.4
Month 6	124.4 ± 15.2	129.6 ± 13.2	121.8 ± 18.9
Diastolic blood pressure			
Baseline	72.1 ± 11.3	75.9 ± 7.4	72.2 ± 7.8
Month 6	70.5 ± 8.9	76.3 ± 12.0	76.1 ± 14.6
Blood glucose			
Baseline	108.7 ± 27.2	107.3 ± 30.4	109.9 ± 44.6
Month 6	108.6 ± 26.8	105.0 ± 22.2	108.7 ± 53.9
Aspartate transaminase (AST)			
Baseline	25.1 ± 10.2	23.8 ± 10.7	24.8 ± 11.6
Month 6	28.8 ± 21.3	26.4 ± 16.1	22.7 ± 8.2
Alanine transaminase (ALT)			
Baseline	28.8 ± 15.5	26.3 ± 12.2	28.4 ± 23.1
Month 6	30.9 ± 22.3	27.1 ± 15.5	26.5 ± 17.7

Table 3: Males clinical outcomes at baseline and month 6 by intervention group.

Discussion

SBP and DBP are associated with cardiovascular mortality at thresholds lower than the current hypertension definition. Published data revealed that throughout middle and old age, BP is strongly and directly associated with CVD and overall mortality, without any evidence of a threshold down to at least 115/75 mmHg (2). In women and men with normal SBP levels, DBP did not influence cardiovascular mortality after adjustment for age and SBP, however, in both genders, CVD mortality increased with the increase in SBP [11-13]. Small decreases in SBP can have a significant effect on cardiovascular outcomes. Several studies have showed that measuring SBP alone would be effective in screening for CVD risk in large populations [14]. Therefore, even relatively small reductions in population SBP can be considered of major interest to public health.

In our current study, we found that black tea consumption for 6 months was associated with significant decrease of SBP among women. A recent systematic review of 10 trials showed that consumption of green or black tea can reduce BP in individuals within pre-hypertensive and hypertensive ranges [15]. The beneficial effects of tea intake on BP were mainly observed when the duration of consumption was slightly ≥ 12 weeks [16].

	Green Tea Mean change (95% CI)	p	Black Tea Mean change (95% CI)	p
Females				
Systolic blood pressure	-4.4 (-12.2; 3.3)	0.26	-10.8 (-19.1; -2.6)	0.01
Diastolic blood pressure	2.7 (-3.3; 8.7)	0.37	- 0.8 (-7.2; 5.5)	0.80
Blood glucose	-5.0 (-15.5; 5.6)	0.35	5.7 (-4.6; 15.9)	0.27
Aspartate transaminase	-10.8 (-24.7; 4.7)	0.18	8.0 (-6.4; 22.2)	0.27
Alanine transaminase	-7.4 (-14.3; -0.6)	0.035	0.9 (-5.8; 7.6)	0.79
Males				
Systolic blood pressure	1.5 (-9.9; 12.8)	0.8	7.7 (-3.6; 18.9)	0.18
Diastolic blood pressure	-4.4 (-13.3; 4.6)	0.33	-2.8	0.53
Blood glucose	11.4 (-22.5; 45.3)	0.50	-0.20 (-31.9; 35.9)	0.91
Aspartate transaminase	6.6 (-2.4; 15.5)	0.15	4.1 (-4.8; 13.0)	0.36
Alanine transaminase	4.7 (-5.2; 14.5)	0.34	0.96 (-8.9; 10.9)	0.85

Table 4: Mean change (95% CI) in clinical outcomes by tea group compared with placebo.

There are a number of potential mechanisms for BP lowering effect by black tea. In addition to their antioxidant properties, tea flavonoids reduce plasma concentrations of endothelin-1 which could contribute to reduced vascular tone and lower BP [17]. Published data showed that regular ingestion of black tea significantly improved brachial artery vasodilator functions among people with elevated serum lipids [18] and reversed endothelial vasomotor dysfunction in patients with CVD [19]. A recent meta-analysis reported that endothelial function can be improved by tea consumption [20].

Serum AST and ALT are known as biomarkers for liver health. Our data showed that regular green tea consumption was associated with significant decrease in serum ALT among females. Recently published randomized clinical trials reported that GTE supplementation decreased ALT and AST levels after 12-week period in patients with non-alcoholic fatty liver disease [21-23]. Based on our results, daily tea consumption of green or black tea does not impair liver function in former or current smokers.

Conclusion

Our study has demonstrated that long-term regular consumption of black tea can result in significantly lower SBP in middle-aged and elderly women with normal to high-normal range BP. Given that a large proportion of the general populations have BP within the range included in this trial, make the results applicable to women at increased risk of hypertension.

Authors' Contributions

Conception and design: I. A. Hakim, R. B. Harris, L. L. Garland, H.-H. Sherry Chow.

Development of methodology: I. A. Hakim, R. B. Harris, H.-H. Sherry Chow.

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): I. A. Hakim and H.-H. Sherry Chow.

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): I. A. Hakim, R. B. Harris, and H.-H. Sherry Chow.

Writing, review, and/or revision of the manuscript: I. A. Hakim, R. B. Harris, L. L. Garland, H.-H. Sherry Chow.

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): I.A. Hakim and data manager.

Study supervision: I. A. Hakim, L. L. Garland, H.-H. Sherry Chow.

References

1. Franklin SS, Gustin W 4th., Wong ND, Larson MG, Weber MA, et al. (1997) Hemodynamic patterns of age-related changes in blood pressure: The Framingham Heart Study. Circulation 96: 308-315.

2. Lewington S, Clarke R, Qizilbash N, Peto R, Collins R (2002) Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet 360: 1903-1913.

3. Hodgson JM, Puddey IB, Woodman RJ, Mulder TP, Fuchs D, et al. (2012) Effects of black tea on blood pressure: a randomized controlled trial. Arch Intern Med 172: 186-188.

4. Sone T, Kuriyama S, Nakaya N, Hozawa A, Shimazu T, et al. (2011) Randomized controlled trial for an effect of catechin-enriched green tea consumption on adiponectin and cardiovascular disease risk factors. Food Nutr Res 55: 8326.

5. Nantz MP, Rowe CA, Bukowski JF, Percival SS (2009) Standardized capsule of Camellia sinensis lowers cardiovascular risk factors in a randomized, double-blind, placebo-controlled study. Nutrition 25: 147-154.

6. Matsuyama T, Tanaka Y, Kamimaki I, Nagao T, Tokimitsu I (2008) Catechin safely improved higher levels of fatness, blood pressure, and cholesterol in children. Obesity 16: 1338-1348.

7. Frank J, George TW, Lodge JK, Rodriguez-Mateos AM, Spencer JP, et al. (2009) Daily consumption of an aqueous green tea extract supplement does not impair liver function or alter cardiovascular disease risk biomarkers in healthy men. J Nutr 139: 58-62.

8. Sarma DN, Barrett ML, Chavez ML, Gardiner P, Ko R, et al. (2008) Safety of green tea extracts: a systematic review by the US Pharmacopeia. Drug Saf 31: 469-484.

9. https://livertox.nih.gov/GreenTea.htm

10. Hakim IA, Garland L, Harris R, Cordova CA, Mikhael DM, et al. (2017) Modulation of Oxidative Damage by Green and Black Tea: Role of Smoking and Gender in a Randomized Trial. J Nutr Food Sci 7: 633.

11. Vishram JK, Borglykke A, Andreasen AH, Jeppesen J, Ibsen H, et al. (2014) Do other cardiovascular risk factors influence the impact of age on the association between blood pressure and mortality? The MORGAM Project. J Hypertens 32: 1025-1032.

12. Vishram JK, Borglykke A, Andreasen AH, Jeppesen J, Ibsen H, et al. (2012) Impact of Age on the Importance of Systolic and Diastolic Blood Pressures for Stroke Risk (MORGAM) Project. Hypertension 60: 1117-1123.

13. Benetos A, Thomas F, Safar ME, Bean KE, Guize L (2001) Should diastolic and systolic blood pressure be considered for cardiovascular risk evaluation: a study in middle-aged men and women. J Am Coll Cardiol 37: 163-168.

14. Sauvaget C, Ramadas K, Thomas G, Thara S, Sankaranarayanan R (2010) Prognosis criteria of casual systolic and diastolic blood pressure values in a prospective study in India. J Epidemiol Community Health 64: 366-372.

15. Yarmolinsky J, Gon G, Edwards P (2015) Effect of tea on blood pressure for secondary prevention of cardiovascular disease: a systematic review and meta-analysis of randomized controlled trials. Nutrition Reviews 73: 236-246.

16. Liu G, Mi XN, Zheng XX, Xu YL, Lu J, et al. (2014) Effects of tea intake on blood pressure: a meta-analysis of randomized controlled trials. Br J Nutr 112: 1043-1054.

17. Loke WM, Hodgson JM, Proudfoot JM, McKinley AJ, Puddey IB, et al. (2008) Pure dietary flavonoids quercetin and (-)-epicatechin augment nitric oxide products and reduce endothelin-1 acutely in healthy men. Am J Clin Nutr 88: 1018-1025.

18. Hodgson JM, Puddey IB, Burke V, Watts GF, Beilin LJ (2002) Regular ingestion of black tea improves brachial artery vasodilator function. Clin Sci (Lond) 102: 195-201.

19. Duffy SJ, Keaney Jr JF, Holbrook M, Gokce N, Swerdloff PL, et al. (2001) Short- and long-term black tea consumption reverses endothelial dysfunction in patients with coronary artery disease. Circulation 104: 151-156.

20. Ras RT, Zock PL, Draijer R (2011) Tea consumption enhances endothelial dependent vasodilation; a meta-analysis. PLoS One. 6: e16974.

21. Hussain M, Habib-Ur-Rehman, Akhtar L (2017) Therapeutic benefits of green tea extract on various parameters in non-alcoholic fatty liver disease patients. Pak J Med Sci 33: 931-936.

22. Pezeshki A, Safi S, Feizi A, Askari G, Karami F (2015) The effect of green tea extract supplementation on liver enzymes in patients with nonalcoholic fatty liver disease. Int J Prev Med 6: 131.

23. Sakata R, Nakamura T, Torimura T, Ueno T, Sata M (2013) Green tea with high-density catechins improves liver function and fat infiltration in non-alcoholic fatty liver disease (NAFLD) patients: a double-blind placebo-controlled study. Int J Mol Med 32: 989-994.