

## ORIGINAL ARTICLE

## Green Tea Attenuates Hypotension Induced by Physical Exercise: A Randomized, Placebo Controlled Study

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### Abstract

**Background:** Studies have shown that chronic administration of green tea decreases blood pressure (BP) at rest, while a single exercise session also promotes reduction of BP.

**Objective:** To investigate whether if a single dose of green tea prior to aerobic exercise session improves post-exercise hypotension (PEH).

**Methods:** Randomized, double-blind, placebo controlled study. Fifteen hypertensive patients ( $53 \pm 3.3$  years) participated in two study sessions: green tea+exercise (GTE) and placebo+exercise (PLE). Thirty minutes after ingesting 2 g of green tea or placebo, they performed 60 minutes of treadmill walking at 60 to 85% of maximum heart rate. BP was measured at rest and at every 10 minutes after exercise for 60 minutes. Blood samples were taken before ingestion of green tea or placebo and immediately after exercise to determine malondialdehyde (MDA) and nitrite (NO) concentrations.

**Results:** On PLE day, systolic PEH was detected at all post-exercise time points (BP reduction by 6.5-11.8 mmHg), whereas on GTE day, PEH was found only at 20 and 40 minutes post-exercise (BP reduction by 5.9 and 5.8 mmHg, respectively). BP reduction was significantly higher in PLE at 10, 20 and 30 minutes post-exercise compared with GTE. In addition, GTE resulted in hypertensive diastolic response, while on PLE day, diastolic PEH was seen only at 20 minutes post-exercise. No changes in MDA or NO concentrations in response to exercise were observed.

**Conclusion:** Green tea supplementation prior to an aerobic exercise session attenuated systolic PEH and induced diastolic hypertensive response to aerobic exercise in hypertensive patients. (Int J Cardiovasc Sci. 2017;30(4):325-333)

**Keywords:** *Camellia sinensis* / drug effects; Hypotension; Exercise; Oxidative Stress; Antioxidants.

### Introduction

It is known that a single bout of aerobic exercise can promote significant and clinically relevant reduction in blood pressure (BP) in hypertensive subjects.<sup>1</sup> This phenomenon is called post-exercise hypotension (PEH). The magnitude and duration of PEH are dependent of intensity and duration of the exercise.<sup>2</sup> However, other factors may influence PEH, such as genetic characteristics<sup>3</sup> and initial blood pressure level. Our group has tested the influence of food on PEH and found that isolated caffeine<sup>4</sup> or coffee intake before or after exercise,<sup>5</sup> abolished hypotension induced by a session of aerobic exercise in hypertensive patients.

Previous studies<sup>6-9</sup> have shown that green tea, despite containing caffeine, promotes reduction of resting BP. This effect can be explained by the high antioxidant and anti-inflammatory capacity of catechins.<sup>7</sup> However, one cannot disregard the presence of caffeine in green tea, and the possibility that isolated intakes of the beverage result in vasoconstriction and elevation of BP at rest, or attenuation of PEH, similarly to what has been reported with coffee.<sup>4,5</sup>

So far, it is unknown whether the consumption of green tea can alleviate PEH or optimize exercise-induced BP reduction due to the presence of antioxidants. Thus, this study was conducted to verify the effect of a

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single dose of green tea before an aerobic exercise session on BP and oxidative stress response in hypertensive middle-aged adults.

## Methods

### Subjects

This was a randomized, double-blind, placebo-controlled study, performed on fifteen hypertensive individuals (8 women) aged  $53 \pm 3.3$  years. These subjects were physically active at least 3 months prior to the trial. This sample size was determined based on previous studies in which hypertensive individuals have experienced the phenomenon of PEH.<sup>10-12</sup> All patients used anti-hypertensive medications and maintained medication throughout the study period. Diabetic subjects and menopausal women were excluded from the study.

The study was approved by the Human Research Ethics Committee of the Health Sciences Centre of the Federal University of Paraiba (identification number 0120/13). All participants signed the informed consent form, according to the National Health Council resolution (no. 466/12).

### Study design

Each subject participated in two experiments, performed on two days separated by 48 hours. Experiments were conducted in the afternoon always at the same time. On each day, each participant received one dose of green tea (GTE, green tea + exercise) or placebo (PLE, placebo + exercise) 30 minutes before the aerobic exercise protocol. Heart rate was measured at rest and in every ten minutes during exercise. BP measurements were taken before (at rest), immediately after exercise and in every ten minutes during the 60-minute recovery period after the exercise. Blood samples were collected prior and immediately after exercise for analysis of plasmatic concentration of nitrite (NO) and malondialdehyde (MDA). The experiment protocol is shown in Figure 1.

### Physical exercise

Aerobic exercise program consisted of 60-minute of treadmill walking at 60% to 85% of maximum heart rate.<sup>13</sup>

Heart rate was monitored using a Polar heart rate monitor (Polar RS800CX, Polar Electro Oy, Kempele, Finland). Furthermore, exercise should be performed at intensity between 11 and 14 on Borg and Noble's 6-20 perceived exertion scale.<sup>14</sup>

### Supplementation of green tea or placebo

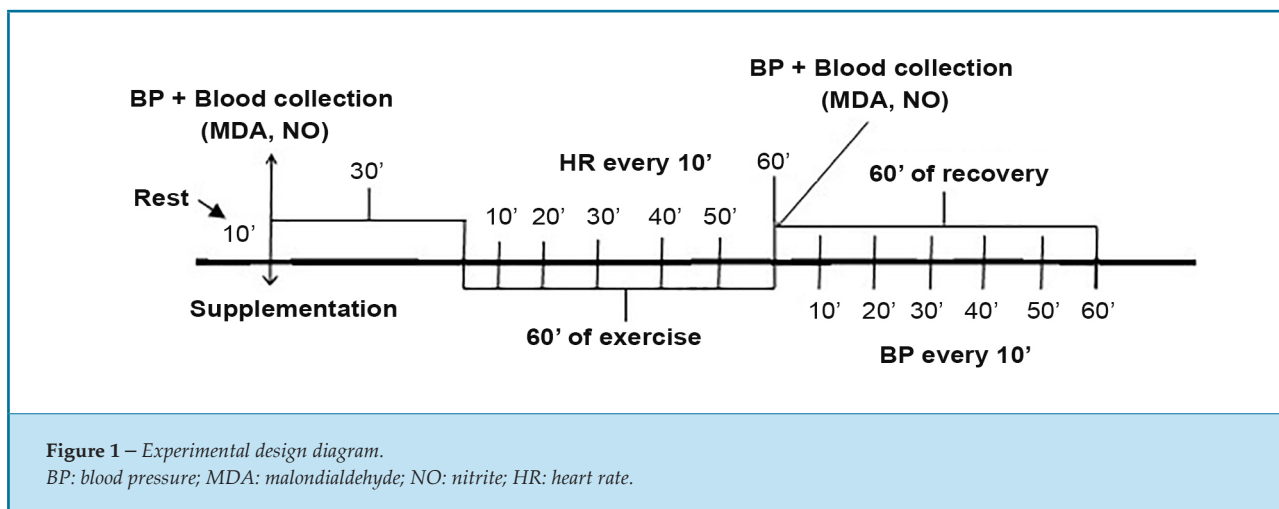
Green tea and placebo capsules were produced in a compounding laboratory. Green tea dose was based on the study by Panza et al.<sup>15</sup> Participants received green tea capsules containing 2 g of concentrated powder – approximately 1,960 mg in polyphenols (636 mg of epigallocatechin gallate) and 20 mg of caffeine – or placebo containing 2 g of cornstarch powder, both swallowed with water. The capsules were administered to patients after blood sample collection. Thirty minutes later, exercise sessions were initiated.

Regular consumption of green tea, polyphenols, catechins and caffeine, as well as consumption of these products on the previous day were assessed 24-hour recall as proposed by Fisberg et al.<sup>16</sup> The instrument was applied on three non-consecutive days to evaluate dietary intake on two weekdays and one weekend day.

During a 48-hour washout period, prior to the sessions, all participants were instructed to refrain from foods rich in polyphenols and epigallocatechin – dark chocolate, red wine, black and green tea, grapes, and apples. Data were analyzed using the Nutwin software (version 1.5, 2003, Brazil). Hypertensive patients were asked to maintain their eating habits during the study period.

### Blood pressure measurement

BP was measured in triplicate at intervals of one minute between measurements in the arm with the highest reading. Individuals had their BPs checked before (at rest), immediately after, and during the 60-minute period post-exercise. BP at rest was verified after the subjects remained seated for 10 minutes; right after the treadmill walking session, BP was checked in seated position and, during the 60-minute recovery period, measurements were taken every 10 minutes. All measurements were performed according to the Brazilian Society of Cardiology and the Brazilian Society of Hypertension guidelines.<sup>17</sup>



### Blood collection and laboratory analysis

Samples of 10 mL of blood were collected from the antecubital vein before and after the exercise, of which 5 mL was placed in test tubes containing EDTA, and carefully homogenized by repeated inversion, and 5 mL was placed in tubes without anticoagulant. The samples were then centrifuged at 3,000 rpm for 20 minutes. Plasma was transferred to microtubes and refrigerated until analysis.

Oxidative activity was quantified by the thiobarbituric acid reaction with products from hydroperoxides decomposition. A volume of 250  $\mu$ L of sample was homogenized with KCl and incubated at 37° C in a water bath for 60 minutes. The mixture was then precipitated with 35% perchloric acid and centrifuged at 14,000 rpm for 10 minutes at 4° C. The supernatant was transferred to new tubes to which 400  $\mu$ l of 0.6% thiobarbituric acid was added, and the mixture incubated at 95-100° C for 30 min. After cooling, the material was read by a spectrophotometer at wavelength of 532 nm. NO measurement was based on the Griess method. Reagent was prepared utilizing equal parts of 5% phosphoric acid, 0.1% N-1-naphthalenediamine (NEED), 1% sulphanilamide, 5% in phosphoric acid and distilled water. To accomplish the test, 100  $\mu$ L of 10% homogenate supernatant made with potassium phosphate buffer was added to 100  $\mu$ L of Griess reagent. Regarding the control, 100  $\mu$ L of the reagent was added to 100  $\mu$ L of buffer and series of dilutions were prepared to construct the standard curve (100, 50, 25, 12.5, 6.25, 3.12, 1.56  $\mu$ m) of NO concentration. The test was performed in a 96 well-plate template and absorbance was read at 560 nm.<sup>18</sup>

### Data analysis

The Shapiro-Wilk and Levene tests were used to test the normality and variability of data, respectively. One-way ANOVA test was applied to compare baseline data between the procedures, and repeated measures ANOVA was used for analysis of heart rate and blood pressure measurements. Data are expressed in mean and standard deviation. Statistical significance was set at 0.05. Analyses were performed using the InStat software (GraphPADInStat, San Diego, CA, USA) version 3.0.

### Results

Subjects had normal glucose and cholesterol levels, and controlled BP despite being diagnosed with hypertension. Before the two experimental procedures, participants had similar values of HR and BP at rest, as well as plasma MDA and NO levels (Table 1). Analyses of the 24-hour recall questionnaires revealed an average consumption of 298  $\pm$  67 mg of antioxidants and 135  $\pm$  49 mg of caffeine.

There was no statistical difference in HR at any time between both procedures as shown in Figure 2, and the intensity of exercise was similar in both occasions. Ratings of perceived exertion reported by the subjects were 11-14 on Borg scale. However, participants exercised at an intensity that was lower than that requested by the investigators. On the GTE day, the minimum mean intensity reached by hypertensive patients was 27.8  $\pm$  12.6% of the HR<sub>max</sub> at 10 minutes, whereas the maximum was 52.3  $\pm$  12.2% at 60 minutes, with a mean between the minimum and the maximum of 39.8  $\pm$  8.7% of the HR<sub>max</sub>. On PLE day, the minimum mean intensity was 29.2  $\pm$  14.1%

at 10 minutes and the maximum was  $50.2 \pm 18.9\%$  at 60 minutes, with an average of  $38.0 \pm 7.0\%$  of the HRmax.

BP response to exercise can be seen in Figure 3. On PLE day, there was a significant decrease in post-exercise systolic BP as compared with the rest period. On the other hand, in the GTE procedure, significant PEH occurred only at 20 and 40 minutes post exercise ( $p = 0.02$  and  $p = 0.03$ , respectively). The magnitude of PEH was statistically higher on PLE day at 10 to 30 minutes as compared with those on GTE ( $p = 0.03$  for both), indicating a significant PEH inhibition promoted by the ingestion of green tea.

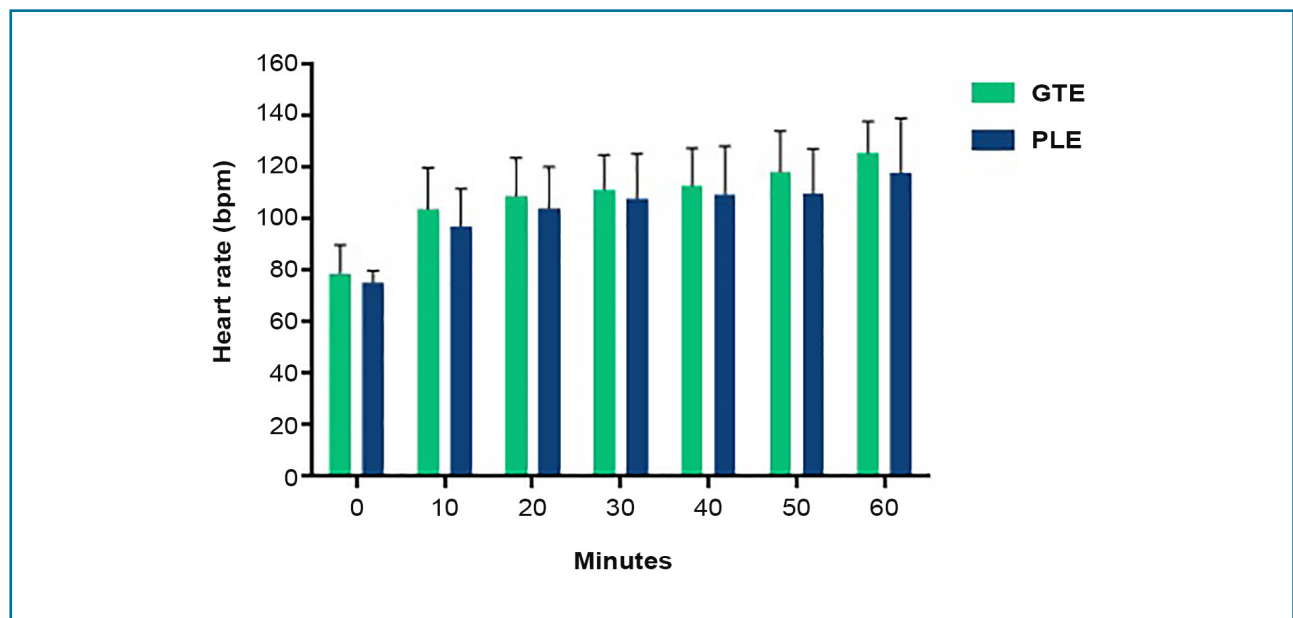
Diastolic PEH occurred only on PLE day, and was significant at 20 minutes of recovery ( $p = 0.04$ ). The ingestion of green tea caused a post-exercise hypertensive response, unlike the PLE experiment. (Figure 3). However, no statistical differences were found between diastolic values post-PLE and post-GTE.

The effects of MDA and NO are presented in Figure 4. There was a subtle, but not relevant reduction in MDA values between pre- and post-exercise conditions in both procedures. Similarly, no changes were observed in NO concentration in response to exercise or to green tea ingestion.

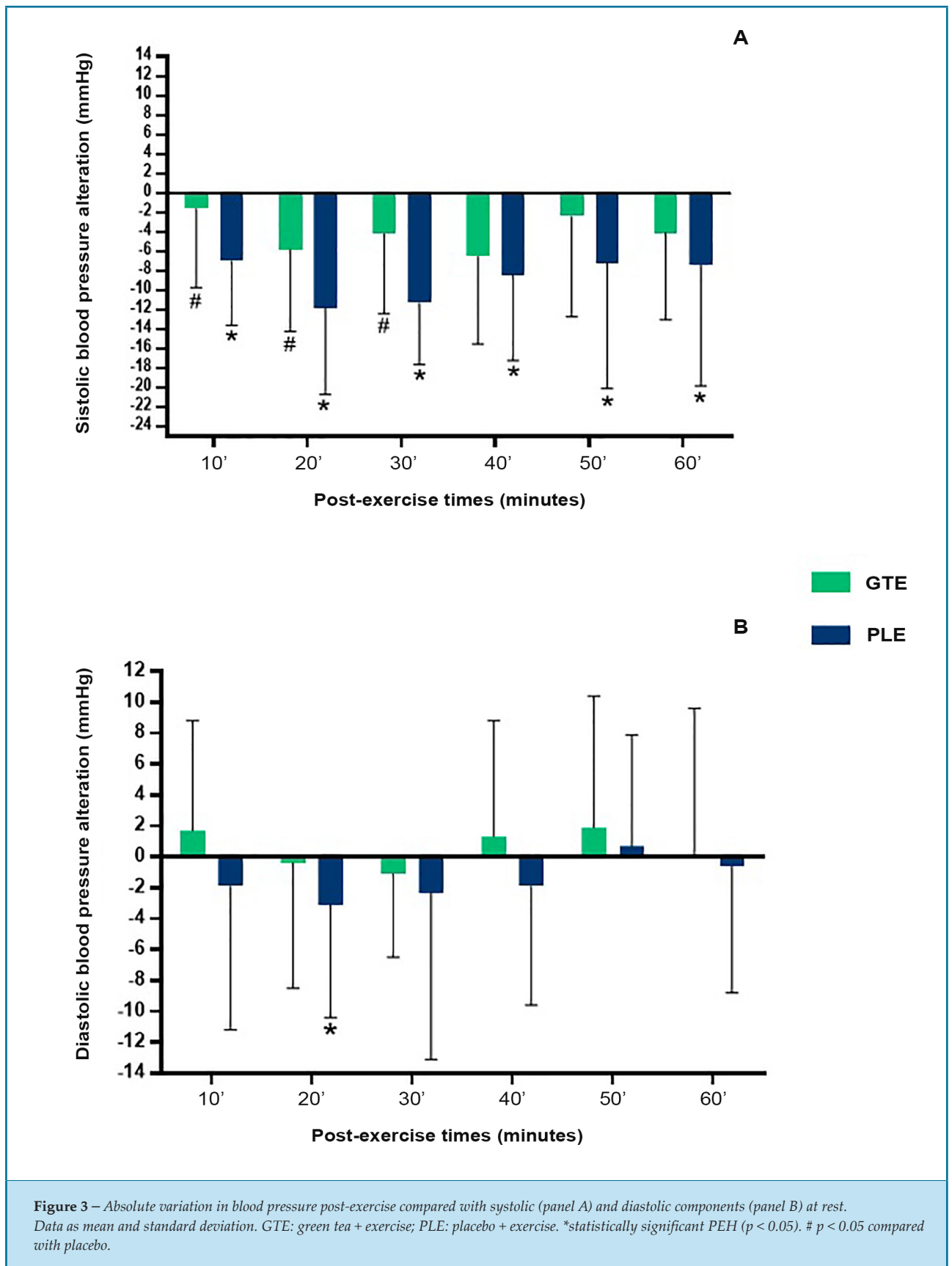
**Table 1 – Baseline anthropometric, hemodynamic and biochemical data of participants**

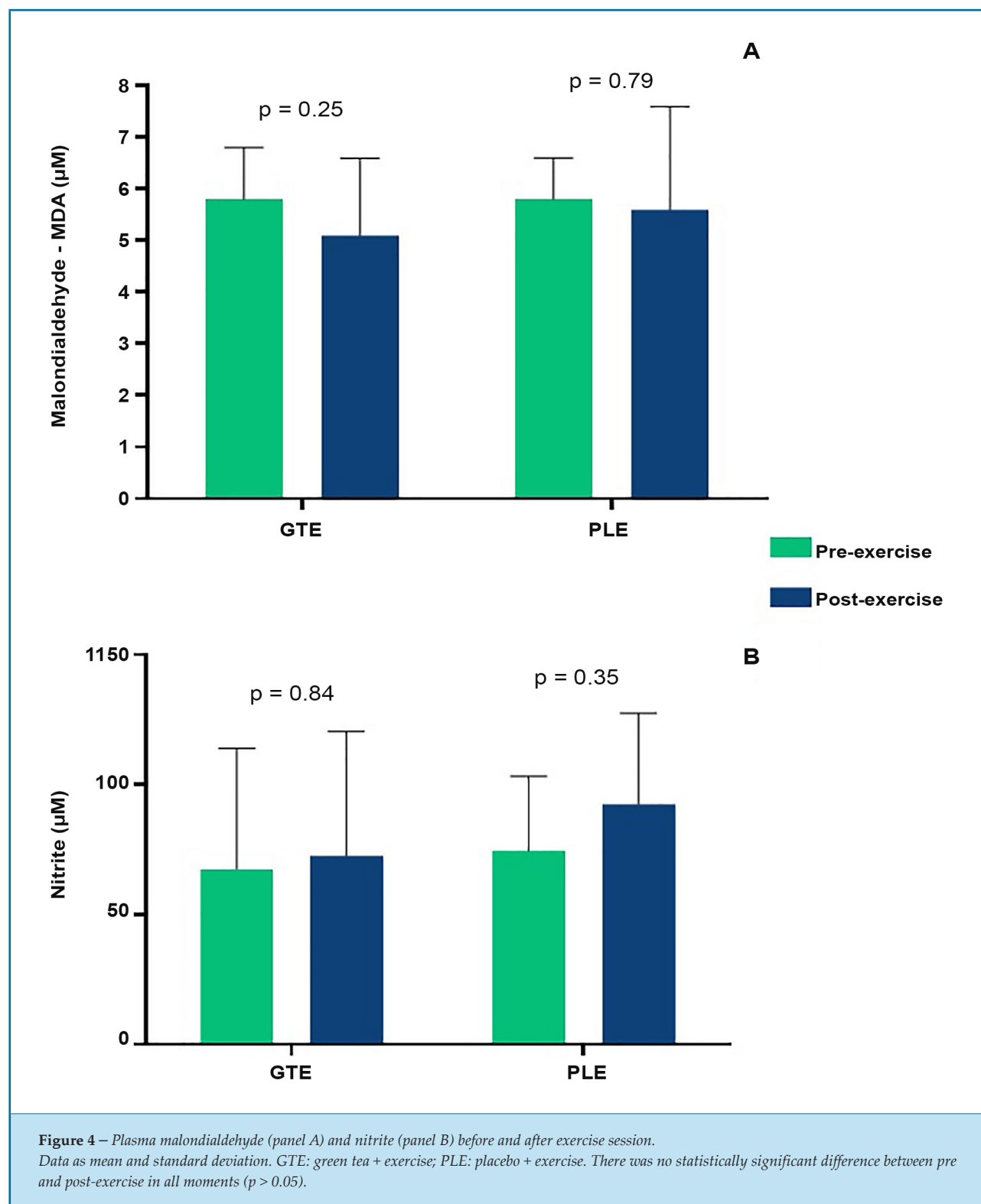
Variable	GTE	PLE	p values
HRR (bpm)	$79.2 \pm 10.8$	$75.5 \pm 4.6$	0.23
SBPR (mm/Hg)	$117.6 \pm 10.0$	$118.1 \pm 12.6$	0.90
DBPR (mm/Hg)	$79.3 \pm 7.8$	$79.2 \pm 8.4$	0.97
BMI (kg/m <sup>2</sup> )		$28.7 \pm 7.6$	
Glucose (mg/dl)		$96.6 \pm 20.6$	
Total cholesterol (mg/dl)		$171.1 \pm 43.9$	
HDL (mg/dl)		$44.3 \pm 16.0$	
Triglycerides (mg/dl)		$191.8 \pm 73.6$	
Malondialdehyde (μM)		$5.8 \pm 1.0$	
Nitrite (μM)		$67.7 \pm 43.5$	

*HRR: heart rate at rest; SBPR: systolic blood pressure at rest; DBPR: diastolic blood pressure at rest; BMI: body mass index; GTE: green tea + exercise; PLE: placebo + exercise; HDL: high density lipoprotein. Data as mean and standard deviation.*



**Figure 2 – Heart rate response to exercise and green tea or placebo intake.** Data as mean and standard deviation. No statistically significant difference was observed between procedures ( $p > 0.05$ ). GTE: green tea + exercise; PLE: placebo + exercise.





## Discussion

Data presented in this study showed that the ingestion of green tea significantly inhibited systolic hypotension

and promoted a subtle hypertensive diastolic response after a session of aerobic exercise in middle-aged hypertensive patients.

Previous studies of Bogdanski et al.<sup>19</sup> and Mozaffari-Khosravi et al.<sup>20</sup> showed that treatment with 379 mg of green tea for three months and 3 g for four months, respectively, resulted in decreased BP in hypertensive adults. This benefits of green tea are attributed to its high content of antioxidants and anti-inflammatory catechins.<sup>15,19,21</sup> Nonetheless, this data may not reflect the effects of a single dose of green tea administration neither in BP nor in antioxidant activity in response to a session of physical exercise. Belza et al.<sup>22</sup> found that a single dose of green tea (500 mg) did not cause significant effects on the blood pressure response of young adults. The study, however, did not include physical exercise in its protocol.

In addition, a single dose of green tea would not be enough to promote an antioxidant activity that could potentiate the PEH. On the other hand, it is known that the vasoconstrictor effects of caffeine occur soon after intestinal absorption, reaching its maximal bloodstream concentration in 15 to 120 minutes after ingestion.<sup>23</sup> This is reinforced by previous studies showing that intravenous,<sup>24</sup> oral<sup>4</sup> administration of caffeine and even coffee intake<sup>5</sup> promoted a hypertensive response after sessions of aerobic exercises. Therefore, in spite of the various substances present in green tea, we may suggest that caffeine contained in green tea was responsible for the attenuating effect on PEH and the hypertensive diastolic response observed in this study.

As far as we know, this was the first study to investigate the effects of green tea ingestion on post-exercise BP response. Arazi et al.<sup>25</sup> supplemented hypertensive women for three weeks prior to the intervention with resistance exercise. The authors showed no changes in PEH, except in mean arterial pressure immediately and 15 minutes after the exercise session. Comparisons between these results with ours are inadequate because these authors worked with chronic supplementation and resistance exercise, while we investigated a single dose of green tea and aerobic exercise.

Practical implication of these findings is that it is common for people to use green tea in their diets. This type of tea is one of the most popular drinks in the world.<sup>26</sup> Thus, hypertensive consumers must be instructed to avoid the ingestion of green tea prior, during or after exercise sessions. However, since this is the first study to demonstrate that green tea ingestion affects BP response to exercise, it is prudent that further studies be undertaken to confirm the presence of other influential factors, as well as green tea dose-dependent effects and duration of the effects.

The following aspects should be considered in future studies: first, it is still necessary to know how long before or after exercise the ingestion of green tea could affect the PEH. Our results suggest a 30 minute-period before exercise. Second, our study did not determine the duration of green tea effects on post-exercise BP. To clarify this point, further studies should include a longer BP monitoring period after exercise than that we used in the present study (60 minutes). Third, other dosages of green tea should be tested, to analyze whether doses lower than 2 g (used in this study) would prevent the post-exercise hypertensive phenomenon. Finally, since the subjects of this study were not regular users of green tea prior to the study, we cannot affirm that attenuation in PEH in response to 2 g of green tea intake would also be observed in regular consumers.

## Conclusion

Data obtained from this study showed that 2 g of green tea supplementation prior to a session of aerobic exercises decreases the magnitude of post-exercise systolic hypotension and promotes a diastolic hypertensive response after exercise in middle-aged hypertensive patients.

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## Author contributions

Conception and design of the research: Silva AS. Acquisition of data: Miranda Neto M, Silva TF, Lima FF. Analysis and interpretation of the data: Miranda Neto M, Silva RSB, Silva TF, Lima FF, Silva AS. Statistical analysis: Miranda Neto M, Silva TF, Lima FF, Silva AS. Obtaining financing: Silva TF, Silva AS. Writing of the manuscript: Miranda Neto M, Silva RSB, Silva TF, Lima FF, Silva AS. Critical revision of the manuscript for intellectual content: Miranda Neto M, Silva RSB, Silva TF, Lima FF, Silva AS.

## Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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## Study Association

This study is not associated with any thesis or dissertation work.

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