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EFFECT OF GREEN TEA (CAMELLIA SINENSIS) CONSUMPTION ON THE COMPONENTS OF METABOLIC SYNDROME IN ELDERLY

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Abstract: *Objective:* To evaluate the effect of the consumption of green tea on components of MS in the elderly. *Design:* Intervention study. *Setting:* The sample was selected from the Geriatric Service of Hospital São Lucas of Pontifical Catholic University of Rio Grande do Sul. *Participants:* 45 elderly with MS were enrolled and allocated into two groups: green tea group (GTG, n= 24), who drank green tea and control group (CG, n= 21) without intervention. *Intervention:* The GTG received sachets of 1.0 g of green tea, and should drink three cups per day for 60 days and the CG was instructed not to make changes in their lifestyle. *Measurements:* The diagnostic criteria for MS used were the International Diabetes Federation. The lipidic and glycemic profile, and anthropometric measurements were evaluated before and after intervention. *Results:* There was a statistically significant weight loss only in GTG [71.5±12.6 kg to 70.3±12.6 kg ($p<0.001$)]. A statistically significant decrease in BMI [-0.5±0.4 kg/m^2 in GTG and -0.2±0.6 kg/m^2 in CG ($P=0.032$)] and waist circumference [-2.2±2.0 cm in GTG and - 0.3±1.8 cm in CG ($P=0.002$)] were observed. The intake of green tea did not change the biochemical parameters. *Conclusion:* The consumption of green tea was effective in inducing weight loss, reducing BMI and waist circumference in the elderly with MS.

Key words: Camellia sinensis, green tea, metabolic syndrome, elderly, anthropometric, parameters.

Introduction

In studies on functional foods, the plant Camellia sinensis has been substantially investigated due to its specific content of flavonoids, which confer numerous therapeutics properties. Green tea, due to the way it is processed, is rich in catechins and is therefore considered in Chinese traditional medicine as an important resource in the prevention of cardiovascular disease (CVD) and other chronic diseases (1). Thus, green tea has been the target of various studies, which have demonstrated antioxidant and anticarcinogenic effects and efficacy in weight loss and protection against CVD, possibly related to epigallocatechin gallate 47(EGCG), the main catechin in the tea (2-4). Metabolic syndrome (MS) is a complex disorder represented by several changes of metabolic origin, representing one of the major challenges for health public in all the world by being associated with the important risk for cardiovascular disease and type 2 diabetes mellitus (DM2) (1, 5). Investigations in Asian populations, particularly Chinese, demonstrate that the daily consumption of green tea can be associated with the decrease in risk factors for cardiovascular diseases, suggesting a protective effect of the tea on health (2). In this context, the aim of the present study was to determine the possible beneficial effects of the intake of green tea as part of a regular diet, by modulating the components of MS in an elderly population.

Methods

Population and Sample

This study was conducted in the Outpatient Clinic of the Geriatric Service of Hospital São Lucas of Pontifical Catholic University of Rio Grande do Sul (PUCRS). Forty-five patients with a diagnosis of MS were selected. The research was approved by the Committee of Ethics in Research of PUCRS (protocol 09/04858), and signed informed consent was obtained from all participants. The criteria utilized for inclusion of the patients were: 60 years or older and diagnosed with MS in accordance with diagnostic criteria proposed by the International Diabetes Federation (IDF) (6). The following were excluded from the study: hypertensive individuals with uncontrolled blood pressure; individuals with hypothyroidism, renal insufficiency, hepatic disease, or alteration in the dose of lipid-lowering drugs, anti- hypertensive and blood sugar regulating medications in the preceding three months; individuals with a medical diagnosis of dementia, according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV); and individuals who drank green tea regularly.

Design of the Study and Intervention

The study was a controlled and randomized research. The individuals were recruited from November 2009 to March 2010. Randomization was done through a 1 by 1 drawing, utilizing a table of numbers in a random sequence, where the sample allocated into two groups: green tea group (GTG) and control group (CG). The participants of the green tea group (n = 24) received sachets of 1.0 g of tea, because it is a form of consumption that can be incorporated in the usual diet. Afterwards, they were instructed to prepare the tea in a cup, adding 200 ml of hot water, but not boiling (approximately 70 °C), onto the sachet, allowing infusion for 5 min. The participants were asked to drink three cups of tea per day, an

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hour before or after meals, and it was suggested that first dose be taken after breakfast, the second after lunch and the third after the afternoon meal or before dinner, for 60 consecutive days. The participants of both groups were instructed not to make changes in their lifestyle, maintaining their usual diet and physical activity, which was monitored by means of a questionnaire administered in three evaluations performed during the intervention period: at the beginning of the study and after 30 and 90 days. To determine the percentage of adherence of the participants in GTG with regard to the consumption of green tea, they were requested to return the sachets that happen to left over and not consumed during the intervention period.

Nutritional Evaluation

The usual food intake of the participants of this study was evaluated based on the responses obtained in a food frequency questionnaire (FFQ), at the beginning of the study (7). Weight and height were determined using a Welmy calibrated digital balance, and with an anthropometric ruler. The participants were assessed dressed in hospital gown and barefoot, positioned in the center of the platform of the balance, with arms extended and standing straight. BMI was calculated throught Quetelet Index. The assessment followed the cutoff points for the classification of the nutritional status of elderly individuals, recommended by Lipschitz (8). Waist circumference (WC) was measured with a nonelastic metric tape, at the midpoint between the last rib and iliac crest, with the individual standing and breathing normally, taking care not to squeeze the skin. The values obtained were compared with the cutoff points proposed by IDF (6). Those with WC over 90 cm, in the case of men, and over 80 cm, for women, were characterized as having abdominal obesity (centripetal type) (6).

Arterial Pressure

Blood pressure (BP) was measured using an aneroid sphygmomanometer, based on the auscultatory technique, by a trained professional. Those with BP ≥ 130/85 mmHg or in treatment were considered hypertensive pacients (6).

Biochemical Examinations

For biochemical examinations of total cholesterol, HDL, LDL, triglycerides and fasting glucose, venous blood samples were drawn after 12 h fasting, on the first day of the intervention and after study period (60 days), for comparison of the results. The biochemical assays were performed with serum of the elderly patients by spectrophotometry in the semi-automated biochemical analyzer TP Analyzer Basic – Thermo Plate. The biochemical tests were carried out with Labtest® kits: total cholesterol– enzymatic system by endpoint reaction; cholesterol HDL – system of selective precipitation of the low and very low density (LDL and VLDL) lipoproteins by endpoint reaction; glucose – enzymatic system by endpoint reaction; triglycerides – enzymatic system by endpoint reaction. LDL was determined by the Friedewald equation for individuals with TG < 400 mg/dL (9). The cutoff points used to glucose, HDL and TG were according to IDF (6).

Statistical Analysis

The databank was structured in Access and later analyzed in SPSS, version 17.0. The quantitative variables with symmetric distribution were analyzed using means and standard deviations and those with asymmetric distribution by median and interquartile range. The qualitative variables were described by absolute and relative frequencies. Student's t test for independent samples was utilized for comparison of the means of the outcome variables before the intervention and of their differences (before and after) between the groups. Student's t test for paired samples was utilized in the comparison of the variables before and after, in each group. Pearson's chi-squared test or Fisher's exact test were utilized for the comparison of the qualitative variables between the groups. Multiple linear regression was used to determine possible confounding effects. Associations were considered significant at the 5% probability level ($P \leq 0.05$).

Results

The demographic and lifestyle characteristics of the participants are presented in Table 1, and none of the variables investigated showed significant difference between the groups. The nutritional analyses, presented in Table 2, demonstrate that there was no statistically significant difference between the two groups related to daily intake of energy and macronutrients, cholesterol and dietary fiber. In relation to micronutrients intake, we just observed a statistically significant difference between the groups with regard to vitamin B6 intake (GTG= 1.79 ± 0.65 mg/CG= 1.42 ± 0.41 mg; p=0.030). For the anthropometric parameters, BMI and waist circumference showed significant differences between the groups after intervention with green tea, as shown in Table 3. A decrease in weight of 1.2kg was observed (p<0.001) in GTG, which was reflected in a significant difference in BMI (p=0.032) between the groups in the post-intervention period. In the control group, there was also weight loss after the study period, but it was not substantial. With regard to waist circumference, there was a reduction of -2.2±2.0 cm (p<0.001) in GTG, but the same did not occur in the control group, which showed a reduction of -0.3±1.8 cm (p=0.487). Therefore, the difference between the groups was statistically significant (p=0.002) after intervention. Multivariate linear regression analysis showed that the decrease in waist circumference, corrected for ingestion of vitamin B6 was dependent on the intervention with green tea (p= 0.004). The same result was obtained for BMI (p=0.034) when adjusted for the ingestion of vitamin B6. After the intervention period with green tea, the difference in systolic and diastolic pressure between the groups was not statistically significant (p=0.654 and 148 p=0.260). The comparisons of the biochemical parameters between groups are presented in Table 4.

Table 1
Demographic characteristics and lifestyle of elderly with metabolic syndrome observed at a geriatric outpatient clinic

Variable	Total n (%)	Group GTG n (%)	Group CG n (%)	P
Sex				0.153
Female	38 (84.4)	22 (91.7)	16 (76.2)	
Male	07 (15.6)	02 (8.3)	05 (23.8)	
Age range				0.262
60-69	14 (31.1)	09 (37.5)	05 (23.8)	
70-79	22 (48.9)	09 (37.5)	13 (61.9)	
≥ 80	09 (20)	06 (25.0)	03 (14.3)	
Ethnicity				0.551
White	37 (82.2)	20 (83.3)	17 (81)	
Not white	08 (17.8)	04 (16.7)	04 (19)	
Marital status				0.920
Married	22 (48.9)	11 (45.8)	11 (52.4)	
Single	06 (13.3)	03 (12.5)	03 (14.3)	
Separated	04 (8.9)	02 (8.3)	02 (9.5)	
Widowed	13 (28.9)	08 (33.4)	05 (23.8)	
Schooling (in years)				0.562
0-4	18 (40.0)	11 (45.8)	07 (33.3)	
5-8	17 (37.8)	09 (37.5)	08 (38.1)	
≥9	10 (22.2)	04 (16.7)	06 (28.6)	
Family income (minimal salary units)				0.388
0-2	13 (28.9)	05 (20.8)	08 (38.1)	
2-3	19 (42.2)	12 (50.0)	07 (33.3)	
≥3	13 (28.9)	07 (29.2)	06 (28.6)	
Smoking				0.636
Smoker	01 (2.2)	01 (4.2)	0	
Non-smoker	29 (64.4)	15 (62.5)	14 (66.7)	
Ex-smokier	15 (33.3)	08 (33.3)	07 (33.3)	
Alcohol consumption				0.739
Yes	16 (35.6)	8 (33.3)	8 (38.1)	
No	29 (64.4)	16 (66.7)	13 (61.9)	

P = chi-squared test.

Table 2
Description of the mean daily intake of energy and macronutrients, cholesterol and dietary fiber in elderly with metabolic syndrome before intervention with green tea

Macronutrient	Group GTG mean±sd n = 24	Group CG mean±sd n = 21	P
Total energy ** (kcal/day)	1531 ± 431	1601 ± 331	0,553
Carbohydrates (% of TEI)	53.2 ± 5.62	53.3 ± 5.21	0.948
Protein (% of TEI)	18.1 ± 4.02	17.9 ± 3.27	0.830
Fats (% of TEI)	28.7 ± 4.30	28.8 ± 5.33	0.927
Saturated fats (g)	13.6 ± 3.83	14.9 ± 3.09	0.197
Polyunsaturated fats (g)	10.2 ± 2.88	9.75 ± 1.95	0.542
Monounsaturated fats (g)	15.3 ± 4.31	16.9 ± 3.20	0.165
Cholesterol (mg)*	172 (121 – 200)	173 (127 – 210)	0.964
Fiber (g)	17.3 ± 4.93	16.51 ± 5.68	0.642

TEI= total energy intake; GTG=green tea group; CG=Group control; sd=standard deviation; P = Student's t test; * described by median (25th – 75th percentiles); ** AI = adequate intake.

Table 3
Description of the anthropometric and physiologic characteristics of elderly with metabolic syndrome before and after intervention with green tea

Variable	Group GTG mean±sd n = 24	Group CG mean±sd n = 21	P
Weight (kg)			
Before	71.5±12.6	74.4±11.6	0.429
After	70.3±12.6	73.9±11.2	
P	< 0.001	0.181	
Difference	-1.2± 0.9	-0.5± 1.6	0.073
BMI (kg/m^2)			
Before	30.5±4.3	30.4±4.5	0.920
After	30.0±4.4	30.2±4.6	
P	< 0.001	0.241	
Difference	-0.5±0.4	-0.2±0.6	0.032
Waist circumference (cm)			
Before	99.0±12.8	98.8±8.1	0.952
After	96.8±13.0	98.5±8.2	
P	< 0.001	0.487	
Difference	-2.2±2.0	-0.3±1.8	0.002
Systolic pressure (mmHg)			
Before	126.7±12.7	137.6±11.8	0.005
After	123.7±9.7	132.9±9.0	
P	0.347	0.096	
Difference	-2.9±14.9	-4.8±12.5	0.654
Diastolic pressure (mmHg)			
Before	76.2±9.2	82.9±12.7	0.056
After	73.3±6.3	76.2±7.4	
P	0.129	0.023	
Difference	-2.9±9.1	-6.7±12.4	0.260

P = Student's t test.

Table 4
Description of the biochemical parameters of elderly with metabolic syndrome before and after intervention with green tea

Variable	Group GTG mean±sd n = 24	Group CG mean±sd n = 21	P
Glucose (mmol/l)			
Before	6.8±2.6	6.4±1.1	0.490
After	6.6±1.7	6.5±1.3	
P	0.493	0.870	
Difference	-0.2±1.6	0.03±1.1	0.522
Total Cholesterol (mmol/l)			
Before	11.1±3.1	10.8±1.9	0.753
After	10.6.±2.3	10.0±1.7	
P	0.247	0.043	
Difference	-0.5±1.9	-0.8±1.7	0.530
Cholesterol,LDL (mmol/l)			
Before	6.5±3.1	6.6±1.6	0.928
After	6.1±2.2	5.9±1.5	
P	0.382	0.074	
Difference	-0.3±1.9	-0.7±1.6	0.544
Cholesterol,HDL (mmol/l)			
Before	2.5±0.4	2.6±0.6	0.862
After	2.4±0.5	2.5±0.8	

P	0.077	0.830	
Difference	-0.1±0.4	-0.02±0.4	0.306
Triglycerides (mmol/l)			
Before	10.1±3.7	8.4±2.7	0.096
After	10.2±3.7	7.7±2.9	
P	0.791	0.110	
Difference	0.1±2.3	-0.7±1.9	0.200

P = Student's t test.

Discussion

We describe the effects of the consumption of green tea, as part of the usual diet, in the modulation of the components of MS in an elderly Brazilian sample.

The results obtained in this study suggest that the consumption of green tea for a period of two months had some beneficial effects in MS, specifically reducing weight, BMI, and waist circumference, as demonstrated earlier in other studies involving humans (10-12). The control of obesity is a factor of great importance in the treatment of the individual with MS. The presence of MS alone cannot predict the global risk of cardiovascular disease, but abdominal obesity (the more predominant manifestation of MS) is a marker of "dysfunctional adipose tissue", where it is of fundamental importance in the clinical diagnosis (13). Marin et al. (14) demonstrated that abdominal or visceral obesity has a strong correlation with metabolic alterations and arterial pressure, where it is highly associated with insulin resistance (IR) and hypertriglyceridemia. Visceral deposits of triglycerides can turnover fatty acids faster than other regions, increasing the availability of free fatty acids in the portal system, stimulating gluconeogenesis and inhibiting hepatic depuration of insulin, which contributes to elevated glycemia, insulinemia and IR.

One of the possible mechanisms of action of green tea in relation to induction of weight loss would be the activation of thermogenesis by the capacity of polyphenols, such as the catechins and their metabolites, of inhibiting catechol-O-methyltransferase (COMT) (15).

In an epidemiological study involving 1103 adults, Wu et al. (12) investigated if regular consumption of teas originating from Camellia sinensis (green, oolong and black tea) could modify the percentage distribution of total body fat in humans. Those who drank tea regularly were found to have a lower percentage of body fat and waist-hip ratio. In general, persons who drank tea regularly for more than 10 years with a daily intake of approximately 435 ml (about two cups), showed a 19.6% reduction in body fat and 2.1% reduction in waist-hip ratio, when compared to those who did not consume tea on a regular basis, revealing that the regular consumption of tea for a long period can influence fat metabolism and can show an inverse relation with the percentage and distribution of body fat in men and women. According to the authors, lipolysis was modulated by the counterregulatory action of insulin and catecholamine. The lipolytic activity induced by catecholamine was greater in visceral fat, compared with subcutaneous peripheral fat, indicating that the consumption of tea can cause healthy weight loss.

The majority of studies that investigated the effects of green tea on the weight utilized the beverage or capsules enriched with catechins (mainly EGCG), obtaining results similar to those of this study. Aimed at investigating the influence of the consumption of catechins on the reduction of body fat, Tsuchida et al. (16) conducted a double-blind study for 12 weeks, with 80 individuals of both sexes who were overweight. The participants ingested a beverage containing 588 mg (catechin group) or 126 mg (control group) catechins. The area of abdominal fat was measured before and after intervention by computed tomography and blood parameters by biochemical assays. The parameters of body fat in the catechin group were significantly lower at the end of the study period, with better results than in the control group. Besides, the ingestion of catechins reduced the area of abdominal fat in males and of subcutaneous fat in females. There was no significant difference in hematological parameters between the groups.

Nagao et al. (17) published a double-blind randomized study in Japanese men and women with visceral obesity. The individuals were divided into two groups, an intervention group receiving 583 mg catechins and a control group given 96 mg catechins per day. The 240 participants maintained regular eating habits and normal physical activity. In the intervention group, there was a greater reduction in weight, BMI, level of body fat, waist and hip circumference, area of visceral fat and area of subcutaneous fat.

These findings suggest that the catechins in tea not only cause weight loss but also affect fat distribution. Based on this hypothesis and with the objective of better understanding the effects of catechins on fat cells, Lin et al. (18) conducted an in vitro study, incubating pre- adipocytes and mature adipocytes for different times and concentrations of EGCG. The results showed that the catechin inhibited adipogenesis and caused apoptosis in mature fat cells. Additionally, EGCG inhibited in dose-dependent manner the accumulation of lipids in pre-adipocytes. These results showed that this catechin can act directly by inhibiting the differentiation of pre-adipocytes and inducing apoptosis in mature adipocytes, reinforcing its importance as an adjuvant in the treatment of obesity.

Some findings, although still controversial, indicate the possibility that catechins in green tea cause weight loss not only through its thermogenic effect and stimulation of the sympathetic nervous system but also through its capacity to decrease appetite, due to the interaction of EGCG with leptin receptors, causing an increase in satiety (19, 20).

There was no significant decrease in the biochemical parameters after intervention with green tea (green tea group). Our findings are in line with those of Santana et al. (21) who recently studied the consumption of green tea and soy for 90 days and did not see any improvement in the lipid profile in the individuals who ingested green tea or soy alone, but did observe an improvement in the group that consumed soy

combined with green tea. Other 220investigators also did not find any association between the consumption of green tea and improvement in lipid levels (1, 22).

The review of the literature indicated that in 13 epidemiological studies that involved the consumption of green tea to confirm its hypocholesterolemic effect, only four showed a significant reduction in the lipid profile (23). It is important to mention that in the present study, the green tea were included in the diet for a short period of time, in a natural form and not in a concentrated form, such as dried extracts of the plant (capsules), where no effect on the levels of biochemical markers was observed.

These findings shows that green tea may have a specific role in the decrease in weight and abdominal fat, raising the hypothesis that this effect may occur through of the increase in thermogenesis, or the diminution of energy intake, due to the decrease in appetite and increase in satiety, and also decrease in the size and number of adipocytes, and not in the direct modulation of biochemical parameters, such as glucose, triglycerides, total cholesterol, HDL cholesterol, and LDL cholesterol. Therefore, a longer study period after the reduction in weight and abdominal fat may be necessary, to green tea can interfere with glucose and lipid metabolism. Considering that individuals with MS are in a chronic state of "metabolic chaos," the task of bringing these biochemical parameters back to normal is very complex, because it involves the interaction of hormonal, genetic, and inflammatory factors and the variable age (aging). However, to confirm the hypothesis that green tea acts in the suppression of appetite and increase in satiety, further investigations would be necessary. Regarding the effects of green tea on blood pressure, we did not find statistically changes. Surprisingly, we observed a significant reduction of diastolic blood pressure (DBP), and total cholesterol among the control group, despite these individuals did not show a decrease in the body composition parameters, and our advise to maintain the habitual dietetic pattern, physical activity pattern, and drug therapy.

However, the present study showed some limitations, particularly the following: a) the absence of chemical analyses to determine the level of polyphenols in the green tea utilized; b) not administering FFQ after intervention with green tea, which could make it possible to resolve the question of its potential effect in the reduction of energy intake, inferring a decrease in appetite; and c) the impossibility of administering a placebo in the group control, since there is no substance that could mimic green tea in flavor and texture and that would be metabolically inert. Despite the limitations of study our results can be important for elucidating the complex relationships involving the interaction between dietary habits and MS.

In summary, the consumption of green tea was found to be effective in reducing weight, BMI and waist circumference in the elderly with MS, but did not modulate any of the biochemical parameters examined.

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