# THE EFFECTS OF GREEN TEA SUPPLEMENTATION IN SUBJECTS WITH METABOLIC SYNDROME IN OKLAHOMA

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TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AER | Albumin excretion rate |
| ATP III | Adult Treatment Panel III |
| BF% | Body fat percentage |
| BIA | Bioelectrical impedance analysis |
| BMI | Body mass index |
| BUN | Blood, urea, nitrogen |
| CVD | Cardiovascular disease |
| DBP | Diastolic blood pressure |
| DNA | Deoxyribonucleic acid |
| DEXA | Dual-energy x-ray absorbtiometry |
| $D_2O$ | Deuterium oxide dilution |
| EC | Epicatechin |
| ECG | Epicatechin gallate |
| EE | Energy expenditure |
| EGC | Epigallocatechin |
| EGCG | Epigallocatechin gallate |
| FFA | Free fatty acid |
| FFM | Fat-free mass |

| | |
|---|---|
| FM | Fat mass |
| Hb | Hemoglobin |
| $HbA_{1c}$ | Hemoglobin $A_{1c}$ |
| HDL-C | High-density lipoprotein cholesterol |
| HOMA-IR | Homeostasis model assessment- insulin resistance |
| HUVEC | Human umbilical vein endothelial cells |
| IFG | Impaired fasting glucose |
| IGT | Impaired glucose tolerance |
| IRB | Institutional Review Board |
| LDL-C | Low-density lipoprotein cholesterol |
| MetS | Metabolic syndrome |
| NCEP | National Cholesterol Education Program |
| NGT | Normal glucose tolerance |
| NO | Nitric oxide |
| OGTT | Oral glucose tolerance test |
| OUHSC | University of Oklahoma Health Sciences Center |
| OUMC | University of Oklahoma Medical Center |
| REE | Resting energy expenditure |
| RQ | Respiratory quotient |
| SBP | Systolic blood pressure |
| SFA | Skinfold anthropometry |
| TSH | Thyroid stimulating hormone |
| WBC | White blood cell |

| | |
|---|---|
| WC | Waist circumference |
| WHO | World Health Organization |
| WHR | Waist-to-hip ratio |

# CHAPTER I

# INTRODUCTION

Metabolic Syndrome (MetS), a constellation of risk factors including dyslipidemia, hypertension, central adiposity, and impaired fasting glucose, is increasing at an alarming rate in the United States (1,2). It is estimated that over 47 million Americans meet the criteria for the metabolic syndrome (3). Current statistics reveal 26.8 percent of adult Oklahomans are categorized as obese (body mass index >30), with Oklahoma ranking as the ninth most obese state in the country (4). Overweight and obesity are positively correlated with the incidence of type 2 diabetes, high blood pressure, asthma, arthritis, and overall poor health status (5). To combat obesity, Americans seek alternative strategies, such as nonprescription dietary supplements (6), fad diets (7), holistic approaches, and phytotherapy involving soy (8) and supplements such as green tea (9). Although it is an ideal practice to increase physical activity and adopt healthy eating habits to prevent obesity, keeping in view their increasing use, alternative nutritional therapies for better health must be investigated.

## Green Tea and Composition

Green tea, or non-fermented tea, is rich in polyphenolic flavonoids, primarily catechins. Although processing and preparation affect the catechin content of green tea

leaves, epigallocatechin gallate (EGCG) is generally the most abundant catechin (49-55%), followed by epigallocatechin (EGC) (9-12%), epicatechin gallate (ECG) (9-12%) and epicatechin (EC) (5-7%) (10). Recently reported data from the Ohsaki study, which included 40,530 Japanese adults who were followed up for up to 11 years (1995-2005), showed an inverse association between green tea consumption and mortality due to all causes and cardiovascular disease (11). Habitual green tea intake of 120 mL or more per day for 1 year was significantly correlated with a risk reduction of developing hypertension in Chinese population, compared to nonhabitual tea drinkers (12). Most of these observational studies have been conducted in China and Japan where green tea is part of traditional diet, in contrast to western countries where it is limited and sporadic.

## Role of Green Tea in Human Subjects and Animal Models

Green tea, or its active compound EGCG, has been widely used in weight loss diets, and has been shown to reduce adipocyte differentiation and proliferation, lipogenesis, fat mass and body weight, and to increase beta-oxidation and thermogenesis (13). In vitro studies with EGCG have also shown a direct inhibition of gastric and pancreatic lipases and stimulation of thermogenesis, via inhibition of enzymatic degradation of noradrenalin, thus suggesting the mechanisms underlying these effects (14). While limited clinical trials have shown the anti-obesity effects of green tea extracts or EGCG (15-17), its effects on body weight and body fat composition in subjects with MetS needs further investigation.

Green tea has also been shown to affect lipid and glucose metabolism in rodents (19, 20) and in blood pressure in normotensive men (21). Murase and colleagues (18)

tested the effects of green tea catechins, on diet-induced obese mice over 11 months. Catechin supplementation (0.2 and 0.5% w/w) reduced the high-fat diet-induced body weight gain, visceral and liver fat accumulation, and the development of hyperinsulinemia, and hyperleptinemia, when compared to mice consuming high-fat diets without catechin supplementation. These data suggest that long-term consumption of tea catechins may be beneficial to counteract diet-induced obesity and obesity-related complications in humans.

Administration of 130mg of powdered green tea per day in male Zucker rats, fed a high-fat diet containing 15% butter and 50% sucrose, was also shown to produce hypocholesterolemic effects as well as a decrease in body weight gain and adiposity (19). EGCG administration was also shown to exert antidiabetic effects and down-regulate genes involved in gluconeogenesis, and the synthesis of fatty acids, triacylglycerol and cholesterol in rodents (20).

While studying the effects of green tea on blood pressure, Hodgson et al. (21) rejected their initial hypothesis that tea consumption (caffeinated) would cause a decrease in blood pressure in normotensive men. An acute increase in blood pressure with green and black tea (4 cups) versus caffeine alone was noted. The study also examined the effects of green and black tea consumption (5 cups/day for 7 days) on 24 hour ambulatory blood pressure versus caffeine alone, and no significant changes were detected. Additional research is needed to determine the effects of decaffeinated green tea and green tea supplements on blood pressure, and lipid and glucose metabolism in humans.

## Study Objectives

Since most of the current research on health benefits of green tea and EGCG has been performed in animal models, in Asian populations and healthy overweight subjects, there exists a need for investigation in "at risk" US adults, consuming a typical western diet. Thus, the purpose of this 2-month study was to compare the effects of decaffeinated green tea beverage and EGCG supplementation on body weight, body fat composition, blood pressure, blood glucose, and lipid levels in subjects with MetS in urban Oklahoma. We also aimed to study any differences on these variables of interest as a result of catechin supplementation from green tea beverage versus green tea extract containing EGCG, thus addressing the research gap between whole food versus dietary supplement.

## Hypotheses

1) Daily consumption of green tea beverage or EGCG supplements will have no significant effect on anthropometric measures in participants with MetS.

2) Daily consumption of green tea beverage or EGCG supplements will have no significant effect on glucose and lipid parameters in participants with MetS.

3) Daily consumption of green tea beverage or EGCG supplements will have no significant effect on dietary intake in participants with MetS.

# CHAPTER II

# REVIEW OF LITERATURE

There exists a need for alternative methods to improve lipid levels in the blood, central adiposity, blood pressure and blood glucose levels, factors intertwined in the definition of MetS.

## Metabolic Syndrome (MetS)

Although the underlying idea of MetS was identified as early as 1923 by Kylin (22) and in 1988 by Reaven (23), the term was not introduced until 2001 by the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III). The term, metabolic syndrome, was coined in response to the increased prevalence of obesity in the United States. According to NCEP ATP III, a person may be classified with this syndrome if three or more of the following features are present: waist circumference $\geq$40 inches in men and $\geq$35 inches in women, triglycerides $\geq$150 mg/dl or drug treatment for elevated triglycerides, high-density lipoprotein cholesterol (HDL-C) <40 mg/dl in men and <50 mg/dl in women or treatment for HDL-C, systolic blood pressure (SBP) $\geq$130 mmHg or diastolic blood pressure (DBP) $\geq$85 mmHg or drug treatment for hypertension, and fasting glucose $\geq$100 mg/dl or drug treatment for elevated glucose (24).

Since first introduced, the definition of MetS has caused controversy among different scientific realms, such as the World Health Organization (WHO) and ATP III. Grundy (2006) stated the classification of MetS as a means to unify the cardiovascular and diabetes worlds in an effort to decrease the risks associated with both conditions. The risk of development of atherosclerotic cardiovascular disease (CVD) and diabetes is increased when MetS is identified (1). Isomaa et al. (25) utilized the definition proposed by WHO (different than ATP III guidelines) to analyze the cardiovascular risk associated with MetS of subjects (n=4,483) participating in the Botnia Study. The components used to define MetS included hypertension (systolic >150 mmHg or diastolic >90 mmHg) or anti-hypertensive treatment, dyslipidemia (plasma triglyceride $\geq$1.7 mmol/l and/or HDL <0.9 mmol/l in men, <1.0 mmol/l in women, obesity (body mass index (BMI) $\geq$30 kg/$m^2$ and/or waist-to-hip ratio of >0.9 in men and >0.85 in women), and microalbuminuria (urinary albumin excretion rate (AER) $\geq$20 µg/min). The subjects were given an oral glucose tolerance test (OGTT), and were categorized based on those results: normal glucose tolerance (NGT), impaired fasting glucose/impaired glucose tolerance (IFG/IGT), and type 2 diabetes. The three groups were defined as follows: NGT, fasting plasma glucose <6.1 mmol/l and 2-h plasma glucose <7.8 mmol/l, IFG/IGT, fasting plasma glucose 6.1-6.9 mmol/l and/or 2-h plasma glucose 7.8-11.0 mmol/l, and type 2 diabetes, fasting plasma glucose $\geq$ 7.0 mmol/l and/or 2-h plasma glucose $\geq$ 11.1 mmol/l. Subjects with type 2 diabetes or IFG/IGT only had to meet two of the criteria, while the NGT had to meet 2 criteria and be insulin resistant. In women and men with IFG/IGT, 42 and 64% were classified with MetS, while 78 and 84% with type 2 diabetes were also classified, respectively. Subjects with the syndrome were three times as likely to develop

coronary heart disease and stroke, when compared to those without the syndrome. Subjects identified with thesyndrome demonstrated a significant increased risk of cardiovascular mortality (12.0%, $p<0.001$) when compared to those without the syndrome (2.2%).

Resnick and colleagues (26) examined insulin resistance, MetS, and risk of CVD in American Indians without diabetes (n=2,283). Unlike the previous study by Isomaa et al. (25), the researchers assessed the presence of MetS with the definition set forth by ATP III, and insulin resistance was determined with the homeostasis model assessment (HOMA). Thirty five percent of the participants met the criteria for MetS, and development of CVD was evident in 7.9% of total subjects during the follow-up period of $7.9 \pm 1.8$ yrs. The results indicated that participants with CVD were older, male, and had a higher systolic pressure. Rates of development of type 2 diabetes in participants with and without CVD after baseline were comparable. Mean baseline of HOMA-IR and MetS as a percentage were also similar among the two groups. Although the researchers concluded that HOMA-IR and MetS were both good indicators of the development of diabetes, neither one could predict CVD independently of other established risk factors. The investigators attributed this weak association with inadequate power, low occurrence of CVD in American Indians, small effect of insulin resistance on CVD risk factors (other than HDL). CVD, as a complication/risk of diabetes may also help to explain the weak relationship, since the sample included only non-diabetics at baseline (26).

The San Antonio Heart Study, conducted by Lorenzo et al. (27), compared two definitions (a modified version of the 1999 WHO versus ATP III) of MetS, and impaired glucose tolerance (IGT), to determine which was a better predictor of type 2 diabetes.

This epidemiological study (n=1,734), included measurements taken at baseline and at a follow-up time between 7 and 8 years. There was a higher sensitivity among the IGT and NCEP definition, in terms of predicting type 2 diabetes. The two definitions also had a lower positive predictive value, when compared to IGT. In conclusion, the NCEP definition proved to be a better predictor than the modified WHO definition. When the fasting glucose cutoff was lowered to 5.4 mmol/l (94 mg/dl) in the NCEP definition of MetS, an even more effective method of prediction of diabetes was demonstrated.

## Green Tea in Human Health- Observational Studies

Green tea is derived from leaves of *Camellia sinensis*. Green tea is non-fermented and is rich polyphenols. Catechins are the primary source of polyphenols in green tea, with EGCG being the most predominant (48-55%), followed by EGC and ECG (both 9-12%), and then EC 5-7% (10). Epidemiological studies in Asian countries have revealed that green tea may reduce the risk of death due to CVD and associated risk factors (11, 28). The Ohsaki National Health Insurance Cohort Study, was conducted with 40,540 Japanese adults, to explore the relationships between green tea consumption and mortality due to all causes and cause-specific (11). Participants were followed for up to 11 years for all-cause mortality and up to 7 years for cause-specific mortality. Men and women were grouped separately and by daily green tea consumption, <1, 1-2, 3-4, and $\geq$ 5 cups/d. There was an inverse relationship between green tea consumption and cardiovascular mortality and all-cause mortality, with the strongest being all-cause mortality. The consumption of green tea and stroke mortality yielded the strongest inverse relationship among the different types of CVD. Although increased green tea

consumption was associated with decreased mortality in these two areas, there was no reduction in mortality due to cancer.

Another epidemiological investigation, conducted by Wu et al. (28), observed the relationship between habitual tea consumption, body fat percentage, and body fat distribution (n=1210) in a sample of Chinese males and females. Subjects were categorized as either habitual tea drinkers (at least 1 cup/wk for at least six months) or nonhabitual tea drinkers. Additional lifestyle characteristics were also obtained from the subjects through structured questionnaires. Bioelectrical impedance analysis (BIA) was used as a tool to measure body fat percentage (BF%) and waist-to-hip ratio (WHR) was used to assess body fat distribution. Of the sample, approximately 43% were habitual tea drinkers. The habitual tea drinkers were more likely to be male, current smokers, and habitual alcohol or coffee drinkers. The breakdown of socioeconomic status (high versus low) was similar for both groups, as well as age, BMI and diabetes history. Although many of the measures collected from this study grouped oolong, green, and black teas together, there was evidence to suggest an inverse relationship between habitual tea consumption, BF%, and body fat distribution, even more so for those who consumed tea regularly for more than ten years. This suggests that tea could be used to decrease and redistribute body fat, which could be beneficial in those with increased risk for CVD and diabetes, with central adiposity and obesity.

### Green Tea, Body Weight, Body Fat, and Clinical Parameters- Clinical Trials

As the American population continues to see a dramatic spike in obesity and obesity-related diseases, the investigation of alternative treatments is crucial. The

potential medicinal properties of green tea have initiated many clinical trials (15,29-33). Green tea supplementation was recently tested for its effect on weight maintenance in moderately obese subjects who had already achieved mild weight loss (15). The subjects were first assigned to a very low energy diet for four weeks to achieve weight loss. The subjects were classified as either low caffeine or high caffeine consumers, and they were treated daily with either a green tea mixture of 270 mg EGCG and 150 mg caffeine, or placebo. Those receiving the green tea mixture, who consumed low levels of caffeine, experienced a significantly smaller amount of weight regain, when compared to the low-caffeine placebo group and high-caffeine tea group. The low-caffeine consuming green tea group also had smaller increases in body mass, BMI, waist circumference (WC), and fat mass (FM), which was attributed to an increase in resting energy expenditure (REE). The concentrations of triacylglycerol and insulin were also the lowest for this group during the period of weight maintenance, while B-hydroxybutyrate, glycerol, and free fatty acids (FFAs) were increased, when compared to the other groups. This study proposes that the intake of a green tea caffeine mixture, along with a low caffeine diet, may help weight maintenance, through thermogenesis and oxidation.

The thermogenic effects of green tea were also observed by Dulloo et al. (29). For this study, 10 healthy men were randomly assigned to one of three treatment groups, green tea extract (50 mg caffeine and 90 mg EGCG), caffeine (50 mg), and placebo, on three separate occasions. The participants were measured for 24-h energy expenditure (EE), respiratory quotient (RQ), and urinary excretion of nitrogen and catecholamines, in a respiratory chamber. When compared to those who received placebo, a significant increase in 24-h EE and a significant decrease in RQ were observed in the green tea

extract group. Those treated with caffeine exhibited no change in EE or RQ. This study suggests that green tea contains thermogenic properties greater than those of caffeine alone. Additional research is needed to investigate long term changes in EE with the consumption of green tea, and decaffeinated green tea.

Henning et al. (30) compared the flavonol absorption and activity in plasma 8 h after a bolus dose of green tea, black tea, or green tea extract supplement was administered to 30 healthy subjects. This crossover study revealed that absorption was best in the subjects who consumed green tea as a supplement, and there was increased bioavailability of the catechins when compared to the green and black tea groups. This produced a small but significant increase in the antioxidant capacity. The outcomes of this study support the use of green tea supplements, as a possible equivalent source of green tea catechins as the beverage.

### Green Tea, Glucose, and Lipids- Clinical Trials

Maron et al. (31) investigated the cholesterol lowering effects of a theaflavin-enriched green tea extract on 240 adult men and women in China through a 12-week randomized controlled trial. Subjects had mild to moderate hypercholesterolemia, based on low-density lipoprotein cholesterol (LDL-C) 130-190 mg/dL, and were on a low-fat diet. They were randomized to receive either a green tea extract capsule or placebo during the intervention period. From baseline, serum total cholesterol and LDL-C decreased by 11.3% and 16.4%, respectively, for the green tea extract group ($p<0.01$). Although not significant, an increase in high-density lipoprotein cholesterol (HDL-C) was observed in the extract group (+2.3%) compared to controls (-0.7%). This study

demonstrated that a theaflavin-enriched green tea extract may be used in conjunction with a low-fat diet to reduce LDL-C in subjects with mild to moderate hypercholesterolemia. Similarly, Erba et al. (32) found similar results after green tea supplementation (2 cups/d) for 42 days (n=24). Diet was controlled throughout the study. There was a moderate but significant decrease in LDL-C (119.9 to 106.6 mg/dL, $p<0.05$), when compared to controls. A significant increase in plasma total antioxidant activity, a significant decrease in plasma peroxides levels, and induced DNA oxidative damage in lymphocytes was also detected in the green tea group.

A study conducted in Japan by Tsuneki et al. (33), tested the effects of green tea on glucose metabolism in healthy humans. The participants ingested 1.5 g of green tea and then underwent an OGTT. Glucose tolerance was improved with the ingestion of green tea, when compared to the group that received hot water.

The effects of green tea supplementation on insulin resistance and inflammation were studied by Fukino et al. (34). Subjects were randomized to either the polyphenol supplemented group or placebo (n=66). After the two month intervention period, the polyphenol group had lower body weight, BMI, systolic and diastolic blood pressures, blood glucose level, $HbA_{1c}$, insulin level and HOMA index than baseline values. However, there was no significant difference in change between the intervention group and placebo at the end of the study. Ryu et al. (35) also tested the effects of a four-week green tea intervention on patients with type 2 diabetes (n=55). Measurements included arterial stiffness, insulin resistance, blood glucose, lipid profiles, serum adiponectin levels, interleukin-6, and C - reactive protein. All parameters remained unchanged,

suggesting additional research is needed to establish mechanisms within the body that provide health benefits after supplementation with green tea.

### Green Tea, Glucose Metabolism, and Lipid Profiles- Animal Studies

Tsuneki et al. (33) tested the effects of green tea on glucose metabolism in diabetic mice. In mice, blood glucose levels were significantly lower 2-6 hours after the green tea was dispensed orally. There was a distinguishable difference in lowering of blood glucose in the same fasting diabetic mice 2 hours after the green tea powder suspension was dispensed, while no significant changes were noted in their normal counterparts. This study proposed the idea that green tea may exert anti-diabetic effects, and suggested the need for further investigation of serum proteins, which could play a pivotal role in this mechanism.

Another study also supported the findings that EGCG could be supplemented in the prevention and treatment of type 2 diabetes, after positive results were yielded from the addition of EGCG in rodent models of type 2 diabetes and H4IIE rat hepatoma cells (20). Powdered green tea as an antilipogenic agent was also tested in male Zucker rats (19). The rats were administered 130 mg powdered green tea, along with a high-fat diet. The rats in the powdered green tea group increased their body weight, at a much slower rate than the controls. Food consumption between the groups was recorded, and no differences were noted. A reduction in weight of adipose organs by about 5-9% was also observed, and liver weight decreased by 11%. In the plasma of the green tea fed Zucker rats, there was a slightly elevated triglyceride level, a significantly higher total protein, and a significantly lower total cholesterol, in comparison to the control rats. In the liver of these rats, there was a significant increase in triglyceride level, as well as a slight

increase in total lipid level, while total cholesterol remained unaffected. Although the decrease in total cholesterol may have been affected by the cholesterol-free diet, powdered green tea proved to have hypocholesterolemic and antilipogenic effects, suggesting that the powder could be a practical method used for the prevention of obesity and in preserving healthy tissues and organs.

Research by Murase et al. (18) also supports the claim that tea catechins are responsible for weight loss on diet-induced obese mice through the stimulation of lipid catabolism in the liver. For this particular study, mice were fed one of three diets, low-fat, high-fat, or high-fat diet supplemented with tea catechins (of which 74% was identified as EGCG) for a period of 11 months. The mice receiving 0.2 and 0.5% catechins showed a noticeably lower rate of weight gain. The mice receiving the supplementation also exhibited lower visceral and liver fat accumulation, which could be attributed to the stimulation of hepatic lipid metabolism. The results indicate that supplementation with green tea catechins may be beneficial for those with diet-induced obesity, which could therefore reduce the risk of obesity related diseases, such as CVD and type 2 diabetes.

## In Vitro Studies

Persson et al. (36) examined the relationship between tea and angiotensin-converting enzyme (ACE) and nitric oxide (NO). The study used cultured endothelial cells from human umbilical veins (HUVEC) and incubated them for ten minutes with green tea, black tea, and Rooibos tea. For green tea and black tea, there was a significant and dose-dependent inhibition of ACE activity in the cells, while the Rooibos tea yielded no significant effects. Cells were also incubated with EC, EGC, ECG and EGCG for ten

minutes. All four tea catechins inhibited ACE activity. NO production was significantly increased when the cells were incubated similarly for 24 hours. This study supports the cardioprotective benefits of green tea on endothelial cells.

Kanadzu et al. (37) examined the dual function of EGCG as an antioxidant and pro-oxidant in healthy human lymphocytes. The results indicated that bleomycin induced deoxyribonucleic acid (DNA) strand breakage was suppressed at concentrations between $10^{-8}$ to $10^{-5}$M, while it was promoted at a concentration of $10^{-3}$M. Although the whole blood lymphocytes were obtained from a healthy, non-smoking 26 year old male, differences in cell function from person to person must be considered. With this in mind, the study still supports the dual-role of EGCG as both an antioxidant and pro-oxidant in human lymphocytes.

## Body Fat Testing

To monitor possible changes in body composition, different methods may be used, such as BIA, DEXA, and underwater weighing. The National Institute of Health released a technological statement about the use of BIA as a means for use in body composition measurement (38). It was determined that BIA is a practical method to obtain body composition because it is straightforward, noninvasive, quick, and cost-effective. Its use is suggested in healthy individuals, mild-to moderately obese individuals, and those with an array of chronic conditions (except for those that may affect water distribution in the body). The article suggests that a 1 cm displacement of electrodes can result in a 2% change in resistance, which must be taken into consideration when assessing the changes in body fat of multiple subjects over time. Additional factors

that may affect the measurement include, hydration, body position, food and/or beverage intake, recent physical activity, and length of time body is in supine position.

Kushner et al. (39) validated the use of BIA in obese female subjects (n=12) with changes in body composition during weight reduction. Of the 12 subjects, nine were placed on very-low-calorie diets (520 kcal/day), with or without supplemental snacks, while the remaining three were given a balanced hypocaloric diet (1000-1200 kcal/day). The subject's body composition was measured after an overnight fast at baseline and at decrements of body weight of approximately 5%. Total body water was determined by deuterium oxide dilution ($D_2O$), and BIA and seven-site skinfold anthropometry (SFA) were used to estimate body composition. The body composition analyzer used for this study utilized a four-surface electrode placement with subjects in the supine position with limbs apart. BIA and SFA were measured in triplicate, and the means were recorded. Significant correlations were obtained between $D_2O$ and BIA (r=0.971) and between D2O and SFA (r=0.932). The greater accuracy and precision made BIA a better predictor of fat-free mass (FFM) than SFA. The authors of this publication stressed two major limitations in the using BIA to predict FFM: the equations used to calculate FFM, which were population specific, and the assumed hydration constant of FFM.

The Bodystat 1500, which is the machine used in this study to determine BF%, was used by Ghosh et al. (40) to compare its measurements with an in-house bioelectrical analysis machine and DEXA. The study concluded that the Bodystat 1500 was an inexpensive and effective tool to perform BIA. Conversely, this study was performed in non-obese and thin adults, unlike the population of our study (40). The Bodystat 1500 has been used in numerous populations, which include, but are not limited to chronic

obstructive pulmonary disease patients and a vast array of surgical patients (41,42). Although this is a quick and inexpensive method to determine BF%, additional research is still needed to validate this particular machine in obese subjects.

## 3-Day Food Records

The use of three-day food records is a pivotal measurement used in assessing nutrient intake in free-living subjects (43-45). Although food records have the ability to provide accurate information about the intake of individuals and are generally a cost effective tool, they have been shown to be subject to bias in several forms. For example, subjects do not want to be "judged" on their intake which may either influence them to change their eating habits, lie, or underreport actual intake. Reporting of intake may also be difficult for subjects who are not able to make educated guesses with regards to portion sizes.

Mertz and colleagues (43) examined the use of food records in 266 male and female subjects, who were trained by dietitians to record their daily intake for a minimum of one week. Those who participated in the study were only allowed to consume food and drinks provided by the research center, and meals were also prepared for them for weekend consumption (diets were designed for subjects to maintain body weight. Of the 266 participants, 81% estimated their average daily intake to be about 700 $\pm$ 379 kcal (underestimated), while 8% reported an intake higher than required for maintenance by about 408 $\pm$ 257 (overestimated). A mere 11% estimated their intake within 100 kcal of their actual needs. For the entire sample, there was an underestimation of intake of about 18%.

Another study performed by de Vries et al. (44) also reported similar results. Pre-experimental food records were collected from 269 non-obese subjects and mean reported intake was compared with required intake derived from the 6-9 week trial, where the food records served as a basic guide. Adjustments to increase total caloric value of the meals were made throughout the study, to help the subjects maintain a consistent weight. This indicated a mean underestimation among all subjects of 10.4%, which was nearly half of the underestimation from the Mertz et al. (43). In this particular study women had a greater degree of underreporting than men, but men with a lower BMI underestimated more than their higher BMI counterparts. This was not the case for the women. Researchers eluded that small underestimations of intake (10.4%) could be attributed to the high level of education of the subjects and a small number of obese subjects enrolled in the study. Johnson et al. (45) discovered underreporting of energy intake was more prominent in a sample of older white females (56-81 y) versus older white males (56-78 y). There was also a direct relationship between BF% and underreporting of dietary intake. Therefore, tendencies of underestimation of energy intake must be considered when utilizing 3-day food records as a research tool to gauge specific macro and micronutrient in different populations.

# CHAPTER III

# RESEARCH DESIGN AND METHODS

## Subjects and Recruitment

This randomized clinical trial was jointly approved by the Institutional Review Board (IRB) at University of Oklahoma Health Sciences Center (OUHSC) and Oklahoma State University. Subjects were recruited through flyers and campus e-mail advertisements at GCRC and the Medical Center at University of Oklahoma. An initial telephone screening was performed prior to the screening visit and written informed consent was obtained from all subjects. Twenty seven subjects with MetS were enrolled in the study between January 2007 and 2008. According to the NCEP guidelines (24), MetS was defined as having any three of the following five features: waist circumference ≥102 cm in men and ≥88 cm in women, triglycerides ≥150 mg/dL, HDL <40 mg/dL in men and < 50mg/dL in women, blood pressure ≥130/85 mmHg, fasting glucose ≥100mg/dL. Eligible subjects received a history and physical examination from the physician on staff prior to enrollment. Adult subjects (> 21 years) with normal hemoglobin (Hb), white blood cells (WBC), platelets, liver, renal, and thyroid function tests, and on stable medications were included in the study. Subjects with any form of pre-existing condition (e.g. diabetes, cancer, heart disease), liver or renal disorders, or anemia were excluded. Participants consuming mega doses of antioxidants/fish oil

supplements, and/or alcohol in excess of 1 oz/day, smokers, as well as those pregnant or lactating were also excluded from the study. During the study period, any subjects with deviations from the normal range of Hb, WBC, platelets, liver enzymes, blood urea nitrogen (BUN), creatinine, or thyroid stimulating hormone (TSH) were dismissed.

## Study Design

This eight-week study examined the effects of green tea (4 cups/day), green tea supplement (2 capsules, 500 mg EGCG, 4 cups water/day), or control (4 cups water/day) on features of MetS (systolic and diastolic blood pressure, waist circumference, triglycerides, HDL, and fasting plasma glucose), body fat, hemoglobin $A_{1C}$ ($HbA_{1c}$), and dietary intake in this eight-week, randomized controlled trial. Age- and sex-matched trios of participants with MetS were randomized to one of three groups. The principal investigators were blinded to participant treatment groups, but the participants were not. Fasting blood draws, blood pressure determination, and anthropometrics were performed at screening, four and eight weeks of the study. Fasting blood samples were tested for glucose and lipid profiles, as well as for safety parameters such as, Hb, WBC, platelets, and liver, renal, and thyroid function tests. The subjects also maintained 3-day food records which were turned in bi-weekly at 2, 4, 6, & 8 weeks of the study. While participants in the control and green tea supplement groups came in for follow-up visits at 2, 4, 6, & 8 weeks (including blood draws at 4 & 8 weeks), the green tea group made daily visits to the GCRC for a fresh supply of tea, to ensure compliance and consistency. Subjects in the green tea group consumed 2 cups of green tea in the morning at GCRC and were provided with another 2 cups in a container and asked to consume later in the

day (6-8 hours later). The Bionutrition unit at GCRC, headed by the research dietitian, prepared the green tea for the subjects, monitored compliance, and assisted the subjects in maintaining 3-day food records. Efforts were made by the bionutrition staff to limit interactions, specifically conversation with the green tea beverage group, that could potentially provide an advantage over the green tea supplement and control groups. Those in the control and supplement groups were provided with containers to measure 4 cups of water to be consumed on a daily basis. Participants in the supplement group received a 2-week supply of capsules during their follow-up visits and we confirmed compliance by pill count. All qualified participants were asked to completely refrain from any other source of green tea or supplements other than that provided by the study, and maintain usual diet, physical activity and lifestyle while enrolled in the study. All participants were compensated during their bi-weekly follow-up visits.

## Green Tea and Supplements

Green tea bags were purchased from RC Bigelow Inc.© (Fairfield, CT). Four decaffeinated green tea bags were steeped in 4 cups of boiled water (8 oz/cup) for 10 minutes. No sugar or milk was added to the tea, but artificial sweetener was used according to the preference of the participants. The subjects consumed 2 cups at GCRC while being monitored, and the remaining 2 cups were provided in a container to drink later in the day. Participants were told not to reheat the tea which they consumed later in the day, but to drink it straight from the container. The subjects received 100mg of EGCG per cup of green tea or 400 mg EGCG per day (catechin analyses performed in the Human Nutrition Laboratory, OSU).

Decaffeinated green tea supplements were purchased from Solaray® (Park City, UT). The capsules were manufactured from the same lot numbers of raw materials and the label claimed 500 mg of green tea extract providing 250 mg of EGCG. Other ingredients in the capsule and filler included vegetable cellulose, magnesium stearate and silica. Participants were instructed to take two capsules a day, one capsule with lunch and dinner.

## Anthropometrics

Anthropometric measurements were obtained by trained staff members at the GCRC. Height, weight, blood pressure, WC, and BF% were measured at screening, four, and eight-week visits. Participants removed shoes and items in pockets, and were weighed on a flat, uncarpeted surface with the SECA 644 Multifunctional Hand Rail Scale (SECA, Hamburg, Germany) and recorded to the nearest 0.1 kg. Height was also measured without shoes, utilizing the Accustat Genentech Stadiometer (San Francisco, CA) and recorded to the nearest 0.1 cm. Systolic and diastolic blood pressure was collected in mmHg with Spot Vital Signs Device (Welch Allyn, Skaneateles Falls, NY). Waist circumference was taken from subjects at the superior iliac crest with the Gulick II Tape Measure (Vital Signs, Gay Mills, WI). Body fat percentage was determined through BIA with the Bodystat 1500 (Bodystat Ltd, Isle of Man, Great Britain).

## Biochemical Analyses

Blood samples were collected immediately after each draw at the GCRC and transported to the University of Oklahoma Medical Center (OUMC) Laboratory for

analyses of fasting glucose, lipid profile {total cholesterol, triglycerides, low-density lipoproteins (LDL), HDL}, and safety parameters including hemoglobin (Hb), platelets, WBCs, liver enzymes, creatinine, BUN, and TSH. $HbA_{1C}$ was analyzed at GCRC using DCA 2000+ (Bayer Corporation, Elkhart, IN).

## Dietary Analyses

All subjects were asked to maintain three-day food records throughout the study to monitor dietary changes. At the randomization visit, subjects were given instruction on how to maintain the record, which included visualization of portion sizes. The records were collected at two, four, six, and eight-week visits. Three day averages of micro and macronutrient intakes were analyzed using Nutritionist Pro (version 3.2, 2007, Axxya Systems, Stafford, TX). Reported intake of vitamin and mineral supplements were included in the analysis.

## Statistical Analyses

The data was first graphed to identify outliers and/or errors. The student's t-test for two independent groups was applied to address any differences between groups at baseline. A *P* value of $<0.05$ was considered statistically significant. Initially, the subjects were randomized to trios by age and gender. However, due to imbalance and incompletion within trios, and small sample size, the data was analyzed by group. Changes from zero to eight weeks were assessed within groups with the paired t-test. Two sample t-test was applied to measure changes from zero to eight weeks between groups. Due to sample size, the data was not corrected for multiple hypotheses testing.

Instead, the data was reviewed for consistencies.

# CHAPTER IV

# RESULTS

A total of twenty women and three men with MetS were included in the analysis of this study. Among the 27 subjects enrolled in the study, one withdrew due to relocation, one began lipid lowering medications, and two were found to be smokers. One subject reported emesis at week 7. The incident was reported to the IRB at the University of Oklahoma and the University Research Compliance at Oklahoma State University, and it was determined to be unrelated to the study. No other adverse events reported throughout the study, and compliance was maintained by all research participants.

## Features of MetS

The distribution of the features of MetS among the three groups is illustrated in Figure 4.1. Increased blood pressure and waist circumference and decreased levels of HDL cholesterol were the most common features among the three groups. The least prevalent feature was hyperglycemia; in controls (27%), green tea (14%), and supplement (20%) groups. The distribution of features was similar for controls, green tea, and green tea supplement groups.

## Baseline Characteristics

Baseline characteristics of the three groups, control, green tea, and green tea supplement, are shown in Table 4.1. No statistical differences were found at baseline among the three groups for weight, age, BMI, BF%, WC, SBP, DBP, fasting plasma glucose, $HbA_{1c}$, triglycerides, total cholesterol, and HDL-C. Medication usage among the participants is also included in Table 4.1. This did not include dietary supplements, herbal remedies, or daily aspirin regimens, but did include oral contraceptives and hormone replacement therapies. The most common medications used included ACE-inhibitors, beta-blockers, and calcium-channel blockers. Medications commonly prescribed for the use in depression and other mental disorders were also popular forms of treatment.

## Anthropometric Indexes and Blood Pressure Changes

Changes in anthropometric indexes and blood pressure measurements from baseline to eight weeks are depicted in Table 4.2. The change in weight and BMI were significantly lower in the green tea group ($p<0.05$), when compared to the controls. Weight decreased by an average of 2.5 kg and BMI by 0.9. The supplement group lost 1.3 kg and BMI decreased by 0.4, which was not significant, but exhibited a similar decrease in trend as the green tea group, compared to the controls. Over the study period, there was a decrease in DBP in the green tea group of 4.7 mmHg. This was not significant when compared to the controls ($p<0.1$). No statistically significant differences were found among the three groups for BF%, WC, SBP, and DBP.

### Fasting Plasma Glucose, Lipid Levels, and $HbA_{1c}$ Changes

Fasting plasma glucose, lipid levels, and $HbA_{1c}$ at baseline and eight weeks are represented in Table 4.3. There were no significant differences among the three groups for these parameters at baseline. For the green tea group, there was a slight increase in HDL (0.9 mg/dL; $p<0.1$), when compared to the controls. No statistically significant changes were observed for fasting plasma glucose, $HbA_{1c}$, triglycerides, LDL-C, and total cholesterol.

### 3-Day Food Records

Three-day mean intakes were calculated by group, at baseline and eight weeks. The changes are represented in Table 4.4. At baseline, there was a statistically significant difference ($p<0.05$) in protein and vitamin A intakes between the supplement group and controls (85g and 69 g of proteins, and 2301 IU and 4309 IU of vitamin A, respectively). There was a significant difference in change at 8 weeks for the green tea group for carbohydrate intake (+67 g), when compared to the controls (-31.2 g). Although not significant, there was a difference in change at eight weeks in mean kilocalorie intake ($p<0.1$) between green tea (+425 kcal) and control (-178 kcal) groups. No other significant dietary changes between the three treatment groups were observed.

### Catechin Content of Green Tea Beverage and Supplement

The catechin content of the green tea beverage and supplement is represented in Table 4.5. The catechin content of the green tea beverage displayed is per cup, and

subjects consumed four cups daily. For the green tea supplement, content was analyzed per capsule, and daily dosage was two capsules.

# TABLES

**Table 4.1 Baseline characteristics of all study participants by treatment group.**

| Variables | Control (n=11) | | | GT (n=7) | | | GS (n=5) | | |
|---|---|---|---|---|---|---|---|---|---|
| Female | 10 | | | 6 | | | 4 | | |
| Male | 1 | | | 1 | | | 1 | | |
| Weight (kg) | 104.6 | ± | 6.9 | 108.6 | ± | 4.4 | 116.5 | ± | 8.3 |
| Mean age (y) | 44.6 | ± | 3.5 | 44.1 | ± | 3.2 | 40 | ± | 2.1 |
| BMI ($kg/m^2$) | 37.4 | ± | 2.8 | 38.6 | ± | 1.5 | 41.5 | ± | 2.1 |
| Body fat (%) | 45.7 | ± | 3.1 | 46.5 | ± | 3.1 | 47.7 | ± | 2.2 |
| Waist circumference (in) | 43 | ± | 2 | 44.2 | ± | 1 | 49.7 | ± | 3.7 |
| Systolic blood pressure (mmHg) | 129.5 | ± | 2.8 | 135.6 | ± | 5.9 | 127.4 | ± | 6.4 |
| Diastolic blood pressure (mmHg) | 78.7 | ± | 2.1 | 83.7 | ± | 3.5 | 80.8 | ± | 2.7 |
| Fasting plasma glucose (mg/dL) | 88.2 | ± | 4.1 | 84.7 | ± | 4.9 | 85 | ± | 5.3 |
| $HbA_{1c}$ (%) | 5.6 | ± | 0.1 | 5.5 | ± | 0.1 | 5.4 | ± | 0.3 |
| Triglycerides (mg/dL) | 121.5 | ± | 21.5 | 176.9 | ± | 42 | 148.4 | ± | 38.4 |
| Total cholesterol (mg/dL) | 207.7 | ± | 10.6 | 194.3 | ± | 17.3 | 164.8 | ± | 22.7 |
| LDL-cholesterol (mg/dL) | 141.1 | ± | 9.7 | 124 | ± | 17.6 | 99.4 | ± | 17.7 |
| HDL-cholesterol (mg/dL) | 42.5 | ± | 1.9 | 41.4 | ± | 2.9 | 35.6 | ± | 3.2 |
| Medication users (%) | 45.4 | | | 85.7 | | | 60 | | |

**Values represented as mean±standard error.**
**No statistically significant differences between groups ($p > 0.05$).**
**GT- Green tea group, GS- Green tea supplement group, BMI- Body mass index, $HbA_{1c}$- Hemoglobin $A_{1c}$, LDL- Low-density lipoprotein, HDL- High density lipoprotein**

**Table 4.2 Changes in anthropometric indexes and blood pressure measurements from zero to eight weeks in green tea beverage and supplement groups, compared to control group.**

| Variables | Week | Control (n=11) | GT (n=7) | GS (n=5) |
|---|---|---|---|---|
| Weight (kg) | 0 | 104.6 ± 6.9 | 108.6 ± 4.4 | 116.5 ± 8.3 |
| | 8 | 105.2 ± 6.9 | 106.1 ± 4 | 115.2 ± 7.7 |
| | Δ | | -2.5 ± 1.2* | |
| BMI (kg/m$^2$) | 0 | 37.4 ± 2.8 | 38.6 ± 1.5 | 41.5 ± 2.1 |
| | 8 | 37.6 ± 2.8 | 37.7 ± 1.4 | 41 ± 2 |
| | Δ | | -0.9 ± 0.4* | |
| Body fat (%) | 0 | 45.7 ± 3.1 | 46.5 ± 3.1 | 47.7 ± 2.2 |
| | 8 | 45.7 ± 3.4 | 46.2 ± 2.6 | 47.5 ± 2 |
| Waist | 0 | 43 ± 2 | 44.2 ± 1 | 49.7 ± 3.7 |
| circumference (in) | 8 | 42.7 ± 1.8 | 45.2 ± 1.5 | 48.3 ± 3 |
| Systolic blood | 0 | 129.5 ± 2.8 | 135.6 ± 5.9 | 127.4 ± 6.4 |
| pressure (mmHg) | 8 | 128 ± 2.8 | 126.3 ± 5.3 | 128 ± 3.8 |
| Diastolic blood | 0 | 78.7 ± 2.1 | 83.7 ± 3.5 | 80.8 ± 2.7 |
| pressure (mmHg) | 8 | 80.2 ± 2.8 | 79 ± 3.7 | 81.6 ± 3.9 |

**Values represented as mean±standard error.**
***Changes at 8 weeks significantly different from control (p<0.05).**
**GT- Green tea group, GS- Green tea supplement group, BMI- Body mass index**

**Table 4.3 Changes in fasting glucose, lipids, & HbA1C from zero to eight weeks in green tea beverage and supplement groups, compared to control group.**

| Variables | Week | Control (n=11) | GT (n=7) | GS (n=5) |
|---|---|---|---|---|
| Glucose | | | | |
| (mg/dL) | 0 | 88.2 ± 4.1 | 84.7 ± 4.9 | 85.0 ± 5.3 |
| | 8 | 82.5 ± 3.0 | 87.9 ± 3.3 | 76.2 ± 11.0 |
| $HbA_{lc}$ (%) | 0 | 5.6 ± 0.1 | 5.5 ± 0.1 | 5.4 ± 0.3 |
| | 8 | 5.5 ± 0.1 | 5.6 ± 0.2 | 5.4 ± 0.3 |
| Triglycerides | 0 | 121.5 ± 21.5 | 176.9 ± 42.0 | 148.4 ± 38.4 |
| (mg/dL) | 8 | 116.5 ± 20.5 | 174.4 ± 40.6 | 151.4 ± 36.1 |
| Total | | | | |
| cholesterol | 0 | 207.7 ± 10.6 | 194.3 ± 17.3 | 164.8 ± 22.7 |
| (mg/dL) | 8 | 208.5 ± 9.1 | 199.1 ± 15.7 | 165.0 ± 14.5 |
| LDL- | | | | |
| cholesterol | 0 | 141.1 ± 9.7 | 124.0 ± 17.6 | 99.4 ± 17.7 |
| (mg/dL) | 8 | 144.3 ± 7.5 | 122.0 ± 13.1 | 98.6 ± 13.7 |
| HDL- | | | | |
| cholesterol | 0 | 42.5 ± 1.9 | 41.4 ± 2.9 | 35.6 ± 3.2 |
| (mg/dL) | 8 | 41.1 ± 1.6 | 42.3 ± 3.5 | 36.2 ± 4.1 |

**Values represented as mean±standard error.**
**No statistically significant differences between groups (p> 0.05).**
**GT- Green tea group, GS- Green tea supplement group, HbA1c – Hemoglobin A1C, LDL-low density lipoprotein, HDL- high-density lipoprotein**

**Table 4.4 Changes in dietary intake from zero to eight weeks in green tea beverage and supplement groups, compared to control group.**

| Variables | Week | Control (n=11) | | | GT (n=7) | | | GS (n=5) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Kilocalories | 0 | 1838.8 | ± | 144 | 1724.4 | ± | 162.2 | 2034.6 | ± | 301.7 |
| | 8 | 1660.5 | ± | 109 | 2148.9 | ± | 249.1 | 1995.2 | ± | 469.1 |
| Protein (g) | 0 | 68.8 | ± | 3.6 | 78.4 | ± | 5.3 | 85.4 | ± | 4.6* |
| | 8 | 70.5 | ± | 5.2 | 86.4 | ± | 8 | 72.5 | ± | 12.7 |
| Carbohydrate (g) | 0 | 220 | ± | 22.3 | 198.7 | ± | 15.7 | 218.9 | ± | 35.2 |
| | 8 | 188.9 | ± | 15.4 | 266 | ± | 31.9 | 242.2 | ± | 67.9 |
| | Δ | | | | 67.4 | ± | 37.8† | | | |
| Total Fat (g) | 0 | 78.3 | ± | 7 | 72.9 | ± | 9.6 | 92.1 | ± | 19.5 |
| | 8 | 67.3 | ± | 4.4 | 85.5 | ± | 12.5 | 84.7 | ± | 18.6 |
| Cholesterol (mg) | 0 | 239.6 | ± | 45 | 209 | ± | 28 | 291 | ± | 25.5 |
| | 8 | 256.4 | ± | 38.1 | 240.9 | ± | 51.2 | 293.9 | ± | 112.5 |
| Saturated fat (g) | 0 | 24.7 | ± | 3 | 23.5 | ± | 1.7 | 33.9 | ± | 10 |
| | 8 | 23 | ± | 2 | 28.9 | ± | 4.7 | 31.1 | ± | 9.3 |
| Monounsaturated fat (g) | 0 | 17.7 | ± | 1.7 | 16.4 | ± | 2.8 | 24.8 | ± | 5.9 |
| | 8 | 16.1 | ± | 1.9 | 20.9 | ± | 4.2 | 15.1 | ± | 3.9 |
| Polyunsaturated fat (g) | 0 | 10.7 | ± | 1 | 9.7 | ± | 2 | 13.4 | ± | 3.2 |
| | 8 | 9.9 | ± | 1.2 | 12.3 | ± | 2.2 | 7.9 | ± | 2 |
| Trans fat (g) | 0 | 1.8 | ± | 0.5 | 0.8 | ± | 0.3 | 1.9 | ± | 1 |
| | 8 | 1.5 | ± | 0.4 | 2.2 | ± | 0.5 | 2.3 | ± | 1.1 |
| Vitamin A (IU) | 0 | 4309.2 | ± | 543 | 4251.9 | ± | 849.9 | 2301.3 | ± | 484.0* |
| | 8 | 3439.7 | ± | 485 | 3229.5 | ± | 339.1 | 2248.5 | ± | 525.1 |
| Vitamin C (mg) | 0 | 71.1 | ± | 33.3 | 50.7 | ± | 15.2 | 35.7 | ± | 9.8 |
| | 8 | 36.4 | ± | 6.9 | 46.1 | ± | 19.4 | 41.6 | ± | 23 |
| Calcium (mg) | 0 | 632.8 | ± | 72.7 | 760.1 | ± | 67.6 | 647.9 | ± | 121.3 |
| | 8 | 618.3 | ± | 48.3 | 905.1 | ± | 157.1 | 715.7 | ± | 163.7 |
| Iron (mg) | 0 | 13.5 | ± | 1.9 | 14 | ± | 3.9 | 12 | ± | 2.3 |
| | 8 | 12.5 | ± | 2 | 14.1 | ± | 1.3 | 10.2 | ± | 2.3 |
| Vitamin E (IU) | 0 | 3.9 | ± | 0.7 | 2.6 | ± | 0.8 | 6.3 | ± | 3.3 |
| | 8 | 2.5 | ± | 0.9 | 4.4 | ± | 0.9 | 3.7 | ± | 1.1 |
| Dietary fiber (g) | 0 | 15.8 | ± | 2 | 19.4 | ± | 2.4 | 13.4 | ± | 1.8 |
| | 8 | 13.4 | ± | 1.5 | 18.2 | ± | 2.7 | 13.6 | ± | 3.9 |

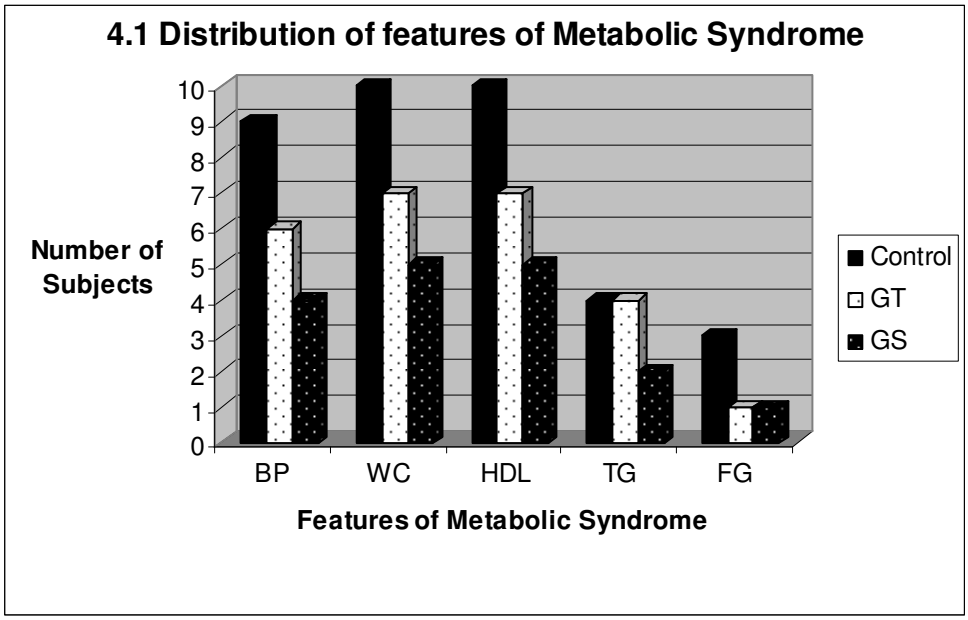
**Values represented as mean±standard error.**
***Statistically different from control at baseline ($p<0.05$).**
**†Changes at 8 weeks significantly different from control ($p<0.05$).**

**Table 4.5 Catechin content of green tea beverage and supplement**

| Catechin | Green Tea Beverage | | Green Tea Supplement | |
|---|---|---|---|---|
| EGCG | 100 | mg/cup | 240 | mg/capsule |
| EGC | 22 | mg/cup | 52 | mg/capsule |
| ECG | 20 | mg/cup | 48 | mg/capsule |
| EC | 12 | mg/cup | 20 | mg/capsule |

**EGCG- Epigallocatechin-3 gallate, EGC- Epigallocatechin, ECG- Epicatechin gallate, EC- Epicatechin**

FIGURES




**GT- Green tea group, GS- Green tea supplement group, BP- Blood pressure, WC- Waist circumference, HDL- High density lipoprotein-cholesterol, TG- Triglycerides, FG- Fasting blood glucose**

# CHAPTER V

# DISCUSSION

This is one of the first studies to test the effects of green tea supplementation in capsule and beverage forms on all features of MetS, collectively. In this study, subjects who consumed 4 cups of decaffeinated green tea beverage on a daily basis showed a significant decrease in total body weight and BMI, when compared to controls. A similar trend was observed for those in the green tea supplement group, but the change did not reach statistical significance. To rule out possible weight changes due to hydration status, the fluid intake for all three treatment groups was the same. Therefore, weight loss may be attributed to the effects of catechins present in the green tea beverage and supplement, as previously reported (17).

## Anthropometric Indexes and Biochemical Changes

Previous studies have also examined the effects of caffeinated green tea on weight loss (15). The beverage and supplements used in our study were decaffeinated, therefore attributing the effects of green tea on weight loss to catechins per se and not the caffeine content. The lack of significant weight loss in the supplement group, suggests that the catechins in freshly brewed tea are more bioavailable. Nagao et al. (17) investigated the supplementation of green tea catechins in beverage in subjects with visceral fat-type

obesity (control group: n=117, high catechin group: n=123). After a 12-week intervention, there was a statistically significant decrease in body weight, BMI, body fat ratio, body fat mass, WC, hip circumference, total fat area, visceral fat area, and subcutaneous fat area in the high catechin group versus placebo. Average weight loss in subjects in this study was 1.7 kg, compared to the 2.5 kg loss in our study. Smaller sample size (n=23) and shorter study duration (8 wk) may possibly explain why no significant differences in other parameters (i.e. lipid levels, fasting plasma glucose, HbA1c, blood pressure, BF% and WC) were observed in our study. Although previous studies have detected decreases in body fat composition following green tea intervention with and without hypocaloric diets (15, 17, 46), BIA used in our study may not be the most effective method for detecting significant changes in body composition in this population due to confounding variables (i.e. improper alignment of electrodes, hydration status, and position of subject body and limbs).

Our study findings of null effects of green tea intervention on fasting glucose and $HbA_{1C}$ may be compared to similar findings reported by MacKenzie et al. (47) and Ryu et al. (35) who did not find any differences in $HbA_{1C}$ following a 3-month supplementation of green and black tea extracts in adults with type 2 diabetes mellitus or in fasting glucose levels following green tea intake for 4 weeks in type 2 diabetes patients, respectively. However, Fukino et al. (34) reported a significant reduction in $HbA_{1C}$ levels in individuals with borderline diabetes following a 2-month supplementation of green tea catechins. Significant results may not have been duplicated in our study based on a smaller study sample and a lower baseline $HbA_{1C.}$

## Carbohydrate Malabsorption

The increase in reported intake of kilocalories and carbohydrate by the green tea group may be explained by the results of a previous study which tested black, green, and mulberry tea extracts on carbohydrate and triacylglycerol absorption in healthy volunteers (n= 20). Consumption of the mixed tea extract resulted in a highly significant increase in breath-hydrogen concentrations, indicative of carbohydrate malabsorption (48). Malabsorption of carbohydrate may lead to additional intake of carbohydrate to compensate for losses. This could possibly explain the increase in carbohydrate intake, with a significant decrease in body weight in the green tea group as a result of caloric content of malabsorbed carbohydrate being unavailable for weight gain.

## Limitations

Human subjects are generally the optimal model for real-life application. However, in working with a population that cannot be fully controlled, limits in clinical research arise. Although compliance was measured in the form of pill counts and the monitoring of green tea consumption, there was no way to monitor subject adherence away from the research center. Physical activity was not monitored, and there could have been lifestyle changes made by the subjects, even though they were instructed to maintain their typical daily activities.

Due to a high percentage of subjects on stable medications, especially for the control blood pressure, benefits of supplementation may have been masked. Combinations of medications may have had additional affects on parameters tested. Middeke et al. (49) investigated the effects of antihypertensive combination therapies in

humans. There were significant increases in both groups for triglycerides ($p < 0.05$). HDL-C decreased significantly ($p < 0.001$ and $< 0.05$) in both groups, while LDL-C increased significantly ($p < 0.05$) in the sotalol group. Fasting plasma glucose and $HbA_{1c}$ increased significantly ($p < 0.05$) in the sotalol combination group, but similar results were not observed for the captopril combination group. The long term use (one year) of a diuretic and beta-blocker combination had adverse effects on the metabolism of lipids and glucose. However, the diuretic/ACE-inhibitor combinations resulted in less pronounced effects on lipid metabolism, and no adverse effects were observed on the metabolism of glucose. This combination of drug therapy had significant effects on parameters, like the variables tested in this study. This article suggests that combinations of medication use may have effects on metabolism, which must also be considered.

Small sample size and short study duration may account for trends that did not reach levels of significance.

## Implications for Future Practice and Research

In summary, this trial confirmed that daily consumption of 4 cups of decaffeinated green tea beverage may be a beneficial tool for weight loss and may help lower DBP and increase HDL, without lifestyle modifications. Furthermore, improvements in these parameters may also help decrease risks of CVD and type II diabetes. Additional research in the area of green tea extract supplements is also needed to support its use for similar purposes, and to possibly explain the trends observed in the green tea supplement group in this study. Due to the high usage of medications by participants in our study, future studies should focus on green tea catechin

supplementation in subjects with or without stable medications. Further research which explains the mechanisms which may cause weight loss with increased carbohydrate intake may also be beneficial to the field of study. Additionally, more significant results may have been achieved with longer study duration and larger sample size.

## Hypotheses

1) We reject the null hypothesis: *Daily consumption of green tea beverage or EGCG supplements will have no significant effect on anthropometric measures in participants with MetS. (Change in body weight & BMI, when compared to controls; $p<0.05$)*

2) We fail to reject the null hypothesis: *Daily consumption of green tea beverage or EGCG supplements will have no significant effect on glucose and lipid parameters in participants with MetS.*

3) We reject the null hypothesis: *Daily consumption of green tea beverage or EGCG supplements will have no significant effect on dietary intake in participants with MetS.(Change in carbohydrate intake, when compared to controls; $p<0.05$)*

## Conclusions

Thus, it can be concluded that daily supplementation of decaffeinated green tea beverage may be beneficial for weight loss in at risk subjects, as it was shown to decrease body weight and BMI significantly, when compared to controls. Although the intervention groups did not reach statistical significance for HDL, an increase in trend was observed, when compared to controls. Similarly, a decrease in trend in DBP was evident in the green tea beverage group. It is possible that other clinical parameters could

reach statistical significance through additional clinical trials with larger sample sizes and longer study duration. Health benefits associated with green tea consumption could therefore be useful in decreasing risk factors linked to cardiovascular disease and type 2 diabetes.

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# APPENDICES

# APPENDIX A

## Oklahoma State University Institutional Review Board

| | |
|---|---|
| Date | Wednesday, November 21, 2007 **Protocol Expires:** 11/20/2008 |
| IRB Application No: | HE06103 |
| Proposal Title: | Effects of Chronic Green Tea Favonoid Supplementation on Biomarkers of Oxidative Stress and Inflammation, and Body Fat Composition Among Subiects with Metabolic Svndrome (MeS) |
| Reviewed and Processed as: | Expedited<br>**Continuation** |

Status Recommended by Reviewer(s): **Approved**

Principal Investigator(s) :


Arpita Basu
416 HES
Stillwater, OK 74078

Timothy J. Lyons
OUHSC WP1345
Okla. City, OK 73104

Karah Sanchez
14900 N. Penn Ave Apt. 1224
Oklahoma City, OK 73134


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Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modifications to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

☒ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

Signature : Sue C Jacobs

Sue C. Jacobs, Chair, Institutional Review Board

Wednesday, November 21, 2007
Date

# APPENDIX B

OUHSC IRB # 13154
OSU IRB # HE 06103
Version date: Oct 30, 2007

**Consent Form**
**University of Oklahoma Health Sciences Center (OUHSC)**
**Oklahoma State University (OSU)**

**Title: Effects of chronic Green Tea Flavonoid Supplementation on Biomarkers of Oxidative Stress and Inflammation, and Body Fat Composition among Subjects with Metabolic Syndrome (MeS)**

**Investigator(s): Dr. Timothy Lyons, University of Oklahoma Health Sciences Center**
**Dr. Arpita Basu, Oklahoma State University**

**Sponsor: Department of Nutritional Sciences, Oklahoma State University**

This is a clinical trial (a type of research study). Clinical trials include only patients who choose to take part in them Please take your time to make your decision. Discuss this with your family and friends.

**Why Have I Been Asked To Participate In This Study?**
You are being asked to take part in this trial/study because you have been diagnosed with metabolic syndrome. (MeS). Metabolic syndrome is a condition where you have at least three of the five following features: being overweight, having high blood pressure, having increased blood sugar, having increased lipids, and low levels of good lipids. This condition puts you at a high risk of developing diabetes and heart disease.

**Why Is This Study Being Done?**
The purpose of this study is to find out about the health effects of green tea compared to green tea supplement intake on certain markers in your blood associated with cell damage linked to MeS. The green tea and green tea supplements do not contain significant amounts of caffeine. We will also find out if green tea or green tea supplement will help you reduce body weight and lead to better use of glucose in your body.

**What is the Status of the Drugs (Devices or Procedures) involved in this study?**
This study involves the use of green tea or green tea supplements which do not contain significant amounts of caffeine. The green tea supplement is not approved by FDA. We will compare the effects of drinking 4 cups of green tea or taking two capsules of green tea extracts on certain markers in blood.

**How Many People Will Take Part In The Study?**
About 60 people will take part in this study

**What Is Involved In The Study?**
This is an 8 week study that will be conducted at the General Clinical Research Center (GCRC) at Oklahoma City, OK. If accepted into the study you will visit the GCRC five times during the 8 weeks.

Screening visit: During this first visit we will do some tests and measurements to determine if you qualify for the study. This will involve:

- Reading and signing the consent form;
- Measuring your height, weight, blood pressure, waist, and the amount of fat in your body;
- Drawing about 3-4 tablespoons of fasting blood for measuring your blood sugar, lipids, blood cell counts, and to do some tests to find out how well your cells, liver, kidney, and thyroid are working;
- Providing you with guidelines and forms for 3-day food record.

If you qualify, we will let you know over the telephone and you will be randomized into one of three groups: green tea beverage group, green tea extract group and a group that uses no green tea (to serve as a control). Randomization means that you are put in a group by chance. You have a 1 in 3 chance of being in any of these groups. A computer program at the study sponsor will make this random assignment. Neither you nor your physician will choose which group you will be in. If you take part in this study and qualify, you could be assigned to any of the three following groups:

**Control Group**: You will follow your usual diet and lifestyle, and drink an additional 4 cups of water per day.

**Green Tea Group:** You will be drinking 4 cups of green tea per day and will be making daily visits to the clinic (except on weekends) to get a supply of the fresh tea.

**Green tea supplement Group:** You will be taking two capsules of green tea supplement per day, and drink an additional 4 cups of water daily.

The following visits will be required for all qualified participants:

- 2 weeks- turn in 3-day food records, short talk on how well you are doing on this study.
- 4 weeks- turn in 3-day food records, draw about 3-4 tablespoons of fasting blood for measuring your blood sugar, lipids, and do some tests to find out how well the cells in your body are working. We will also measure your body weight, blood pressure, and the amount of fat in your body, and do some safety tests.
- 6 weeks- turn in 3-day food records, short talk on how well you are doing on this study.
- 8 weeks- This will be your final visit; turn in 3-day food records, draw about 3-4 tablespoons of fasting blood for measuring your blood sugar, lipids, and do some tests to find out how well the cells in your body are working. We will also measure your body weight, blood pressure, and the amount of fat in your body, and do some safety tests.

**How Long Will I Be In The Study?**

We think that you will be in the study for a period of 8 weeks and 5 total visits. The duration of each visit will be between ½ - 1 hour. If you are in the green tea group, you will be making daily visits (except on weekends) to get freshly made green tea.

The researcher may decide to take you off the study if you develop any serious side effects while drinking green tea or taking green tea supplements.

You can stop participating in this study at anytime. However, if you decide to stop participating in the study, we encourage you to talk to the researcher and your regular doctor first. However, there are no serious consequences of sudden withdrawal from the study.



2

**What Are The Risks of The Study?**
While on the study, you are at risk for these side effects. You should discuss these with the researcher and/or your regular doctor. There also may be other side effects that we cannot predict.
Green Tea Group:

Likely: the risks involved with drinking 4 cups of green tea per day may include some stomach pain, gas, or headache.

Less likely: you may develop some allergies

Green Tea Supplement Group:

Likely: the risks involved with green tea supplements may be some stomach pain, gas, loose stools, or headache.

Less likely: you may develop some allergies. Some studies have shown liver problems upon taking very high doses of green tea supplements. However, this is less likely to happen at the dose we are using in this study.

**Are There Benefits to Taking Part in The Study?**
If you agree to take part in this study, there mayor may not be direct medical benefit to you. We hope that the information learned from this study will benefit other patients with this disease in the future.

**What Other Options Are There?**
You may choose not to participate in the study and please talk to your doctor about other options.

**What About Confidentiality?**
Efforts will be made to keep your personal information confidential. All participants will be assigned a code and data will be stored using that code. You will not be identifiable by name or description in any reports or publications about this study. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. You will be asked to sign a separate authorization form for use or sharing of your protected health information. There are organizations that may inspect and/or copy your research records for quality assurance and data analysis. These organizations include the US Food & Drug Administration, the Oklahoma State University at Stillwater, and the OUHSC Institutional Review Board.

**What Are the Costs?**
The study sponsor will pay for all costs related to your participation in this study.

**Will I Be Paid For Participating in This Study?**
You will not be paid for participating in this study but you will be reimbursed $ 30 per visit to cover travel and expenses; a total of$150. Also, if you participate in the green tea beverage group, you will not be compensated for the expenses involved while you come and pick up your tea each day.

**What if I am Injured or Become Ill While Participating in this Study?**
It is not anticipated that you will be injured participating in this study. No funds have been set aside by Oklahoma State University or The University of Oklahoma Health Sciences Center (General Clinical Research Center) to compensate you in the event of injury.

**What Are My Rights As a Participant?**
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. If you agree to take part and then decide against it, you can withdraw for any reason. Leaving the study will not result in any penalty or loss of benefits that you would otherwise receive.

We will tell you about any new information that may affect your health, welfare or willingness to stay in this study. You may also obtain green tea beverages and supplements outside of the study if you choose not to participate.
You understand that you have the right to access the medical information that has been collected about you as a part of this research study. However, you agree that you may not have access to this medical information until the entire research study has completely finished and you consent to this temporary restriction.

**Whom Do I Call If I have Questions or Problems?**
If you have questions the study or have a research-related injury, contact Dr. Arpita Basu at 405-744-4437 (9AM -5PM, Monday-Friday)or at 916-607-4143 (anytime) or Timothy Lyons, MD at 405-271-5896 (8AM-5PM), or 405-255-3340 (anytime), or the General Clinical Research Center (GCRC) at 405-271-4272 (8:00AM-5:00PM).
If you have questions about your rights as a research participant, you may contact Dr. Sue C. Jacobs, OSU IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-1676 or irb@okstate.edu or the OUHSC Director, Human Research Participant Protection Program at 405-271-2045.

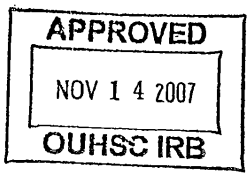
**Signature:**
By signing this form, you are agreeing to participate in this research study under the conditions described. You have not given up any of your legal rights or released any individual or entity from liability for negligence. You have been given an opportunity to ask questions. You will be given a copy of this consent document.

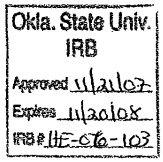
I agree to participate in this study:

Research Subject: _____
Date: _____

Subject's Printed Name: _____

Person Obtaining Informed Consent: _____
Date: _____

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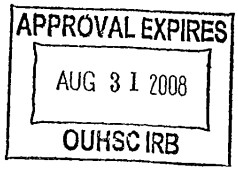

# APPENDIX C



University of Oklahoma H[illegible]lth Sciences Center

Research Privacy Form 1
HI Research Authorization

IRB No.:13154

## AUTHORIZATION TO USE or DISCLOSE PROTECTED HEALTH INFORMATION FOR RESEARCH

*An additional Informed Consent Document for Research Participation may also be required.*
*Form 2 must be used for research involving psychotherapy notes.*

Title of Research Project: **Effects of chronic Green Tea Flavonoid Supplementation on Biomarkers of Oxidative Stress and Inflammation, and body fat composition among subjects with Metabolic Syndrome (MeS)**

Leader of Research Team: **Timothy Lyons, MD**

Address: **Department of Nutritional Sciences, 416 Human Environmental Sciences, Stillwater, OK 74078-6141**

Phone Number: 405-744-4437

If you decide to join this research project, University of Oklahoma Health Sciences Center (OUHSC) researchers may use or share (disclose) information about you that is considered to be protected health information for their research. Protected health information will be called private information in this Authorization.

**Private Information To Be Used or Shared**. Federal law requires that researchers get your permission (authorization) to use or share your private information. If you give permission, the researchers may use or share with the people identified in this Authorization any private information related to this research from your medical records and from any test results. Information, used or shared, may include all information relating to any tests, procedures, surveys, or interviews as outlined in the consent form, medical records and charts, name, address, telephone number, date of birth, race, and government-issued identification number.

**Purposes for Using or Sharing Private Information**. If you give permission, the researchers may use your private information to design future research projects on the basis of the results from the present study.

**Other Use and Sharing of Private Information**. If you give permission, the researchers may also use your private information to develop new procedures or commercial products. They may share your private information with the research sponsor, the OUHSC Institutional Review Board, auditors and inspectors who check the research, and government agencies such as the Food and Drug Administration (FDA) and the Department of Health and Human Services (HHS). The researchers may also share your private information with other researchers for future research projects.



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Confidentiality. Although the researchers may report their findings in scientific journals or meetings, they will not identify you in their reports. The researchers will try to keep your information confidential, but confidentiality is not guaranteed. Any person or organization receiving the information based on this authorization could re-release the information to others and federal law would no longer protect it.

**YOU MUST UNDERSTAND THAT YOUR PROTECTED HEALTH INFORMATION MAY INCLUDE INFORMATION REGARDING ANY CONDITIONS CONSIDERED AS A COMMUNICABLE OR VENEREAL DISEASE WHICH MAY INCLUDE, BUT ARE NOT LIMITED TO, DISEASES SUCH AS HEPATITIS, SYPHILIS, GONORRHEA, AND HUMAN IMMUNODEFICIENCY VIRUS ALSO KNOWN AS ACQUIRED IMMUNE DEFICIENCY SYNDROME (AIDS).**

Voluntary Choice. The choice to give OUHSC researchers permission to use or share your private information for their research is voluntary. It is completely up to you. No one can force you to give permission. However, you must give permission for OUHSC researchers to use or share your private health information if you want to participate in the research and if you revoke your authorization, you can no longer participate in this study.

Refusing to give permission will not affect your ability to get routine treatment or health care from OUHSC.

Revoking Permission. If you give the OUHSC researchers permission to use or share your private information, you have a right to revoke your permission whenever you want. However, revoking your permission will not apply to information that the researchers have already used, relied on, or shared.

End of Permission. Unless you revoke it, permission for OUHSC researchers to use or share your private information for their research will end on 01/2009. You may revoke your permission at any time by writing to:

Privacy Official
University of Oklahoma Health Sciences Center
PO Box 26901, Oklahoma City, OK 73190
If you have questions call: (405) 271-2511

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# APPENDIX D

***Day/ Date of Appointment:*** _____ ***Time:*** _____

**SCREENING QUESTIONNAIRE FOR GREEN TEA STUDY**

NAME: _____

ADDRESS: _____

_____

PHONE (WORK): _____

PHONE (HOME): _____

AGE: _____ DATE OF BIRTH: _____ GENDER: _____

**SCREENING QUESTIONS:**

Do you currently take any cholesterol/triglyceride lowering medications? YES NO

Are you pregnant or lactating? YES NO N/A

Do you smoke? YES NO

Do you currently take vitamins or nutritional supplements? YES NO
What are they? _____
_____

Have you taken antioxidant **supplements** regularly in the past 3-6 months? YES NO

Do you take more than 1 g/day of fish oil capsules? YES NO

Do you exercise ≥ 60 min/day? YES NO

Do you drink more than 1 oz of alcohol/day? YES NO
(1 oz alcohol = 2 beers or 10 oz of wine or 2 ½ oz liquor)

Do you have diabetes? YES NO UNSURE
We will confirm with fasting blood glucose

Do you have hypo/hyperthyroidism? YES NO UNSURE
We will check TSH

*Day/ Date of Appointment:* _____ *Time:* _____

Do you have any gastrointestinal problems? YES NO

Do you have anemia? YES NO

Are you suffering from any other disorder or illness? YES NO
(Cardiovascular disease, rheumatoid arthritis, etc.)

Do you have high blood pressure? YES NO
If controlled, what medications does the patient take?
_____

Are you taking any other medications on a regular basis? YES NO

If you are taking medications, what are they? And, how long have you been taking them?
_____
_____

Do you take aspirin? How often? Dose? _____
_____

Do you take estrogen or oral contraceptives? YES NO N/A

***Is the subject <u>ELIGIBLE</u> based on the questionnaire?*** YES NO

---

**<u>ELIGIBILITY REQUIRES 3 OF THE 5 FEATURES:</u>**

**FEATURES OF METABOLIC SYNDROME (Check all that apply):**

1. _____ **Waist circumference** **(Male ≥ 40 inches)** (Value:_____)
**(Female ≥ 35 inches)**

2. _____ **Hypertension controlled by anti-hypertensive medication**
_____ **Systolic Blood Pressure** **(≥ 130 mmHg)** (Value:_____)
_____ **Diastolic Blood Pressure** **(≥ 85 mmHg)** (Value:_____)

3. _____ **HDL Cholesterol** **(Male ≤ 40 mg/dL)** (Value:_____)
**(Female ≤ 50 mg/dL)**

4. _____ **Triglycerides** **(≥ 150 mg/dL)** (Value:_____)

5. _____ **Fasting Blood Glucose (≥ 100 mg/dL and < 126 mg/dL)** (Value:_____)

**University of Oklahoma Health Sciences Center**
**General Clinical Research Center, Green Tea Study**
**Food Diary**

**Name:** _____ **ID#**_____ **Protocol No:**_____

**Date of Record:**_____ **Day of Week:**_____

**Please record everything you eat today. Please include descriptions, brand names, and weighed and measured amounts (Please save labels). In the first column under meal and place, please put what meal you ate and where you ate it. You may use the codes at the bottom of the page for convenience. Thank you.**

| Meal* Place* | Amount | Food Description | Office Use Only |
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*Meal Codes:
Breakfast - BR
Morning Snack – MS
Lunch – LU
Afternoon Snack –AS
Supper – SU
Evening Snack – ES

*Place Codes:
Home – HO
Restaurant – RE (Please Specify name of Restaurant)
Friends –FR
Work- W

**University of Oklahoma Health Sciences Center**
**General Clinical Research Center, Green Tea Study**
**Food Diary Continued-Page 2**

**Name:** _____ **ID#**_____ **Protocol No:**_____

| Meal* Place* | Amount | Food Description | Office Use Only |
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VITA

Karah Reena Sanchez

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF GREEN TEA SUPPLEMENTATION ON SUBJECTS WITH METABOLIC SYNDROME IN OKLAHOMA

Major Field: Nutritional Sciences

Biographical:

Personal Data: Born in Corpus Christi on February 6, 1983, daughter of Dr. and Mrs. Jose Armando Sanchez of Round Rock, TX.

Education:
Graduated from McNeil High School in May 2000. Earned a Bachelor of Science in Nutrition from The University of Texas, Austin, Texas in December 2005. Completed the requirements for the Master of Science in Nutritional Sciences from Oklahoma State University, Stillwater, Oklahoma in May, 2008.

Experience:
Has been a graduate research assistant for Dr. Arpita Basu since August 2006. Completed the requirements of the Dietetic Internship Program at Oklahoma State University, Stillwater, Oklahoma in August, 2007, and is a Registered Dietitian.

Professional Memberships:
American Society for Nutrition, American Dietetic Association, Oklahoma Dietetic Association, Oklahoma City District Dietetic Association, Sports, Cardiovascular and Wellness Nutritionists (SCAN), Kappa Omicron Nu Honor Society, Phi Kappa Phi Honor Society

Name: Karah Reena Sanchez Date of Degree: May, 2008

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: EFFECTS OF GREEN TEA SUPPLEMENTATION ON SUBJECTS WITH METABOLIC SYNDROME IN OKLAHOMA

Pages in Study: 54 Candidate for the Degree of Master of Science

Major Field: Nutritional Sciences

Scope and Method of Study: Green tea, rich in flavonoids, has been shown to possess cardiovascular health benefits. This is a randomized controlled trial investigating whether green tea beverage or extract supplementation improved the cardiovascular risk profile associated with metabolic syndrome (MetS). Subjects with MetS were matched for age and sex and were randomly assigned to control (4 cups water/day), green tea (4 cups/day), or green tea supplement (2 capsules & 4 cups water/day) group for 8 weeks. Fasting blood samples, anthropometric measurements, and 3-day food records were taken at screening, 4 & 8 weeks. Blood samples were analyzed for lipid and glucose levels using standard clinical chemistry techniques. Dietary data were analyzed for nutritional content using Nutritionist Pro, version 3.2.

Findings and Conclusions: Daily supplementation of decaffeinated green tea (4 cups/day) may be beneficial to humans diagnosed with the metabolic syndrome (MetS), as it may help decrease total body weight. Body weight and BMI decreased significantly ($p<0.05$) in green tea (-2.5 kg and -0.9, respectively) versus control (+0.6 kg and + 0.2 kg) at eight weeks. Although the supplement group did not reach significance, a similar weight loss trend was observed (-1.3 kg), which also decreased BMI (-0.4). When compared to controls, there were no significant differences in change at eight weeks for the green tea beverage or supplement group in fasting plasma glucose levels, lipid levels, body fat percentage, waist circumference, or blood pressure. However, a decrease in trend ($p<0.1$) of diastolic blood pressure at eight weeks for the green tea group (-4.7 mmHg) compared to placebo (+1.5 mmHg) was noted, and the same trend did not exist for the supplement group. An increase in trend ($p<0.1$) was observed for HDL cholesterol in green tea (+0.9 mg/dL) versus control (-1.4 mg/dL). A similar pattern was true for the supplement group (+0.6 mg/dL). At eight weeks, carbohydrate intake was significantly higher ($p<0.05$) for the green tea group (+67 g) versus control (-31 g). The supplement group exhibited a similar trend, (+24 g), suggesting possible carbohydrate malabsorption in both the green beverage and supplement groups. Thus, green tea beverage or supplements may be a beneficial tool to aid weight loss. Additional research, including longer study duration and larger sample size, is needed to confirm benefits such as a decrease in diastolic blood pressure and increase in HDL cholesterol with green tea flavonoid supplementation.

ADVISER'S APPROVAL: Dr. Arpita Basu