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Effects of *Garcinia cambogia* (Hydroxycitric Acid) on Visceral Fat Accumulation: A Double-Blind, Randomized, Placebo-Controlled Trial

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ABSTRACT

Background: (-)-Hydroxycitric acid (HCA) is an active ingredient extracted from the rind of the Indian fruit *Garcinia cambogia.* It inhibits adenosine triphosphate citrate lyase and has been used in the treatment of obesity.

Objective: The primary end point of this study was the effects of 12 weeks of *G cambogia* extract administration on visceral fat accumulation. The secondary end points were body indices (including height, body weight, body mass index [BMI], waist and hip circumference, and waist–hip ratio) and laboratory values (including total cholesterol, triacylglycerol, and free fatty acid).

Methods: This study was performed according to a double-blind, randomized, placebo-controlled, parallel-group design. Subjects aged 20 to 65 years with a visceral fat area >90 cm^2 were enrolled. Subjects were randomly assigned to receive treatment for 12 weeks with *G cambogia* (containing 1000 mg of HCA per day) or placebo. At the end of the treatment period, both groups were administered placebo for 4 weeks to assess any rebound effect. Each subject underwent a computed tomography scan at the umbilical level at –2, 0, 12, and 16 weeks.

Results: Forty-four subjects were randomized at baseline, and 39 completed the study (*G cambogia* group, n = 18; placebo group, n = 21). At 16 weeks, the *G cambogia* group had significantly reduced visceral, subcutaneous, and total fat areas compared with the placebo group (all indices $P < 0.001$). No severe adverse effect was observed at any time in the test period. There were no

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significant differences in BMI or body weight at week 12, but there were slight numeric decreases in body weight and BMI in men. There were no signs of a rebound effect from week 12 to week 16.

Conclusion: *G cambogia* reduced abdominal fat accumulation in subjects, regardless of sex, who had the visceral fat accumulation type of obesity. No rebound effect was observed. It is therefore expected that *G cambogia* may be useful for the prevention and reduction of accumulation of visceral fat. (*Curr Ther Res Clin Exp.* 2003;64:551–567)

Key words: *Garcinia cambogia*, hydroxycitric acid, visceral fat accumulation, computed tomography scan.

INTRODUCTION

The prevalence of overweight has increased substantially in Japan during the past decade and it continues to rise. According to recent statistics, >30% of the Japanese adult population meets the current definition of overweight (body mass index [BMI] ≥25 kg/m^2).[1] Obesity is a problem not only in the Western world but also in Japan. It is well accepted that obesity is a risk factor for type 2 diabetes, coronary heart disease, and hypertension.[2–13] Several studies, however, have shown that measurement of overall adiposity or body weight, such as with BMI, may not adequately describe the relationship of body fat to disease.[14] It appears that visceral fat area (VFA) more fully explains this relationship.[15,16] The clustering of hyperinsulinemia, dyslipidemia, type 2 diabetes mellitus, and hypertension is called the *insulin resistance syndrome* or *metabolic syndrome,* and *syndrome X*.[17] Accordingly, evaluation of obesity for the prevention of syndrome X must be conducted using not only body weight or BMI but also VFA. Incidentally, it has been reported that a high-carbohydrate (sucrose) diet increases visceral fat accumulation in rats.[18] Therefore, controlling the surplus energy from a high-carbohydrate diet is expected to be effective in preventing the accumulation of visceral fat.

Several studies have demonstrated that (-)-hydroxycitric acid (HCA), the principal acid of the rind of the Indian fruit *Garcinia cambogia*, is a competitive inhibitor of adenosine triphosphate citrate lyase,[19–21] the enzyme that catalyzes the extramitochondrial cleavage of citrate to oxaloacetate and acetyl coenzyme A. This action of HCA should reduce the acetyl coenzyme A pool, thus limiting the availability of 2-carbon units required for fatty acid and cholesterol biosynthesis.[22] In vitro and in vivo studies show that HCA inhibits the actions of citrate cleavage enzyme, suppresses de novo fatty acid synthesis, increases rates of hepatic glycogen synthesis, and decreases body weight gain.[23–27] In human studies, only supporting evidence exists for the efficacy of *G cambogia* in weight control, and it has yet to be assessed in relationship to visceral fat accumulation.[28–31]

We previously reported[32] that the efficacy of HCA depends on initial VFA values and was obvious in subjects whose initial VFA was >90 cm^2. Because we enrolled overweight or obese class 1 subjects (BMI, 25–35 kg/m^2) in that study, high VFA was not one of the inclusion criteria. The goal of the present study was to examine the effects of 12 weeks of *G cambogia* treatment on visceral fat accumulation in subjects having a VFA >90 cm^2.

SUBJECTS AND METHODS

Subjects

All subjects had to be between the ages of 20 and 65 years and have a VFA >90 cm^2. All of the subjects were to be generally healthy and have no history of diabetes mellitus; dysfunction of the liver, kidney, or heart; or hematologic disease. Other inclusion and exclusion criteria are given in Table I. Most of the subjects were classified as level 1 to 2 (mild) in terms of self-reported daily activity according to the *6th Recommended Dietary Allowances for the Japanese*.[33]

This study was carried out with sufficient respect for the spirit of the Declaration of Helsinki and was approved by the institutional review boards of FANCL Corporation, Maebashi Hirosegawa Clinic (Gunma, Japan), and Ono Clinic (Osaka, Japan). The procedures were fully explained to all the subjects in advance, and all gave their written informed consent before participating.

Treatment

G cambogia extract was provided by Nippon Shinyaku Co., Ltd., Kyoto, Japan. The HCA concentration was 60% as determined by high-performance liquid

Table I. Study inclusion and exclusion criteria.

Inclusion criteria
Age 20–65 years
Overweight (BMI ≥25 kg/m^2)
Visceral fat area >90 cm^2
No fluctuation of BMI by the end of the run-in period
Provision of written informed consent
Exclusion criteria
Diabetes (fasting plasma glucose, 126 mg/dL)
Dysfunction of liver, kidneys, or heart
Hematologic disease
History of drug hypersensitivity or allergic condition that might interfere with the study
Use of drugs or dietary supplements that might influence body weight, body fat, or serum lipid levels
Pregnancy or lactation
Any other abnormality of potential clinical significance

BMI = body mass index.

chromatography. The active herbal was a 270-mg tablet containing 185.25 mg of *G cambogia* extract. In the placebo tablet, the active compound was replaced with cellulose (Avicel, Asahi Kasei Corp., Tokyo, Japan) as an inert ingredient. The excipients were dextrin and cellulose.

Subjects were instructed to take 3 tablets 30 minutes before each meal (9 tablets/d). The total daily dose was 1667.25 mg of *G cambogia* extract, containing 1000 mg of HCA.

Protocol

This study was performed according to a double-blind, placebo-controlled, parallel-group design (Figure 1). Randomization was performed by random number generation, and group assignment was placed in a sealed envelope. The primary end point of this study was the effects of 12 weeks of *G cambogia* extract administration on visceral fat accumulation. The secondary end points were body indices (including height, body weight, BMI, waist and hip circumference, and waist–hip ratio [WHR]) and laboratory values (including total cholesterol [TC], triacylglycerol, and free fatty acid).

Subjects received no treatment during a 2-week run-in period. After run-in, subjects underwent body weight measurement, computed tomography (CT), and laboratory analysis. They were then randomly assigned to either the *G cambogia* group (containing 1000 mg of HCA per day) or the placebo group. The treatment period lasted 12 weeks. At the end of the treatment period, both groups were administered placebo for 4 weeks to assess any rebound effect.

Subjects were started on a dietary intervention by a nationally registered dietitian in each institute. Subjects' intake was limited to 2250 kcal/d for men

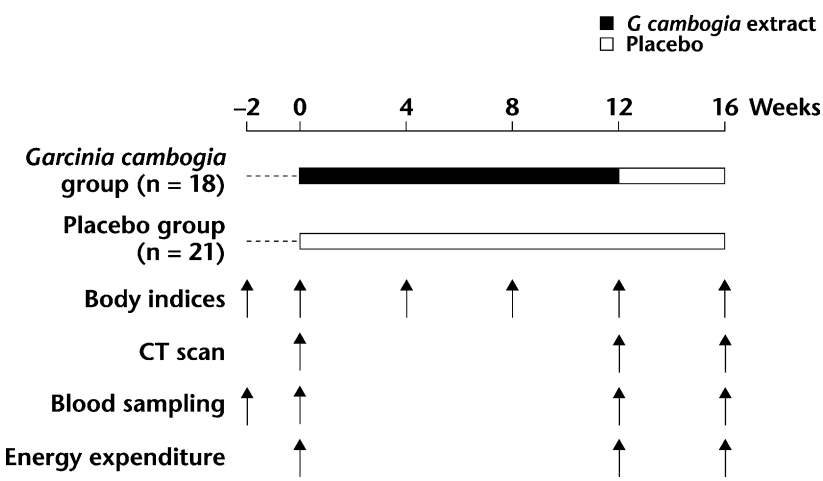

Figure 1. Protocol of the efficacy test of *Garcinia cambogia.* Subjects received no treatment during a 2-week run-in period. CT = computed tomography.

and 1800 kcal/d for women.[33] Energy expenditure was determined by questionnaires completed at weeks 0, 12, and 16. At the same time, the aforementioned dietitians assessed dietary intervention, using a questionnaire, at each visit.

The subjects underwent CT at weeks 0, 12, and 16 at either the Maebashi Hirosegawa Clinic, using a Toshiba Medical TCT-300 machine (Toshiba Corp., Tokyo, Japan), or the Ono Clinic, using a Toshiba Medical X-force machine (Toshiba Corp.). VFA and subcutaneous fat area (SFA) were determined by the FAT Scan Program (N2 System Corp., Osaka, Japan) from CT image data at the level of the umbilicus. All CT scans were performed by radiologists blinded to participants' group randomization.

Body indices were measured at week –2 and every 4 weeks during the study. They included height, body weight, BMI, waist and hip circumference, and WHR.

Blood samples were collected from the subjects between 9:00 and 11:30 AM after an overnight fast, which began at 9:00 PM on the previous night. Laboratory parameters were red and white blood cell counts, hemoglobin, hematocrit, platelets, TC, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, triacylglycerol, free fatty acid, aspartate aminotransferase, alanine aminotransferase, γ-glutamyltransferase, lactate dehydrogenase, blood urea nitrogen, creatinine, fasting plasma glucose, insulin, acetoacetic acid, 3-hydroxybutyric acid, and total ketone bodies. Clinical laboratory data were measured at –2, 0, 12, and 16 weeks.

Statistical Analysis

Rates of change were calculated for the CT scans and body indices, and the differences in effects between the *G cambogia* and placebo groups were calculated according to the Student *t* test. The evaluation of rebound was calculated according to the paired *t* test at weeks 12 and 16. The analysis of laboratory parameters to determine a safety profile was performed using the paired *t* test and the Student *t* test. For baseline data, we used mean values calculated from the start and end points of the run-in period. All analyses were conducted at the 2-tailed α level of 0.05. Data were analyzed using the statistical program StatView Version 5.0 (SAS Institute Inc., Cary, North Carolina).

RESULTS

Subject Characteristics

Forty-four subjects were randomized at baseline to either the *G cambogia* group (n = 21) or the placebo group (n = 23) (Figure 2). The mean (SEM) VFA was 145.5 (6.0) cm^2, and their mean (SEM) BMI was 28.7 (0.7) kg/m^2 (overweight [BMI 25–<30 kg/m^2], 30 patients [68.2%]; obesity class I [BMI 30–<35 kg/m^2], 7 patients [15.9%]; obesity class II [BMI 35–<40 kg/m^2], 6 patients [13.6%]; obesity class III [BMI ≥40 kg/m^2], 1 patient [2.3%]). Eighteen of the 21 subjects

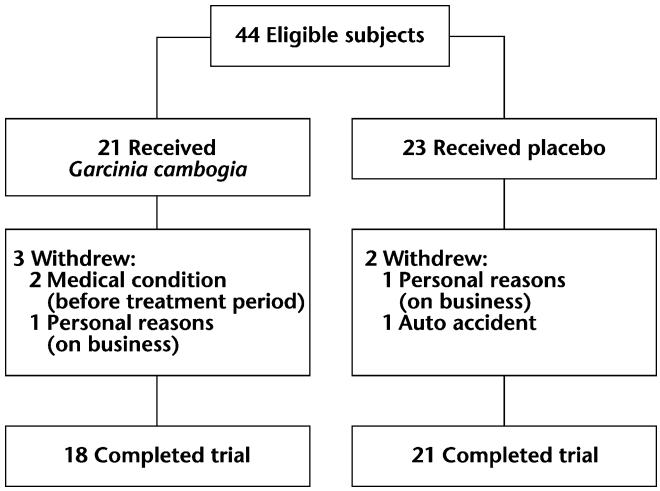

Figure 2. Study flow diagram.

in the *G cambogia* group and 21 of the 23 placebo group subjects completed the 16-week protocol. Reasons for subject withdrawal are summarized in Figure 2. The number of *G cambogia* and placebo subjects, respectively, assessed at each period were as follows: week 0, 21 and 23; week 4, 19 and 23; week 8, 19 and 22; and weeks 12 and 16, 18 and 21.

The study subjects ranged in age from 20 to 65 years (mean [SEM] age, 44 [1.8] years). In an analysis including the subjects who withdrew, no significant differences were found in initial age, body weight, BMI, waist and hip circumference, WHR, VFA, SFA, or total fat area (TFA) between the placebo group and the *G cambogia* group (Table II).

Nutrient Intake

Table III compares the nutrient intake by subjects in the 2 groups. In the male subjects in both groups, energy expenditure was slightly lower than the 2250 kcal/d established by their dietary intervention. In the female subjects in both groups, energy expenditure was approximately equal to the 1800 kcal/d established by their dietary intervention. During the 16-week experiment period, there were no significant between-group differences in nutrient intake or energy expenditure.

Abdominal Fat Distribution and Body Indices

Abdominal fat distribution and body indices are shown in Tables IV and V, respectively. Regardless of sex, the VFA, SFA, and TFA of subjects in the *G cambogia* group were significantly lower at 12 weeks ($P = 0.009$, 0.003, and

Table II. Baseline characteristics of study subjects (N = 44). (Values are given as mean [SEM] unless otherwise noted.)

Characteristic	*Garcinia cambogia* Group (n = 21)	Placebo Group (n = 23)
Age, y		
Mean (SEM)	43.7 (2.6)	45.2 (2.7)
Range	23–64	23–65
Sex, no. (%)		
Men	11 (52.4)	13 (56.5)
Women	10 (47.6)	10 (43.5)
Body weight, kg		
Men	83.9 (4.7)	78.7 (3.2)
Women	72.8 (3.8)	74.5 (4.2)
Height, cm		
Men	170.8 (1.8)	171.2 (1.9)
Women	154.2 (1.4)	156.1 (1.5)
BMI, kg/m^2		
Men	28.8 (1.7)	26.8 (0.8)
Women	30.6 (1.5)	30.6 (1.7)
Waist circumference, cm		
Men	94.6 (2.9)	91.3 (1.9)
Women	97.9 (3.0)	98.2 (2.4)
Hip circumference, cm		
Men	99.8 (1.9)	100.2 (1.9)
Women	103.5 (2.5)	104.7 (2.4)
WHR		
Men	0.94 (0.01)	0.92 (0.01)
Women	0.95 (0.01)	0.94 (0.01)
Visceral fat area, cm^2		
Men	156.6 (10.5)	137.0 (7.8)
Women	138.2 (14.4)	147.9 (13.6)
Subcutaneous fat area, cm^2		
Men	203.9 (30.3)	176.1 (17.9)
Women	279.6 (21.9)	280.4 (28.2)
Total fat area, cm^2		
Men	363.9 (34.6)	312.7 (16.3)
Women	414.9 (25.1)	427.9 (34.4)

BMI = body mass index; WHR = waist–hip ratio.

<0.001, respectively) and 16 weeks ($P = 0.001$, <0.001, and <0.001, respectively) than in the placebo group (Table IV). Within the *G cambogia* group, each of these fat areas decreased by ~10% to 15% from baseline to week 16.

When comparing the findings at week 12 versus week 16 in the *G cambogia* group, no significant changes were observed in VFA, SFA, or TFA. Therefore,

Table III. Comparison of nutrient intake and energy expenditure between the *Garcinia cambogia* and placebo groups over 16 weeks (N = 44). (Values are given as mean [SEM].)

Nutrient	*Garcinia cambogia* Group (n = 21)	Placebo Group (n = 23)
Protein, g/d		
Men	77.7 (3.4)	71.8 (3.1)
Women	68.3 (2.9)	69.1 (2.2)
Fat, g/d		
Men	59.5 (4.0)	57.4 (3.9)
Women	56.4 (3.8)	55.6 (4.2)
Carbohydrate, g/d		
Men	273.5 (17.6)	285.7 (9.1)
Women	260.0 (12.7)	264.5 (11.2)
Energy expenditure, kcal/d		
Men	2015.5 (105.5)	2018.3 (76.2)
Women	1869.3 (60.1)	1862.1 (81.3)

there were no signs of a rebound effect from week 12 to week 16 in the *G cambogia* group.

At 12 weeks, both body weight and BMI were numerically but not significantly lower in the *G cambogia* group than in the placebo group, and were significantly lower in the *G cambogia* group than in the placebo group at 16 weeks ($P = 0.04$ and 0.02, respectively, vs placebo). However, these findings were observed only in men, among whom the WHR in the *G cambogia* group tended to be lower than in the placebo group, although the difference was not significant (Table V). No significant differences in other indices were detected in either sex between the 2 treatment groups.

Clinical Laboratory Tests

The results of clinical laboratory tests are shown in Table VI. Serum triacylglycerol values tended to decrease over time in the *G cambogia* group but not significantly. The mean values of the hematologic, hemobiochemical, and endocrinologic data did not change in the *G cambogia* group.

Adverse Effects

No subject was removed from the study protocol for treatment-related adverse effects. The following adverse effects occurred in the *G cambogia* and placebo group, respectively: common cold, 1 (4.8%) and 10 (43.5%); toothache, 3 (14.3%) and 3 (13.0%); diarrhea, 2 (9.5%) and 4 (17.4%); and headache, 0 (0.0%) and 4 (17.4%).

Table IV. Mean (SEM) changes in abdominal fat distribution versus baseline in patients who completed the study (N = 39). (Values are expressed as % unless otherwise noted.)

	All Subjects			Men			Women		
Fat Distribution/ Study Week	*Garcinia cambogia* Group (n = 18)	Placebo Group (n = 21)	*P**	*Garcinia cambogia* Group (n = 8)	Placebo Group (n = 11)	*P**	*Garcinia cambogia* Group (n = 10)	Placebo Group (n = 10)	*P**
Visceral fat area									
Week 0, mean (SEM), cm^2	146.2 (9.9)	144.9 (7.5)	–	156.2 (13.5)	142.2 (8.1)	–	138.2 (14.4)	147.9 (13.6)	–
Week 12	89.2 (2.5)	105.1 (3.2)	0.009	87.8 (4.6)	105.5 (5.5)	0.032	90.2 (2.9)	104.8 (3.2)	0.003
Week 16	86.4 (2.1)	106.9 (3.8)	0.001	82.3 (3.5)	107.2 (5.9)	0.004	89.7 (2.3)	106.5 (5.2)	0.004
Subcutaneous fat area									
Week 0, mean (SEM), cm^2	231.3 (20.2)	223.4 (20.2)	–	170.9 (22.7)	171.5 (18.6)	–	279.6 (21.9)	280.4 (28.2)	–
Week 12	87.6 (2.4)	106.7 (3.1)	0.003	90.1 (2.7)	107.0 (5.0)	0.017	85.6 (3.8)	106.3 (3.9)	0.001
Week 16	85.4 (3.1)	108.0 (2.6)	<0.001	88.9 (3.9)	110.5 (3.3)	<0.001	82.5 (4.7)	110.5 (3.3)	<0.001
Total fat area									
Week 0, mean (SEM), cm^2	379.2 (21.9)	367.9 (22.4)	–	334.6 (32.9)	313.3 (17.8)	–	414.9 (25.1)	427.9 (34.4)	–
Week 12	87.7 (1.6)	105.6 (2.2)	<0.001	87.8 (2.6)	105.6 (3.4)	0.001	87.6 (2.2)	105.6 (3.4)	<0.001
Week 16	85.2 (2.3)	106.3 (2.2)	<0.001	84.8 (2.9)	107.7 (3.4)	<0.001	85.5 (3.6)	104.7 (2.7)	<0.001

*Between-group difference.

Table V. Mean (SEM) changes in anthropometric values, by sex, in patients who completed the study (N = 39). (Values are expressed as % unless otherwise noted.)

	All Subjects		Men		Women	
Parameter/Study Week	*Garcinia cambogia* Group (n = 18)	Placebo Group (n = 21)	*Garcinia cambogia* Group (n = 8)	Placebo Group (n = 11)	*Garcinia cambogia* Group (n = 10)	Placebo Group (n = 10)
Body weight						
Week 0, mean (SEM), kg	75.1 (2.9)	75.9 (2.5)	78.2 (4.5)	77.5 (3.0)	72.8 (3.8)	74.3 (4.2)
Week 4	99.4 (0.3)	99.8 (0.3)	99.2 (0.5)	100.1 (0.5)	99.4 (0.4)	99.4 (0.4)
Week 8	98.8 (0.4)	99.0 (0.4)	98.8 (0.7)	99.7 (0.6)	98.8 (0.5)	98.3 (0.5)
Week 12	98.2 (0.5)	99.4 (0.5)	98.1 (0.8)	100.3 (0.7)	98.3 (0.6)	98.5 (0.5)
Week 16	98.0 (0.6)*	99.9 (0.5)	98.3 (0.8)†	100.7 (0.7)	97.8 (0.9)	98.9 (0.7)
BMI						
Week 0, mean (SEM), kg/m^2	28.9 (1.1)	28.5 (1.0)	26.8 (1.3)	26.7 (0.8)	30.6 (1.5)	30.5 (1.7)
Week 4	99.4 (0.3)	99.8 (0.3)	99.3 (0.5)	99.4 (0.4)	99.4 (0.4)	99.4 (0.4)
Week 8	98.8 (0.4)	99.0 (0.4)	98.8 (0.7)	99.7 (0.6)	98.8 (0.5)	98.3 (0.5)
Week 12	98.2 (0.5)	99.4 (0.5)	98.2 (0.8)	100.3 (0.7)	98.3 (0.6)	98.5 (0.5)
Week 16	98.0 (0.6)	99.9 (0.5)	98.3 (0.8)*	100.7 (0.7)	97.8 (0.9)	98.9 (0.7)
Waist circumference						
Week 0, mean (SEM), cm	95.4 (2.2)	94.5 (1.7)	92.2 (3.1)	91.0 (2.0)	97.9 (3.0)	98.5 (2.3)
Week 4	99.6 (0.4)	100.3 (0.4)	99.8 (0.6)	100.6 (0.6)	99.4 (0.6)	100.0 (0.5)
Week 8	99.2 (0.5)	100.1 (0.4)	99.7 (0.8)	100.8 (0.5)	98.9 (0.7)	99.4 (0.5)
Week 12	98.8 (0.6)	99.3 (0.3)	99.1 (0.9)	99.6 (0.3)	98.5 (0.9)	98.9 (0.4)
Week 16	98.0 (0.7)	99.0 (0.4)	98.3 (1.2)	99.8 (0.4)	97.8 (0.9)	98.3 (0.7)

(continued)

Table V. (Continued)

Parameter/Study Week	All Subjects		Men		Women	
	Garcinia cambogia Group (n = 18)	Placebo Group (n = 21)	*Garcinia cambogia* Group (n = 8)	Placebo Group (n = 11)	*Garcinia cambogia* Group (n = 10)	Placebo Group (n = 10)
Hip circumference						
Week 0, mean (SEM), cm	100.8 (1.7)	100.9 (1.4)	98.4 (1.8)	98.5 (1.4)	103.1 (2.6)	104.6 (2.3)
Week 4	99.9 (0.2)	100.1 (0.3)	99.5 (0.4)	100.0 (0.5)	100.1 (0.3)	100.1 (0.3)
Week 8	99.4 (0.4)	99.5 (0.3)	99.1 (0.8)	99.3 (0.5)	99.7 (0.2)	99.7 (0.3)
Week 12	99.0 (0.3)	99.0 (0.3)	99.1 (0.8)	99.0 (0.5)	98.8 (0.2)	99.0 (0.4)
Week 16	98.6 (0.4)	98.9 (0.3)	99.0 (0.7)	99.0 (0.5)	98.2 (0.3)	98.8 (0.5)
WHR						
Week 0, mean (SEM)	0.94 (0.01)	0.94 (0.01)	0.94 (0.02)	0.92 (0.01)	0.95 (0.01)	0.94 (0.01)
Week 4	99.7 (0.4)	100.2 (0.3)	100.3 (0.4)	100.6 (0.5)	99.3 (0.7)	99.9 (0.4)
Week 8	99.8 (0.5)	100.6 (0.4)	100.6 (0.6)	101.4 (0.5)	99.2 (0.8)	99.7 (0.4)
Week 12	99.8 (0.6)	100.2 (0.3)	100.0 (0.4)	100.5 (0.4)	99.7 (1.0)	99.9 (0.5)
Week 16	99.4 (0.6)	100.1 (0.4)	99.2 (0.6)	100.8 (0.5)	99.6 (1.1)	99.4 (0.7)

BMI = body mass index; WHR = waist–hip ratio.
*$P = 0.02$ versus placebo group.
†$P = 0.04$ versus placebo group.

Table VI. Effects of *Garcinia cambogia* on hematologic, hemobiochemical, and endocrinologic parameters in all patients (N = 43). (Values are expressed as mean [SEM].)

Parameter	Normal Value	*Garcinia cambogia* Group			Placebo Group		
		Week 0 (n = 21)	Week 12 (n = 18)	Week 16 (n = 18)	Week 0 (n = 23)	Week 12 (n = 21)	Week 16 (n = 21)
Hematology							
WBC count, cells/μL	3500–9700	6695 (394)	6573 (456)	7011 (494)	6533 (309)	6983 (324)*	6867 (417)*
RBC count, cells × 10^6/μL	Men, 4.38–5.77; women, 3.76–5.16	4.83 (0.01)	4.79 (0.07)	4.85 (0.09)	4.81 (0.10)	4.85 (0.11)*	4.88 (0.10)†
Hb, g/dL	Men, 13.6–18.3; women, 11.2–15.2	14.4 (0.4)	14.4 (0.4)	14.5 (0.4)	14.6 (0.3)	14.7 (0.3)*	14.8 (0.3)*
Hematocrit, %	Men, 40.4–51.9; women, 34.3–45.2	45.0 (1.1)	45.0 (1.1)	45.0 (1.0)	45.1 (0.5)	45.9 (0.7)†	45.9 (0.6)†
Platelet count, cells × 10^3/μL	140–379	270 (12)	265 (17)	268 (18)	255 (13)	235 (15)	253 (15)
Hemobiochemistry							
AST, U/L	10.0–40.0	32.0 (3.0)	31.2 (3.3)	34.1 (4.4)	28.8 (1.9)	30.4 (2.5)	30.1 (2.4)
ALT, U/L	5.0–45.0	51.9 (8.4)	43.2 (5.9)	48.6 (7.8)	40.9 (4.7)	42.5 (5.2)	43.0 (5.4)
GGTP, U/L	16.0–73.0	57.9 (7.6)	62.6 (10.0)	63.9 (9.4)	54.7 (7.9)	55.0 (8.8)	54.0 (8.8)
LDH, U/L	220.0–430.0	344.3 (11.8)	334.2 (14.8)	335.7 (11.8)	354.2 (10.9)	358.8 (19.5)	347.9 (10.2)
BUN, mg/dL	8.0–20.0	13.0 (0.7)	12.9 (0.9)	12.9 (0.8)	12.8 (0.5)	12.6 (0.6)	13.3 (0.5)
Creatinine, mg/dL	0.6–1.3	0.97 (0.03)	0.94 (0.03)	0.94 (0.03)	0.99 (0.03)	0.94 (0.03)†	0.92 (0.04)†
Triacylglycerol, mg/dL	50.0–149.0	169.1 (11.7)	154.4 (14.1)	146.2 (15.2)	177.4 (20.7)	183.7 (19.0)	173.7 (19.7)
FFA, mEq/L	0.10–0.81	0.73 (0.05)	0.72 (0.05)	0.71 (0.07)	0.73 (0.05)	0.71 (0.07)	0.68 (0.06)
TC, mg/dL	150.0–219.0	213.4 (5.7)	208.8 (7.7)	210.8 (6.7)	211.8 (8.1)	213.7 (9.0)	217.7 (9.1)

(continued)

Table VI. (Continued)

Parameter	Normal Value	*Garcinia cambogia* Group			Placebo Group		
		Week 0 (n = 21)	Week 12 (n = 18)	Week 16 (n = 18)	Week 0 (n = 23)	Week 12 (n = 21)	Week 16 (n = 21)
HDL-C, mg/dL	Men, 41.0–80.0; women, 41.0–90.0	48.9 (2.4)	48.7 (2.4)	50.7 (1.8)	47.8 (2.2)	46.6 (2.1)	47.9 (2.1)
LDL-C, mg/dL	60–130	140.1 (4.9)	137.3 (6.1)	139.1 (6.4)	139.2 (6.6)	140.2 (7.9)	143.0 (7.4)
FPG, mg/dL	70–139	94.0 (2.2)	92.1 (1.7)	94.3 (2.8)	90.8 (1.7)	91.3 (1.9)	90.0 (1.6)
Acetoacetic acid, μmol/L	≤55.0	17.2 (2.7)	20.6 (1.6)	21.6 (4.3)	16.8 (1.4)	17.8 (2.5)	16.2 (1.6)
3-Hydroxybutyric acid, μmol/L	≤85	38.6 (6.1)	37.8 (3.2)	45.1 (9.7)	33.0 (3.6)	33.2 (5.5)	30.0 (3.5)
Total ketone bodies, μmol/L	≤131.0	55.8 (8.5)	58.4 (4.3)	66.7 (13.9)	49.8 (4.3)	51.0 (7.6)	46.2 (4.4)
Endocrinology							
Insulin, μU/mL	3.0–18.0	13.3 (2.0)	9.9 (1.1)	11.8 (1.6)	9.8 (1.1)	11.9 (1.5)	11.6 (1.5)

WBC = white blood cell; RBC = red blood cell; Hb = hemoglobin; AST = aspartate aminotransferase; ALT = alanine aminotransferase; GGTP = γ-glutamyltransferase; LDH = lactate dehydrogenase; BUN = blood urea nitrogen; FFA = free fatty acid; TC = total cholesterol; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol; FPG = fasting plasma glucose.
*$P < 0.05$ versus week 0 (paired t test).
†$P < 0.01$ versus week 0 (paired t test).

DISCUSSION

The dietary habits of the Japanese have been Westernized rapidly since the end of World War II. With poorer nutrition (ie, higher fat intake), the causes of death in Japan have changed considerably.[1] In the early research into obesity in Japan and in Western countries, many studies investigated the relationship between body weight or BMI and lifestyle diseases such as type 2 diabetes, coronary heart disease, and hypertension.[14] Recently, attention has focused on the relationship between abdominal fat distribution and lifestyle diseases by CT analysis; in particular, the relationship between VFA and multiple risk factors (type 2 diabetes mellitus, dysglycemia, hypertension, coronary heart disease, hyperuricemia) has been reported.[14] According to the Japan Society for the Study of Obesity,[14] visceral fat obesity is diagnosed when VFA is $\geq$100 cm^2. The concept of a "visceral fat accumulation" type of obesity is new and very important for the study of obesity as a disease, and it is expected to be useful in studies of the prevention of the aforementioned risk factors.

The present study was designed to assess the efficacy of *G cambogia* extract in anti–visceral fat accumulation in obese subjects. To account for previsceral fat obesity, inclusion criteria included VFA >90 cm^2. The VFA inclusion criterion was set at >90 cm^2 because that amount accounted for "previsceral fat obesity." Compared with the placebo group, the *G cambogia* group had significant decreases in VFA, SFA, and TFA; no significant differences were observed between male and female subjects. Furthermore, the test results for abdominal fat area had sufficient power ($1 - ß > 0.8$), so the sample size was appropriate. In a previous study,[32] we reported on the efficacy of HCA, but the subjects were classified as overweight or obese using BMI, whereas in our study, both BMI and VFA were used to define obesity, and all subjects were classified as obese. Other differences between that study and the present one are that the treatment period was 8 weeks, and there was no detailed dietary intervention. In that previous report, unlike the present one, there was no observed effect of *G cambogia* on SFA or TFA. However, these differences in outcomes were expected because of the differences in the treatment periods, the VFA levels of the subjects, and the use of dietary intervention. In the present study, subjects in the *G cambogia* group underwent a 4-week placebo treatment after their 12-week treatment to detect any rebound effect. No such effect was found. This result was expected because the decrease in abdominal fat from weeks 0 to 12 was mild.

A CT scan was performed at 0, 12, and 16 weeks. If these measurements had been conducted every 4 weeks, the effect of *G cambogia* may have been detected at an earlier period.

Anthropometric indices included body weight, BMI, and WHR. Body weight and BMI tended to be lower in the *G cambogia* group than in the placebo group at both 12 and 16 weeks but only in men. In their investigation of an antiobesity effect of *G cambogia,* Heymsfield et al[34] reported that body weight change during their 12-week study period did not differ significantly between the *G cambogia* and placebo groups. In that report, most of the subjects were

women. Among the female subjects in our study, body weight and BMI did not differ between the 2 groups, and to that extent our results and those of Heymsfield et al are similar.

The results of clinical laboratory tests did not change significantly, and no adverse effects were observed at any time in the test period. The *G cambogia* tablet used in this study was well tolerated throughout the 12-week treatment period.

CONCLUSION

G cambogia reduced abdominal fat accumulation in subjects, regardless of sex, who had the visceral fat accumulation type of obesity, and no rebound effect was observed. It is therefore hypothesized that *G cambogia* may be useful for the prevention and reduction of accumulation of visceral fat.

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