BPB Reports

Regular Article

A Randomized Placebo-controlled, Double-blind Study of Kosen-cha, a Polymerized Catechin-rich Green Tea, for Obesity in Pre-obese Japanese Subjects

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Received October 25, 2020; Accepted November 22, 2020

Green tea contains catechins, possessing anti-obesity and anti-oxidative effects, and has been consumed for hundreds of years. Our previous pilot study reported that Kosen-cha improves obesity and the parameters of metabolic syndromes in obese patients, however, the effect of Kosen-cha on obesity is still unclear in pre-obese subjects. The aim of this study was to investigate the effect of Kosen-cha on obesity and related clinical parameters including blood lipid and liver functions in a randomized placebo-controlled, double-blinded study. In total, 54 subjects with body mass index (BMI) of 25–30 were enrolled and randomized to receive either Kosen-cha or a placebo. The subjects drank Kosen-cha or the placebo thrice-daily for 12 weeks. Thereafter, we examined the effect of Kosen-cha on obesity (body weight, BMI, body fat, waist circumference, and visceral fat), lipid metabolism (triglyceride and high- and low-density lipoprotein cholesterol), and serum liver enzymes (aspartate aminotransferase, alanine aminotransferase (ALT), and γ-glutamyl transpeptidase). None of the subjects reported adverse effects from drinking Kosen-cha. Body weight, BMI, body fat, waist circumference, and visceral fat area remained unchanged in both groups. However, the change ratio of ALT significantly reduced between placebo and Kosen-cha groups after 12 weeks (Kosen-cha: −11.1 ± 32.7% vs. placebo: 8.46 ± 23.4%, $p = 0.019$). These results show that the consumption of Kosen-cha did not significantly improve obesity and may reduce liver enzyme levels in pre-obese Japanese subjects.

Key words Kosen-cha, polymerized catechin, obesity, liver enzymes

INTRODUCTION

Obesity is an important risk factor for diabetes mellitus, hypertension, and hyperlipidemia; these metabolic diseases accelerate atherosclerosis and increase the risk of cardiovascular and cerebrovascular diseases.[1)] Moreover, nonalcoholic fatty liver disease (NAFLD), an obesity-related liver disorder, is associated with the progression of liver cirrhosis and carcinoma.[2)] To prevent the onset of these maladies, reducing body weight and obesity is of great importance.

Green tea, one of the most widely consumed beverages, contains large amount of catechins, vitamin C, dietary fiber, and β-carotene and has potential anti-oxidative and hepatoprotective effects. Recently, several studies reported that green tea catechins facilitate reduction of obesity.[3–6)] These catechins are primarily categorized into eight groups depending on their structures; (-)-epigallocatechin gallate (the most effective catechin) is known to improve lipid metabolism, glucose tolerance, and obesity via activation of the AMPK pathway.[7–9)] The hepatoprotective effects of green tea catechins have been reported both in animal experiments and clinical trials. [10–12)] Reportedly, serum aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels were reduced in patients with NAFLD after consuming green tea extract for 90 d.[12)] However, green tea catechins have a strong bitter taste, which negatively affects its consumption in large quantities. We prepared Kosen-cha, a less bitter tea that is processed from green tea leaves. Kosen-cha contains large amounts of polymerized green tea catechins. Previous studies have shown that polymerized polyphenols have the potential to repress triglyceride absorption and increase energy consumption.[13,14)] In a pilot study, we reported that Kosen-cha reduced the body weight of patients with metabolic syndrome.[15)] However, whether it reduces the body weight of pre-obese subjects is yet to be elu-

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cidated. Therefore, the aim of the present study was to investigate the effect of Kosen-cha on obesity (body weight, BMI, and visceral fat area) and various biomarkers for metabolic syndromes (blood pressure, lipid, glucose, liver and kidney functions) of pre-obese Japanese subjects.

MATERIALS AND METHODS

Beverages (Kosen-cha and Placebo) Kosen-cha, which was prepared from green tea leaves processed at high temperature and pressure, was supplied by SUNDIA Co., Ltd (Tokyo, Japan).[15] Barley tea was used as the placebo because it contains no polymerized green tea catechins but has a similar color. Both Kosen-cha and the placebo were provided to the subjects as teabags containing 1.7 g of tea leaves in each bag; the subjects prepared tea each morning by adding 1,000 mL boiling water to the 3 teabags and drank the tea thrice daily with meals for 12 weeks. Tea bags were packed in aluminum pouch and stored at room temperature.

Subjects and Research Ethics In total, 54 pre-obese Japanese subjects without medication were enrolled in the present study. The inclusion criteria were (i) age 20-65 years, and (ii) BMI 25-30, whereas the exclusion criteria were as follows: (i) hospitalized or on medication, (ii) pregnant or lactating women, (iii) participation in other clinical trials, (iv) current smoking, (v) consumption of concentrated catechin drinks within the past three months, (vi) active malignant neoplasm, (vii) severe liver dysfunction, (viii) serum creatinine > 2.0 mg/dL, (ix) unable to supply written consent because of developmental disability, and (x) other conditions during study duration that the attending physician deemed grounds for exclusion. All subjects maintained their regular diet and lifestyle and were requested to avoid consuming beverages and supplements that influence body composition.

All subjects provided written informed consent before enrollment in this study. All researchers conformed to the World Medical Association Declaration of Helsinki, Oct (2013 revised) and Ethical Guidelines for Medical and Health Research Involving Human Subjects, the Ministry of Health, Labour, and Welfare during this study. The study protocol was approved by the Institutional Review Board of SBS Shizuoka Health Promotion Center and the University of Shizuoka (Shizuoka, Japan). The protocol was registered in the University Hospital Medical Information Network (UMIN000020068).

Study Design This randomized, parallel, double-blinded, and placebo-controlled study was conducted from December 2015 to April 2016 at SBS Shizuoka health promotion center. Fifty-four subjects who provided written informed consent were randomized into the Kosen-cha or placebo group. Sample size was determined by a result of previous study. The size in this study is above the calculation (power = 0.8; alpha = 0.05). Randomized assignment was performed using an envelope method by a statistician at the Kyoto Medical Center. Measurements and blood collections were performed thrice: prior to beginning consumption of the tea and after 6 and 12 weeks of drinking the tea as instructed. Blood samples were collected from all subjects under fasting conditions. To monitor drinking adherence, we instructed all subjects to record a patient diary, which was checked by the principal investigator once every 6 weeks. The data analysis was performed by Per Protocol analysis. The per-protocol set was defined before disclosure of data. Primary endpoints of this study were body weight, BMI, and visceral fat area and secondary endpoints were other clinical parameters including blood pressure, fasting blood glucose, HbA1c, blood lipid levels (TG, LDL-C, HDL-C), liver enzyme levels (AST, ALT, γ-GTP), adiponectin, and creatinine at the drinking for 12 weeks.

Measurements The measured criteria were as follows: body weight, BMI, body fat ratio, waist circumference, visceral fat area, subcutaneous fat area, blood pressure, and pulse rate. Visceral fat area and subcutaneous fat area were measured by single sliced computed tomography in SBS Shizuoka Health Promotion Center using ECLOS-16S and fatPointer software (HITACHI, Chiba, Japan). Blood tests were performed by SRL Inc. (Tokyo, Japan). Further, glucose, HbA1c (NGSP%), serum insulin, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglyceride (TG), AST, ALT, γ-glutamyl transpeptidase, alkaline phosphatase, cholinesterase, direct bilirubin, creatine kinase, adiponectin, leptin, hsCRP, serum creatinine, serum uric acid, sodium, chloride, and potassium were measured.

Statistical Analysis All data are expressed as means ± standard deviations. Statistical analysis of data was performed by Student's *t*-tests to compare the results of the Kosen-cha and placebo groups using IBM SPSS Statistics 21 (IBM Japan Ltd., Tokyo, Japan). A p-value < 0.05 was considered statistically significant.

RESULTS

Of the 54 subjects, four were excluded because of poor adherence (drinking frequency < 80%), and one was excluded because he participated in a marathon on the day before examination and this activity constituted a major change, which may have affected the results. Finally, 49 subjects completed the study, and their measurements were statistically evaluated (Fig. 1). Notably, during this study, no adverse effects were observed in any of the 54 subjects, including the five excluded subjects.

Owing to random assignment, there were no significant differences observed in terms of sex (Kosen-cha vs. placebo: 14 males, 9 females vs. 17 males, 9 females), age (44 ± 10 vs. 44 ± 10 years), and height (166.3 ± 8.3 vs. 166.6 ± 9.0 cm) between the two groups.

First, we compared the results from the Kosen-cha group with those of placebo group at each evaluation. Body weight, BMI, body fat, waist circumference, and visceral fat remained unchanged during the study duration (Table 1). The percent change rate of these measurements showed no significant differences between the two groups (Table 2).

Next, we evaluated blood pressure, blood glucose, blood lipids, and serum liver enzymes. These measurements showed no significant differences between the groups after 12 weeks (Table 3). However, the percent change rate of ALT significantly reduced in the Kosen-cha group after 12 weeks (Kosen-cha: -11.1 ± 32.7%; placebo: 8.46 ± 23.4%; p = 0.019; Table 4). After 6 weeks, the percent change rate of AST significantly reduced in the Kosen-cha group (Kosen-cha: -9.12 ± 24.7%; placebo: 4.27 ± 14.8%; p = 0.024; Table 4).

DISCUSSION

Polymerized polyphenols are considered anti-obesity com-

Table 1. Changes in Obesity-related Measurements (Kosen-cha vs. Placebo)

				0 week		6 weeks		12 weeks	
		Group	n	Average ± SD	*p* value	Average ± SD	*p* value	Average ± SD	*p* value
Body weight	(kg)	Kosen-cha	23	74.2 ± 9.2	0.849	74.4 ± 9.7	0.775	74.1 ± 9.5	0.771
		Placebo	26	73.7 ± 8.9		73.6 ± 8.8		73.4 ± 8.8	
BMI	(kg/m^2)	Kosen-cha	23	26.7 ± 1.4	0.472	26.8 ± 1.6	0.329	26.7 ± 1.7	0.378
		Placebo	26	26.5 ± 1.3		26.4 ± 1.3		26.3 ± 1.5	
Body fat	(%)	Kosen-cha	23	31.5 ± 6.6	0.439	31.8 ± 6.6	0.451	31.5 ± 6.9	0.481
		Placebo	26	30.0 ± 6.7		30.4 ± 6.4		30.1 ± 6.7	
Waist circumference	(cm)	Kosen-cha	23	90.4 ± 4.4	0.444	90.4 ± 4.7	0.463	90.0 ± 4.9	0.549
		Placebo	26	89.3 ± 6.1		89.3 ± 5.4		89.1 ± 5.6	
Visceral fat	(cm^2)	Kosen-cha	23	84.8 ± 32.3	0.304	Not performed		89.2 ± 40.2	0.151
		Placebo	26	76.1 ± 26.8				74.6 ± 29.8	

n: number of subjects, SD: standard deviation, BMI: body mass index
Comparison of the Kosen-cha and placebo group using Student's *t*-test

Table 2. Percent Change Rate of the Obesity-related Measurements (Kosen-cha vs. Placebo, %)

			Change rate from 0 to 6 weeks (%)		Change rate from 0 to 12 weeks (%)	
	Group	n	Average ± SD	*p* value	Average ± SD	*p* value
Body weight	Kosen-cha	23	0.148 ± 1.50	0.522	-0.139 ± 1.63	0.626
	Placebo	26	-0.122 ± 1.44		-0.439 ± 2.50	
BMI	Kosen-cha	23	0.303 ± 1.86	0.309	-0.238 ± 1.75	0.446
	Placebo	26	-0.203 ± 1.59		-0.703 ± 2.39	
Body fat	Kosen-cha	23	0.908 ± 3.66	0.639	-0.320 ± 2.89	0.743
	Placebo	26	1.37 ± 3.25		0.216 ± 3.86	
Waist circumference	Kosen-cha	23	-0.0433 ± 2.03	0.743	-0.458 ± 2.27	0.589
	Placebo	26	0.127 ± 1.58		-0.0824 ± 2.53	
Visceral fat	Kosen-cha	23	Not done		3.33 ± 15.3	0.214
	Placebo	26			-2.02 ± 14.4	

n: number of subjects, SD: standard deviation, BMI: body mass index
Comparison of the Kosen-cha and placebo groups using Student's *t*-test

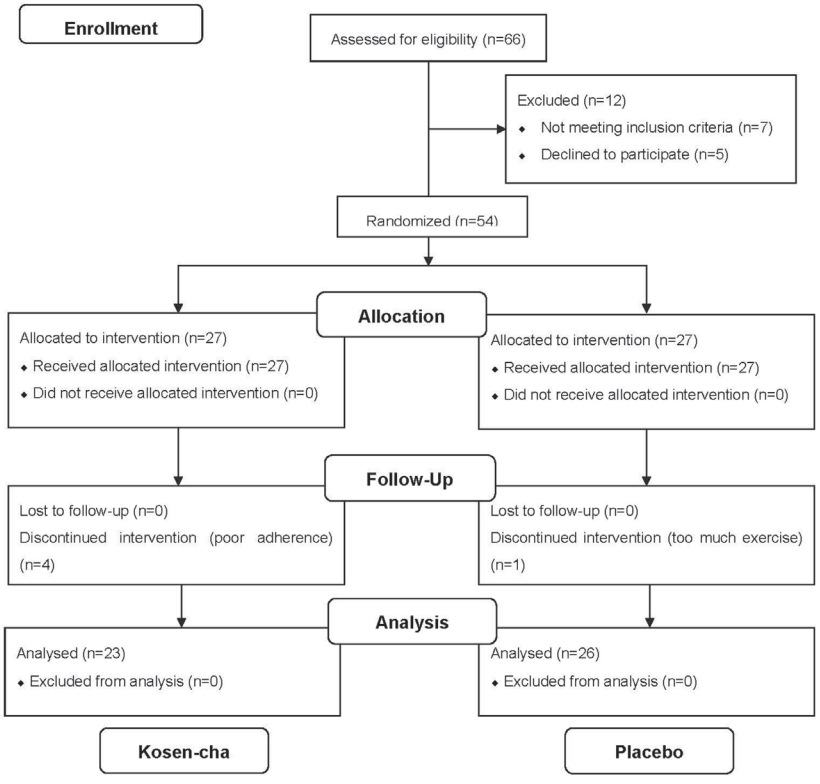

Fig. 1. Study Flow Chart

Subjects were randomly divided into two groups and followed during this study.

Table 3. Changes in Each Measurement (Kosen-cha vs. Placebo)

				0 week		6 weeks		12 weeks	
		Group	n	Average ± SD	*p* value	Average ± SD	*p* value	Average ± SD	*p* value
Subcutaneous fat	(cm^2)	Kosen-cha	23	213 ± 59.9	0.951	Not performed		216 ± 54.8	0.833
		Placebo	26	212 ± 62.6				212 ± 57.7	
SBP	(mmHg)	Kosen-cha	23	119 ± 17	0.695	117 ± 13	0.729	116 ± 13	0.664
		Placebo	26	120 ± 13		116 ± 13		118 ± 12	
DBP	(mmHg)	Kosen-cha	23	75 ± 11	0.424	71 ± 11	0.858	69 ± 9	0.975
		Placebo	26	72 ± 10		72 ± 12		69 ± 12	
Pulse rate	(bpm)	Kosen-cha	23	74 ± 12	0.013*	73 ± 12	0.047*	72 ± 10	0.185
		Placebo	26	66 ± 9		67 ± 10		69 ± 9	
Glucose	(mg/dL)	Kosen-cha	23	95 ± 12	0.050	94 ± 8	0.015*	95 ± 12	0.068
		Placebo	26	90 ± 6		89 ± 7		90 ± 9	
HbA1c	(NGSP%)	Kosen-cha	23	5.5 ± 0.4	0.179	5.5 ± 0.4	0.319	5.5 ± 0.4	0.317
		Placebo	26	5.3 ± 0.2		5.4 ± 0.2		5.4 ± 0.2	
Insulin	(μIU/mL)	Kosen-cha	23	6.85 ± 2.14	0.864	6.61 ± 3.28	0.710	6.78 ± 2.88	0.648
		Placebo	26	6.73 ± 2.64		7.02 ± 4.19		7.25 ± 3.89	
HDL-C	(mg/dL)	Kosen-cha	23	56 ± 17	0.855	56 ± 15	0.267	56 ± 12	0.995
		Placebo	26	56 ± 11		52 ± 11		56 ± 12	
LDL-C	(mg/dL)	Kosen-cha	23	122 ± 32	0.919	133 ± 37	0.458	123 ± 30	0.922
		Placebo	26	123 ± 22		126 ± 23		124 ± 23	
TG	(mg/dL)	Kosen-cha	23	139 ± 99	0.637	119 ± 57	0.374	116 ± 83	0.873
		Placebo	26	128 ± 70		135 ± 67		119 ± 63	
AST	(U/L)	Kosen-cha	23	26 ± 13	0.071	22 ± 4	0.657	24 ± 7	0.521
		Placebo	26	21 ± 4		22 ± 5		23 ± 6	
ALT	(U/L)	Kosen-cha	23	32 ± 21	0.065	27 ± 16	0.767	26 ± 16	0.877
		Placebo	26	24 ± 8		26 ± 11		25 ± 11	
γ-GTP	(U/L)	Kosen-cha	23	55 ± 48	0.049*	49 ± 38	0.272	43 ± 37	0.338
		Placebo	26	35 ± 19		38 ± 25		35 ± 19	
ALP	(U/L)	Kosen-cha	23	211 ± 69	0.545	199 ± 57	0.784	196 ± 63	0.938
		Placebo	26	201 ± 46		203 ± 57		195 ± 47	
ChE	(U/L)	Kosen-cha	23	375 ± 68	0.528	385 ± 72	0.306	369 ± 70	0.877
		Placebo	26	364 ± 60		365 ± 65		372 ± 70	
D-Bil	(mg/dL)	Kosen-cha	23	0.2 ± 0.1	0.986	0.2 ± 0.1	0.861	0.2 ± 0.1	0.832
		Placebo	26	0.2 ± 0.1		0.2 ± 0.1		0.2 ± 0.1	
CK	(U/L)	Kosen-cha	23	128 ± 79	0.656	114 ± 69	0.924	190 ± 172	0.733
		Placebo	26	139 ± 102		112 ± 37		215 ± 314	
Adiponectin	(μg/mL)	Kosen-cha	23	8.8 ± 6.2	0.725	8.9 ± 7.3	0.921	8.5 ± 6.5	0.680
		Placebo	26	9.3 ± 4.9		9.1 ± 4.7		9.2 ± 5.1	
Leptin	(ng/mL)	Kosen-cha	23	12.5 ± 7.6	0.779	15.4 ± 10.4	0.240	15.5 ± 11.0	0.508
		Placebo	26	11.9 ± 6.9		12.3 ± 8.2		13.4 ± 10.5	
hs-CRP	(ng/mL)	Kosen-cha	23	2987 ± 6638	0.192	1088 ± 1104	0.684	2082 ± 3957	0.691
		Placebo	26	1182 ± 1991		942 ± 1355		1564 ± 4974	
Creatinine	(mg/dL)	Kosen-cha	23	0.77 ± 0.15	0.744	0.80 ± 0.18	0.631	0.80 ± 0.17	0.752
		Placebo	26	0.76 ± 0.14		0.78 ± 0.14		0.79 ± 0.13	
Uric acid	(mg/dL)	Kosen-cha	23	5.9 ± 1.2	0.806	6.0 ± 1.4	0.931	6.1 ± 1.5	0.670
		Placebo	26	6.0 ± 1.5		6.0 ± 1.4		6.3 ± 1.3	
Na^+	(mEq/L)	Kosen-cha	23	140 ± 2	0.212	139 ± 2	0.110	140 ± 2	0.082
		Placebo	26	141 ± 1		140 ± 2		141 ± 1	
Cl^-	(mEq/L)	Kosen-cha	23	103 ± 1	0.306	103 ± 2	0.541	104 ± 2	0.205
		Placebo	26	104 ± 2		103 ± 1		104 ± 1	
K^+	(mEq/L)	Kosen-cha	23	4.1 ± 0.2	0.965	4.1 ± 0.3	0.681	4.1 ± 0.3	0.622
		Placebo	26	4.1 ± 0.2		4.1 ± 0.3		4.1 ± 0.3	

n: number of subjects, SD: standard deviation, SBP: systolic blood pressure, DBP: diastolic blood pressure, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, TG: triglyceride, AST: aspartate aminotransferase, ALT: alanine aminotransferase, γ-GTP: γ-glutamyl transpeptidase, ALP: alkaline phosphatase, ChE: cholinesterase, D-Bil: direct bilirubin, CK: creatine kinase, hs-CRP: high sensitivity C-reactive protein
Comparison of the Kosen-cha and placebo groups using Student's *t*-test, *$p < 0.05$

Table 4. Percent Change Rate of Each Measurement (Kosen-cha vs. Placebo, %)

			Change rate 0-6 weeks (%)		Change rate 0-12 weeks (%)	
	Group	n	Average ± SD	*p* value	Average ± SD	*p* value
Subcutaneous fat	Kosen-cha	23	Not performed		2.01 ± 7.58	0.912
	Placebo	26			1.67 ± 12.7	
SBP	Kosen-cha	23	-0.610 ± 9.90	0.242	-1.40 ± 10.5	0.847
	Placebo	26	-3.55 ± 7.39		-1.89 ± 7.22	
DBP	Kosen-cha	23	-4.45 ± 11.4	0.218	-6.34 ± 11.9	0.429
	Placebo	26	-0.779 ± 9.20		-3.36 ± 14.0	
Pulse rate	Kosen-cha	23	-0.338 ± 13.2	0.622	-1.23 ± 14.4	0.185
	Placebo	26	1.32 ± 10.2		4.38 ± 13.0	
Glucose	Kosen-cha	23	-0.156 ± 12.4	0.615	0.872 ± 13.3	0.726
	Placebo	26	-1.53 ± 5.91		-0.185 ± 7.23	
HbA1c	Kosen-cha	23	0.450 ± 3.10	0.454	0.138 ± 3.69	0.593
	Placebo	26	1.09 ± 2.82		0.616 ± 2.47	
Insulin	Kosen-cha	23	-1.70 ± 40.4	0.399	3.58 ± 43.9	0.606
	Placebo	26	9.43 ± 49.9		10.4 ± 47.7	
HDL-C	Kosen-cha	23	1.52 ± 11.9	0.047*	2.00 ± 12.8	0.752
	Placebo	26	-5.41 ± 11.8		0.938 ± 10.5	
LDL-C	Kosen-cha	23	9.10 ± 16.0	0.313	1.61 ± 13.6	0.839
	Placebo	26	4.12 ± 18.0		0.849 ± 12.6	
TG	Kosen-cha	23	8.26 ± 54.5	0.532	-3.92 ± 42.9	0.737
	Placebo	26	17.9 ± 52.5		0.271 ± 43.6	
AST	Kosen-cha	23	-9.12 ± 24.7	0.024*	0.158 ± 34.6	0.433
	Placebo	26	4.27 ± 14.8		6.24 ± 17.4	
ALT	Kosen-cha	23	-5.90 ± 34.0	0.061	-11.1 ± 32.7	0.019*
	Placebo	26	11.7 ± 30.0		8.46 ± 23.4	
γ-GTP	Kosen-cha	23	1.50 ± 34.8	0.389	-11.5 ± 29.2	0.063
	Placebo	26	9.85 ± 32.4		2.29 ± 21.2	
ALP	Kosen-cha	23	-4.80 ± 8.65	0.062	-6.80 ± 10.9	0.131
	Placebo	26	1.00 ± 12.0		-2.52 ± 8.51	
ChE	Kosen-cha	23	2.87 ± 6.05	0.168	-1.58 ± 6.87	0.094
	Placebo	26	0.325 ± 6.63		2.14 ± 8.18	
D-Bil	Kosen-cha	23	13.8 ± 52.8	0.665	29.3 ± 58.4	0.872
	Placebo	26	7.69 ± 45.9		31.7 ± 47.6	
CK	Kosen-cha	23	-2.26 ± 32.5	0.753	71.1 ± 195	0.912
	Placebo	26	-5.08 ± 29.7		78.4 ± 253	
Adiponectin	Kosen-cha	23	-0.930 ± 13.2	0.768	-4.51 ± 16.3	0.568
	Placebo	26	-1.85 ± 8.23		-2.45 ± 7.75	
Leptin	Kosen-cha	23	24.8 ± 52.8	0.060	21.4 ± 48.4	0.163
	Placebo	26	2.25 ± 26.2		4.28 ± 35.9	
hs-CRP	Kosen-cha	23	73.2 ± 356	0.643	520 ± 1860	0.291
	Placebo	26	37.0 ± 166		119 ± 422	
Creatinine	Kosen-cha	23	3.36 ± 6.44	0.843	3.80 ± 7.36	0.707
	Placebo	26	2.99 ± 6.49		4.55 ± 6.55	
Uric acid	Kosen-cha	23	2.65 ± 19.3	0.637	4.41 ± 20.4	0.639
	Placebo	26	0.555 ± 11.0		6.68 ± 13.0	
Na^+	Kosen-cha	23	-0.951 ± 2.00	0.483	0.254 ± 1.35	0.539
	Placebo	26	-0.596 ± 1.50		0.471 ± 1.10	
Cl^-	Kosen-cha	23	-0.409 ± 1.85	0.730	0.381 ± 1.84	0.639
	Placebo	26	-0.578 ± 1.54		0.607 ± 1.51	
K^+	Kosen-cha	23	0.557 ± 6.23	0.646	0.470 ± 7.53	0.603
	Placebo	26	1.34 ± 5.60		1.44 ± 5.36	

n: number of subjects, SD: standard deviation, SBP: systolic blood pressure, DBP: diastolic blood pressure, HDL-C: high-density lipoprotein cholesterol, LDL-C: low-density lipoprotein cholesterol, TG: triglyceride, AST: aspartate aminotransferase, ALT: alanine aminotransferase, γ-GTP: γ-glutamyl transpeptidase, ALP: alkaline phosphatase, ChE: cholinesterase, D-Bil: direct bilirubin, CK: creatine kinase, hs-CRP: high sensitivity C-reactive protein
Comparison of the Kosen-cha and placebo groups using Student's *t*-test, *$p < 0.05$

pounds because they increase energy consumption and reduce lipid absorption through the inhibition of lipase.[14,16] Reportedly, daily consumption of 8 g oolong tea leaves, which is rich in polymerized polyphenols, reduced body weight and subcutaneous fat.[17] Our pilot study showed that Kosen-cha significantly reduced the body weight and BMI of overweight patients.[15] However, in the present study, body weight, BMI, waist circumference, blood glucose, LDL-C, and TG remained unchanged between the two groups. The BMI of the all subjects enrolled in the pilot study was > 30, and the consumption of Kosen-cha reduced their body weight over 12-week administration. Conversely, the subjects enrolled in the present study had a BMI < 30, suggesting that Kosen-cha might exert anti-obesity effect in the subjects with obese class I (WHO).

Polymerized polyphenols can repress lipid and sugar absorption from the intestine.[13] Unfortunately, Kosen-cha did not significantly change blood glucose or lipid levels in the present study; the measurements of all enrolled subjects remained within the normal range during the study duration. It is reported that green tea improves obesity and serum liver enzymes.[18] Monomeric polyphenols in green tea (e.g., catechins) have strong anti-oxidative effects, repress inflammation in hepatocytes, and reduce serum AST and ALT, resulting in protection of the liver.[19,20] In our present study, Kosen-cha significantly improved the percent change rate of ALT. However, these changes in ALT level are within the normal range. Therefore, another clinical study is required to completely elucidate the effect of monomeric and polymerized polyphenols on serum liver enzymes.

The results of the present study show that the consumption of Kosen-cha for 12 weeks did not significantly improve obesity in pre-obese Japanese subjects. As the results suggest that Kosen-cha has potential protective effect on liver enzymes, we anticipate the value of performing a clinical trial of Kosen-cha in subjects with mild liver dysfunction to elucidate these effects.

Limitations The limitations of the present study are as follows: 1) we did not compare the consumption of green tea; and 2) we were unable to perform a stratified analysis due to the shortage of subject information related to habits such as exercise, eating, and sleeping.

Acknowledgment Dr. Yasuo Shimizu, the Shimizu Technician office chief, was initial member of the Kosen-cha projects. Unfortunately, he was sudden died before finish this project. We thank him for his contributions and wish he rest in peace.

Conflicts of interest This study was sponsored by SUNDIA Co., Ltd. under collaboration research agreement.

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