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ORIGINAL PAPER

Effect of intake of gardenia fruits and combined exercise of middle-aged obese women on hormones regulating energy metabolism

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[Purpose] This study is aimed at analyzing how exercise and gardenia affect hormones that regulate energy metabolism by having middle aged, obese women exercise and take gardenia simultaneously. **[Methods]** This study assigned a total of 35 middle-aged obese women with body fat percentage of more than 35 percent into 9 people of the complex treatment group of intake of gardenia and exercise, 9 people of the exercise group, 9 people of the gardenia group and 8 people of the control group in order to find out the effect of the intake of gardenia fruits and Combined exercise of 8 weeks on the body composition, hormones regulating energy metabolism. This study arranged .08 g per weight of 1 kg of the gardenia fruits to be taken twice a day for 8 weeks after breakfast and dinner through the numerical method of roasting the gardenia fruits on fire. And the exercise program was set to be five times a week for 8 weeks, whereas the aerobic exercise of 60 to 70 minutes was 50 to 60 percent for HRmax; thus, the resistance exercise was set to be 1-RM 50 percent. As for the data analysis, the two-way repeated measures ANOVA was utilized for the analysis of interactive effect between groups and times. **[Results]** Thus, the obtained conclusion is as follows: The %fat and WHR has decreased further in the gardenia+exercise group and the exercise group as compared with the control group. And the visceral fat area has decreased further in the gardenia and exercise group and the gardenia group as compared with the control group ($p<.05$). In addition, the gardenia+exercise group and the exercise group were found to have a significant improvement effect in all the items of body composition, and the gardenia group has reduced the fat percentage and BMI after the treatment ($p<.05$). Leptin has decreased further in the gardenia+exercise group and the exercise group as compared with the control group, and the insulin resistance and GLP-1 have decreased in all the treatment groups ($p<.05$). **[Conclusion]** As a result of this study, all the treatment groups were found to have an improvement effect of research variables in general; therefore, the single treatment and complex treatment for the middle-aged obese women were found to have a positive impact on body composition, adjusting factors for energy metabolism. Also, the complex treatment was found to be more positive in terms of change amount. In particular, in the case of visceral fat area that is the major risk factor for metabolic disease of middle-aged obese women, it was found to have decreased further in the complex treatment group than the gardenia group; therefore, the complex treatment was found to be more advantageous. **[Keyword]** exercise, gardenia fruits, Middle-aged Obese Women, Leptin, GLP-1, insulin resistance.

INTRODUCTION

Obesity causes an imbalance of the body metabolic processes in the aftermath of excessive intake compared to the consumption of energy. Further progressed obesity leads to changes in lipid metabolism, sugar metabolism, and adipocytokine secretion in fat cells [1]. The reduction in insulin secretion caused by obesity can result in developing a wide range of diseases such as diabetes, hypertension, hyperlipidemia, and metabolic syndrome [2]. As women in their fifties or sixties are more likely to rapidly develop the obesity-related diseases [3], it is essential to actively tackle obesity in order to reduce the social costs caused by treating middle-aged obese women.

Exercise and eating habits are important to prevent and treat obesity. There are reports indicating that in particular, exercise and the intake of natural products including green tea, green beans, and gardenia can increase energy consumption [4-7].

It has been reported that insulin, GLP-1(Glucagon-Like Peptide-1), and leptin, which are related to the occurrence of obesity caused by an imbalance of energy, are hormones that regulate appetite and energy expenditure [8,15,38].

Insulin, which is synthesized in the pancreatic β-cell and

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secreted, acts to maintain glucose concentration in the blood. Higher glucose concentration in the blood makes insulin secreted to let the blood glucose influx into cells so as to be saved in the form of glycogen and help convert into fatty acids in fat tissue. Diseases such as obesity and diabetes cause insulin to be higher in blood, which means tissue's insulin resistance. Regular exercise is reported to lead to weight loss and a reduction in blood insulin levels [9].

GLP-1, a hormone secreted from the digestive system while nutrients are being absorbed, is known to regulate blood sugar by stimulating the pancreas to secrete insulin [10]. This hormone is also shown to increase the hydrolysis of TG in adipose tissue. Once the blood glucose is restored to normal, GLP-1 is no longer secreted and blocks the secretion of insulin not to cause hypoglycemia [11]. In some studies, those who were obese exercised continuously. As a result, some participants lost weight and their GLP-1 levels increased [12], while others found that their GLP-1 levels decreased. Of course, these were contradictory results [13,14].

Leptin plays a pivotal role in energy intake and metabolism and is closely related to the amount of fat tissue [15]. An increase in leptin levels acts on receptors in the hypothalamus, which leads to the feeling of satiety. This also stimulates sympathetic nerves to increase energy consumption, which results in reducing body fat tissue. Regular exercise has been reported to reduce body fat and leptin levels [16].

Gardenia jasminoides, reported to be effective in improving obesity, is the fruit of Gardenia jasminoides Ellis which belongs to Rubi-aceue species. Its principal ingredients include Genipin, Geniposide, Geniposidic acid, Ursolic acid, Rutin, Chlorogenic acid, Stigmasterol, Crocetin, and Crocin <Table 1> [17].

Geniposide, one of the main ingredients of Gardenia jasminoides, is known to be effective in inhibiting body weight gain as well as improving abnormal lipid levels, high insulin levels, impaired glucose intolerance, and insulin resistance [18]. Also, this ingredient improved serum triglycerides, phospholipids, lipid peroxidation, blood glucose, and free fatty acids levels as well as the results of liver function tests of rats that were bred with food containing high sugar [19].

Table 1. The components of gardenia fruit (mg)

Compound name	mg
Ursolic acid	32
Rutin	475
Chlorogenic acid	140
Stigmasterol	161
Geniposide	30
Genipin	1,000
Geniposidic acid	30
Crocetin	15
Crocin	500

Genipin promoted fat oxidation of free fatty acids by increasing the revelation of PPAR-α (Peroxisome Proliferator Activated Receptor-α) [18]. It also inhibited the activity of UCP-2(Uncoupling Protein-2) which prevents the generation of ATP. As a result, this improved insulin resistance and diabetes by ameliorating pancreatic β-cell dysfunction caused by obesity and hyperglycemia [20].

Many studies have reported that as for obese people, exercise has positive effects on hormones that regulate energy metabolism. However, the reports on the effects of GLP-1 have not been consistent. It is reported that the causes of this include the negative energy balance, exercise intensity, exercise methods, exercise period, and participants' characteristic [12,21,22]. Additional research is needed to compensate this. As for gardenia effects on obesity, studies on energy metabolism have been reported but it is difficult to find studies on people. The effects of exercise on energy metabolism have been reported and gardenia effects associated with energy metabolism have been also reported. However, there are no studies on differences in energy metabolism among those who exercise and take gardenia versus those who only do one or the other. Therefore, this study is aimed at analyzing how exercise and gardenia affect hormones that regulate energy metabolism by having middle-aged, obese women exercise and take gardenia simultaneously.

METHODS

Test Subjects

This study was conducted on a total of 35 middle-aged women in their 40s-60s who lived in 'C' City, who had not done any kind of regular exercise for the past 6 months, who had their body mass index (BMI) of greater than 25, and who had their body fat percentage of higher than 35%. And

Table 2. Physical characteristics of the subjects

Variables	G + Eg (n = 9)	Eg (n = 9)	Gg (n = 9)	Cg (n = 8)
years (yrs)	57.89 ± 6.29	56.88 ± 5.16	58.89 ± 5.36	56.13 ± 5.36
heigt (cm)	153.52 ± 4.84	156.26 ± 4.02	159.81 ± 9.19	158.17 ± 4.42
weight (kg)	61.97 ± 4.75	64.68 ± 7.18	67.27 ± 4.14	69.84 ± 11.79
BMI	26.28 ± 2.01	26.46 ± 2.04	26.61 ± 3.76	27.76 ± 3.38
fat (%)	37.11 ± 2.52	36.41 ± 1.74	36.84 ± 5.19	37.34 ± 5.12

values are means ± SD, Gardenia + Exercise group: G + Eg, Exercise group: Eg, Gardenia group: Gg, Control group: Cg.

then, the test subjects were divided into 4 groups: 9 persons for the complex gardenia intake and exercise group, 9 for the exercise group, 9 for the gardenia group, and the remaining 8 for the control group.

The test subjects were explained fully about the objective of this study, and each of them signed on an agreement for voluntary participation. The physical features of the test subjects are as shown in <Table 2>.

Measurement Method

Body compositional analysis

All test subjects were asked to stand upright on the electrode of "Inbody 720 (Bio space Co., Korea)" after 10 hours of fasting and were instructed to hold both handles with each hand and to gently push an electrode switch with each thumb while keeping a distance between the armpits and the body. The Bioelectrical Impedance Analysis (Inbody 720, Bio space Co., Korea) was used to measure the electricity resistances on the left and right sole and on the fingers, and to record the values of the body weight (kg), the BMI (%) and the visceral fat area (cm^2).

Blood collecting and serological test

To conduct an analysis on energy metabolism regulating hormones, the test subjects were asked to have their blood collected at 8 o'clock in the following morning after 10 hours of fasting. Approximately 10 ml of blood per person was drawn from the cubital vein in a sitting position. In this process, an anticoagulant-treated vacuum blood-collecting tube was used to collect blood. The collected venous blood was stirred in a centrifuge for 10 min at a rate of 3,000 rpm to extract blood serum, which was stored at a temperature of -70℃ until being analyzed. The analysis on a blood-sugar level was done with the auto biochemistry analyzer (Bio Systems, Co Spain). By using the ELISA (Enzyme-Linked Immunosorbent Assay) Kit (Promega, USA) and in accordance with the manual, the optical density of the serum insulin and leptin were measure at 450 nm, while that of GLP-1 was done at 355 nm/460 nm using Multiskan Go (Thermo, Co USA).

Insulin resistance calculation method

HOMA-IR, an insulin resistance factor, was calculated using the formula of [Insulin at fasting (µU/ml) × blood-sugar level at fasting (mg/dl)/405] [23].

Energy consumption measurement

The energy and nutrition intake were analyzed with the nutrition analysis program CANPro 3.0 (Korea Nutrition Society, Korea) based on the meals consumed one day before and after the treatment, which were recorded with a 24 hour recall method.

Gardenia processing and intake method

The study used the top quality Boseong gardenia fruits for the test, which were purchased through an oriental medicine middleman. The Korean term "Suchi" means a process of preparing a raw herb medicine. The aim of the traditional processing method is to enhance the medicinal benefits by maximizing the efficacy and minimizing the toxicity. The most commonly used methods of processing gardenia fruits are roasting or grilling them on heat. Naturally dried gardenias were roasted on heat in accordance with the traditional processing methods, as shown in [24] and [25]. In terms of a gardenia intake method, a dosage of 3-10 grams is recommended for both male and female test subjects (26). After this study took into account the body weights of each test subject, a dosage of .08 g per kg was packaged into a separate package and was given to the test subject on a weekly basis, and they were told to intake the medication two times per day after breakfast and dinner.

Exercise test

The target heart rate was determined using the HRmax and HRmax of an individual test subject in accordance with the Karvonen formula; Target Heart Rate = [Exercise Intensity × (HRmax - HRrest) + HRrest] [27]. The muscle resistance exercise test was done by substituting the 1-RM to an indirect measurement formula [28], as shown in <Table 3>. The measurement consists of 5 exercise items; Shoulder Press, Arm Curl, Leg Extension, Leg Press, Sit Up. Each item was conducted twice, and the results were added up and were averaged to obtain the 1-RM.

Exercise Method

An aerobic test was done at 50-60% of the HRmax. Each test subject was required to wear an auto heart rate monitor (Polar Heart Rate Analyzer: Polar Electro OY, Finland) during exercise to confirm whether the exercise intensity set prior to the measurement was met by monitoring the heart rates.

Table 3. 1 - RM Indirect estimation method

1-RM = W0 + W1
W1 = W0 × 0.025 × R
W0 : a bit heavy weight enough to think after warm enough (Repeat 14 to 15 times the weight for exercise)
R = number of repetitions

Table 4. Exercise program

Warming-up	Main exercise	Cool down	Exercise time	Exercise intensity
Stretching 10 minutes	**Aerobicexercise** * treadmil	Stretching 10 minutes	20 minutes	Hrmax 50% - 60%
	Resistance exercise * arm curl, * shoulder Press * leg extension, * leg press, * sit up		1-4 weeks, 15 times, 2set 20 minutes 5-8weeks, 15 times, 3set 30 minutes	1-RM 50%

Table 5. Changes of body compositions

Variables	Group	Pre	Post	△ (%)	Source	*F*	p
Weight (kg)	G + Eg (a)	61.97 ± 5.85	60.29 ± 6.01**	-1.68(-2.79)			
	Eg (b)	64.68 ± 7.18	60.42 ± 7.10***	-4.26(-7.05)	Group	2.132	.116
	Gg (c)	67.27 ± 4.14	65.04 ± 5.60*	-2.23(-3.43)	Time	20.984	.001
	Cg (d)	69.84 ± 11.79	70.63 ± 12.15	0.79(1.12)	G*T	5.746	.003
	post-hoc	NS	NS				
Fat (%)	G + Eg (a)	37.11 ± 2.52	32.86 ± 3.28**	-0.13(-12.93)			
	Eg (b)	36.41 ± 1.74	31.57 ± 1.96***	-4.84(-15.33)	Group	1.823	.164
	Gg (c)	36.84 ± 5.19	34.99 ± 6.13**	-1.85(-5.29)	Time	42.720	.001
	Cg (d)	37.34 ± 5.12	39.46 ± 5.16*	2.12(5.37)	G*T	21.024	.001
	post-hoc	NS	a, b < d				
BMI	G + Eg (a)	26.29 ± 2.01	25.57 ± 2.08**	-0.72(-2.82)			
	Eg (b)	26.46 ± 2.04	25.51 ± 1.97***	-0.95(-3.72)	Group	.856	.474
	Gg (c)	26.61 ± 3.76	25.77 ± 4.17*	-0.84(-3.26)	Time	19.874	.001
	Cg (d)	27.76 ± 3.38	28.10 ± 3.57	0.34(1.21)	G*T	5.615	.003
	post-hoc	NS	NS				
VFA (cm^2)	G + Eg (a)	117.800 ± 10.03	87.12 ± 18.45***	-30.68(-35.22)			
	Eg (b)	114.23 ± 5.24	102.23 ± 11.02*	-12(-11.74)	Group	2.212	.106
	Gg (c)	118.26 ± 29.47	120.59 ± 26.88	-2.33(-1.8)	Time	19.508	.001
	Cg (d)	120.70 ± 19.40	124.46 ± 17.52	3.76(3.02)	G*T	15.088	.001
	post-hoc	NS	a < c, d				
FFA (kg)	G + Eg (a)	38.89 ± 3.07	39.87 ± 3.74*	0.98(2.46)			
	Eg (b)	41.07 ± 3.92	41.92 ± 3.94**	0.85(2.03)	Group	1.510	.231
	Gg (c)	42.31 ± 1.47	41.01 ± 2.42	-1.3(-3.17)	Time	.005	.942
	Cg (d)	43.35 ± 5.02	42.59 ± 4.68	-0.76(-1.78)	G*T	4.172	.014
	post-hoc	NS	NS				
WHR (index)	G + Eg (a)	.938 ± .023	.888 ± .022***	-.05(-5.63)			
	Eg (b)	.926 ± .045	.901 ± .035*	-.03(-2.77)	Group	2.726	.061
	Gg (c)	.940 ± .046	.924 ± .042	-.016(-1.74)	Time	24.718	.001
	Cg (d)	.942 ± .061	.965 ± .039	.023(2.38)	G*T	8.039	.001
	post-hoc	NS	a, b < d				

values are means ± SD, * paired t-test significant difference p < .05, ** paired t-test significant difference p < .01, *** paired t-test significant difference p < .001, △: Post value-pre value, Gardenia + Exercise group: G + Eg, Exercise group: Eg, Gardenia group: Gg, Control group: Cg, G*T: Group*Time, VFA: Visceral fat area, FFA: Fat free mass, WHR: Waist hip ratio.

The resistance exercise was done at 50% of the 1-RM for the two sets of 15 repetitions for the first 4 weeks and for 3 sets of 15 repetitions from the 5th to 8th week. The resting time between the sets should not last for more than 30 seconds, while that between the exercises should not be longer than 1 minute. For the resistance exercise, a health machine (Lexco, Taeyoung Co, Korea) was used.

As seen in <Table 4>, a 60-70 min session of the complex exercise program was carried out 5 times a week for 8 weeks. One session consists of 10 min of warm-up, 40-50 min of a main exercise (20 min of aerobic exercise: Treadmill, 20-30 min of resistance exercise: Shoulder Press, Arm Curl, Leg

Extension, Leg Press, Sit Up), and 10 min of warm down.

Data processing

The test results were calculated using SPSS Ver. 14.0 Program. All data are combined to calculate an average and standard deviation. The one-way ANOVA was used for the homogenous pre-test. When the homogeneity of the pre-test values were confirmed, the two-way repeated measures ANOVA was adopted to verify changes between times and groups and the interactions, and the post verification was done using the Paired t-test and the one-way ANOVA. In case that there was a significant difference among groups, the Scheffe method was used. The statistical significance level of all data was set at .05.

RESULTS

As shown in <Table 5>, the body composition showed significant interactions in all test items. The analysis results on time-specific differences of each group showed that all treatment groups recorded a decrease in the body weight, % fat and BMI, while both the gardenia + exercise group and the exercise group presented a decrease in the visceral fat area and the WHR in contrast to an increase in the fat-free mass ($p < .05$). In addition, the complex treatment group showed a greater drop in the visceral fat area than the gardenia group.

The energy metabolism regulating hormones as shown in <Table 6> indicated an interaction with insulin resistance and leptin. According to the analysis results on time-specific

Table 6. Changes of hormones regulating energy metabolism

Variables	Group	Pre	Post	△ (%)	Source	*F*	p
Insulin (μm/ml)	G + Eg (a)	8.03 ± 2.37	6.18 ± 3.09	-1.85(-29.94)			
	Eg (b)	8.04 ± 1.66	7.14 ± 2.29	-0.9(-12.61)	Group	.605	.617
	Gg (c)	8.10 ± 2.41	6.05 ± 1.38*	-2.05(-33.88)	Time	9.403	.004
	Cg (d)	8.05 ± 2.15	8.34 ± 2.11	0.29(3.48)	G*T	20.33	.130
	post-hoc	NS	NS				
Glouse (mg/dl)	G + Eg (a)	102.56 ± 8.52	93.11 ± 12.97*	-9.45(-10.15)			
	Eg (b)	101.89 ± 6.92	92.15 ± 10.08*	-9.74(-10.57)	Group	.387	.763
	Gg (c)	102.00 ± 9.23	97.11 ± 15.815	-4.89(-5.04)	Time	11.054	.002
	Cg (d)	102.25 ± 6.18	100.13 ± 10.33	-2.12(-2.12)	G*T	.859	.473
	post-hoc	NS	NS				
Insulin resistance (index)	G + Eg (a)	2.04 ± .61	1.43 ± ..74*	-0.61(-42.66)			
	Eg (b)	2.02 ± .44	1.62 ± ..52*	-0.4(-2.69)	Group	.579	.633
	Gg (c)	2.06 ± .71	1.47 ± ..49**	-0.59(-40.14)	Time	20.636	.001
	Cg (d)	2.01 ± .47	2.06 ± ..55	0.05(2.43)	G*T	3.003	.045
	post-hoc	NS	NS				
GLP-1 (ng/ml)	G + Eg (a)	4.11 ± .29	3.82 ± ..42*	-0.29(-7.59)			
	Eg (b)	4.22 ± .30	4.04 ± ..36*	-0.18(-4.45)	Group	.576	.635
	Gg (c)	4.12 ± .32	3.82 ± ..28**	-0.30(-7.85)	Time	15.856	.001
	Cg (d)	4.17 ± .41	4.19 ± ..76	0.02(0.48)	G*T	2.859	.045
	post-hoc	NS	NS				
Leptin (ng/ml)	G + Eg (a)	11.03 ± 4.92	6.51 ± 3.68***	-4.52(-69.43)			
	Eg (b)	11.49 ± 2.62	7.06 ± 2.20**	-4.43(-62.75)	Group	1.069	.377
	Gg (c)	11.24 ± 4.06	8.53 ± 3.41**	-2.71(-30.78)	Time	42.548	.001
	Cg (d)	11.46 ± 4.79	11.76 ± 2.96	0.30(2.56)	G*T	6.390	.002
	post-hoc	NS	a, b < d				
Energy intake (kcal)	G + Eg (a)	1880.34 ± 277.45	1691.47 ± 334.34*	-188.87(-11.17)			
	Eg (b)	1892.03 ± 259.51	1822.91 ± 313.50	-69.12(-3.80)	Group	.341	.796
	Gg (c)	1888.18 ± 146.12	1697.78 ± 247.72**	-190.4(-19.04)	Time	13.319	.001
	Cg (d)	1892.45 ± 334.12	1909.30 ± 345.31	16.85(0.88)	G*T	2.818	.055
	post-hoc	NS	NS				

values are means ± SD, * paired t-test significant difference $p < .05$, ** paired t-test significant difference $p < .01$, *** paired t-test significant difference $p < .001$, △: Post value-pre value, Gardenia + Exercise group: G + Eg, Exercise group: Eg, Gardenia group: Gg, Control group: Cg, G*T: Group*Time, GLP-1: Glucagon Like Peptide-1.

differences by group, the insulin resistance, GLP-1 and leptin were all decreased, while the gardenia + exercise group showed a decrease in blood-sugar level and energy consumption and the exercise group recorded a drop in blood-sugar level. And the gardenia group presented a drop in insulin and energy consumption ($p < .05$).

DISCUSSION

As weight loss through a dietary regimen can cause an excessive loss of body liquid and muscle, it is highly likely to regain the original weight. Therefore, to increase energy consumption and fat-free mass through a physical activity such as exercise is more effective than through a dietary regimen, in terms of weight loss [29]. To utilize such benefits of an exercise, a complex exercise combining an aerobic exercise effective for lipid decomposition with a muscle resistance contributing to increasing the basal metabolic rate (BMR) is being actively done to reduce the body and to improve the fat-free mass [12-14]. It was reported that after middle-aged obese women were engaged in a complex exercise program on a regular base for a long period of time, they showed a decrease in the body weight, %fat, WHR, BMI and the visceral fat area while presenting an increase in the fat-free mass and basal metabolisms rate. This was due to an increased free fatty acid, an improved lipid oxidation capacity, a reduced body weight, visceral fat quantity, abdominal subcutaneous fat and waist size, and an increased muscle quantity, fat-free mass and basal metabolism rate. [30,31]. In a study targeting rats instead of humans, the intake of Geniposide, one of gardenia's ingredients, was reported to contributing to increasing the body weight and suppressing the visceral fat area.

According to the results of this study, the complex treatment group of gardenia intake and exercise and the exercise group experienced decreases in the body weight, %fat, WHR, BMI and the visceral fat area, while both groups showed positive changes in improving the free fat mass and the basal metabolism rate. And the complex treatment group showed relatively greater changes in all test items, especially in the WHR and the visceral fat area related with metabolism diseases, and the gardenia group experienced decreases in the body weight and, %fat and the BMI.

According to the previous study results, the exercise group's body weight, %fat, WHR, visceral fat area were decreased, whereas their fat-free mass and basal metabolism quantities were increased. In this study, a combination of an aerobic exercise with a resistance exercise can expand the fat-free mass and energy consumption, realizing an exercise benefit of reducing the body fat, and the decreased body weight of the gardenia group was ascribed to the effect of Geniposide, one of gardenia's main ingredients, which is believed to suppress weight gain. Considering the results of the gardenia and exercise group, the exercise benefit and Geniposide effect are mutually complementary. However, the gardenia group showed a decrease in the body weight, %fat and BMI, while their WHR, visceral fat area, body fat and basal metabolism were not influenced significantly by the gardenia, which is not consistent with the previous findings. The result might be due to a difference in the test subjects, for which the study used rats instead of humans. Therefore, more follow-up studies need to be conducted on human subjects.

Considering the results of these changes in the body composition, it can be said that the gardenia + exercise complex treatment group showed more significant improvements in all test items compared with the single treatment group. Especially, it is presumed that the complex treatment is effective in reducing major risk factors such as the WHR and the visceral fat area.

It was reported that obese people tend to regain their original weights within one or two years after a sudden weight loss [32], and the major culprit behind a weight loss failure is due to the fact that the body weight is regulated by homeostasis, which is activated to compensate for a change in terms of appetite and energy consumption [33]. In relation to this, it has been recently reported that there are biomarkers such as insulin, GLP-1 and leptin, which are functionally connected to the hypothalamus and the neuropeptide system in the appetite and energy metabolism regulation mechanism [34].

Various studies on exercise-related metabolism have been actively done, and there are some studies which presented the contrasting results;, no decrease in %fat or insulin [35], [36]. The results of GLP-1 were not consistent: some reported a decrease in GLP-1 after exercise but others claimed otherwise [12,13,37,38]. In terms of the leptin, a regular exercise can reduce the leptin concentration [16].

Insulin resistance is one of the major causes of chronic diseases such as cardiovascular disorders, high blood pressure, diabetes and hyperlipidemia, and it is also a risk factor for arteriosclerosis and myocardial infarction [39]. A regular exercise increases energy consumption, which in turn leads to weight loss, activates metabolism and improves insulin resistance by stepping up the transfer of blood sugar into muscle cells [21]. Genipin, one of the gardenia's main ingredients, suppresses the activation of UCP-2 which interferes with the formation of ATP, recovers the malfunction of pancreatic β-cell, and ultimately improves diabetes and insulin resistance [40].

This study results found that the gardenia + exercise group, the exercise group and the gardenia group experienced a decrease in insulin resistance after the 8 week-long complex treatment. According to the results of the previous studies, it is presumed that the cause of the decreased insulin resistance in the exercise group may be because of insulin stimulation due to the activation of energy, and a cause of a reduced insulin resistance in the gardenia group is owing to Genipin's improvement effect on pancreas.

GLP-1 is an intestinal peptide, which is secreted when food is consumed, which delays the transfer of nutrients and suppresses appetite by giving satiety to the central nerves, and which lowers blood sugar levels by promoting insulin secretion [41]. Some reported that obese people experienced weight loss and a drop in the GLP-1 concentration after they did exercise on a regular basis [12,38], whereas others reported that their GLP-1 levels were decreased [13,37]. Also, a study in which obese people underwent low calorie diets for 6 weeks to lose weight, they experienced appetite loss and a decrease in the GLP-1 compared with the time before they lost weight, which is considered to be the process of progressing to a negative energy balance due to weight loss [21].

According to the results of this study, the gardenia + exercise group, the exercise group, and the gardenia group showed a decrease in GLP-1, which was consistent with the previous findings [13,21,37]. Considering the previous studies, a decreased GLP-1 secretin in the exercise group was ascribed to an increased energy consumption resulting from exercise and weight loss due to appetite suppression, and the subsequent negative balance contributed to decreasing GLP-1. The cause of a decrease in the GLP1 of the gardenia + exercise group and the gardenia group is because the gardenia may contains an appetite suppressing ingredient, which led to a reduced energy intake.

The leptin plays a role in directly controlling and regulating energy intake and consumption by proving information about fat mass to the central nerves. In addition, it is engaged in glucose absorption by peripheral tissues, glucose formation by the liver, and carbohydrate and fat oxidation. Leptin is related to Type 2 diabetes. In terms of insulin resistance, insulin and leptin have a relation with obesity; the blood leptin levels in obesity and diabetes patients are higher than normal people, which is due to insulin resistance by tissues [42]. A previous study was conducted on a total of 41 middle-aged obese women who did an aerobic exercise for 10 weeks, and the results showed their leptin levels were decreased [43]. It was reported that those middle-aged women who did a complex exercise demonstrated a decrease in their body fat percentage and leptin concentration [44], and that a regular exercise reduces energy intake by suppressing appetite and accelerates the lipolysis by inducing energy consumption, which subsequently reduces the body fat and lowers the leptin formation rate [45]. It was said that Genipin, an ingredient in the gardenia fruit, recovers the malfunction of pancreatic β-cell, improves insulin secretion, and consequently reduces the leptin secretion.

According to the results of this study, the gardenia + exercise group, the exercise group and the gardenia group all showed a decrease in leptin after 8 weeks of treatment. Given the previous studies, a decrease in leptin of the exercise group may be caused by the suppressed appetite and reduced energy intake due to a regular exercise, while the leptin level of the gardenia group was ascribed to a reduced leptin secretion due to improvement of insulin sensitivity. The decrease in the leptin of the gardenia & exercise group is thought to result from the mutually complementary interaction between the exercise effect and the benefit of gardenia fruits.

If all the above study results on metabolism-related factors are taken into consideration, it is thought that both exercise and gardenia intake have positive effects on improvement of energy metabolism by reducing body fat percentage due to an increased fat-burning effect. However, as the gardenia + exercise group and the exercise group experienced a greater decrease of leptin than the control group while the gardenia group showed little change, it was concluded that exercise is more effect in reducing leptin.

CONCLUSION

This study aimed to find out the influence of an 8 week-long gardenia intake and complex exercise on the body composition, blood lipid, energy metabolism regulating hormones and inflammation-related factors in middle-aged obese women, and as a result, all treatment groups generally showed improvement in all test variables and experienced positive effects on the body composition and energy metabolism regulating hormones. Especially, as the complex treatment group showed a greater decrease than the gardenia group in terms of the visceral fat area, a major risk factor of metabolism-related diseases among middle-aged obese women, it seems that a complex treatment is more effect than a single treatment.

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