Original Article

Effects of light resistance exercise using dumbbells and rubber band with mild energy restriction on body composition and physical fitness in obese Korean women

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The effects of light resistance exercise using dumbbells and rubber band with mild energy restriction on body composition and physical fitness were studied in 11 mildly obese Korean women aged 38-59 years. The subjects performed dumbbell exercises with pairs of 0.5-1 kg dumbbells and rubber band exercise 3 days per week for approximately 40 min. Subjects were restricted to approximately 80% of energy intake RDA for Korean women for 12 weeks. Subjects were measured for body composition, physical fitness, and blood and serum biochemical data before commencing the experiment and again at 12 weeks while still dieting. During the 12-week experimental period, body weight and body fat decreased significantly without reducing fat free mass. Grip and back strength increased significantly during the experimental period. These results suggest that combination of dumbbell and rubber band exercises decreases body weight and body fat without reducing FFM while increasing physical fitness.

Key Words: dumbbell exercise, rubber band exercise, restrictive diet, body composition, physical fitness, women,Korea

Introduction

Obesity is a major health problem in advanced nations.[1] It is associated with a significant increase in diabetes, hypertension, coronary artery disease and mortality from certain types of cancer.[2,3] Any successful obesity treatment programs need to define parameters that influence long-term treatment success. However, no consensus has emerged regarding the optimum dietary therapy for reduction and long-term maintenance of body weight and body fat. Exercise training and food restriction are the most popular therapies for obese individuals.[4] Severe food restriction through low calorie diets (LCD) or very low calorie diets (VLCD) are well-known weight loss strategies.[5-7] Though proposed as a means of accelerating the active weight loss process, severe food restriction programs have been criticized for their failure to incorporate basic nutritional principles.[8]

It is difficult for obese individuals to maintain fat free mass (FFM) under severe food restriction even when combined with regular exercise, but maintaining FFM is important to successful weight reduction. A decrease in FFM slows the rate of weight reduction as a result of the concomitant decrease in resting metabolic rate (RMR) and diet-induced thermogenesis (DIT).[9] Therefore, exercise with mild food restriction could be important to maintaining FFM or the rate of decrease during weight reduction programs. Previously, we reported that 12-weeks dumbbell exercise (aerobic-resistance exercise with light-weight dumbbells, which is popular in Japan and Korea) decrease body weight and body fat without reducing FFM in relation to increasing RMR and DIT.[10-12] LCD may enhance the effects of dumbbell exercise on body weight and body fat, but weaken the effects on FFM. However, no studies have demonstrated the effects of dumbbell exercise with mild food restriction on body composition. .

Recently, another light-resistance exercise using a rubber band has been introduced around the world.[13,14] This exercise is safe and anyone can do it at any time and in any place. Moreover, rubber band exercise trains the small muscles that the dumbbell exercise does not strengthen. Therefore, the purpose of this study was to examine the effects of combination of dumbbell and rubber band exercises with mild energy restriction on body composition and physical fitness in mildly obese women.

Methods

Subjects

Eleven middle-aged Korean women (38-59 years) who did not have a habit of daily exercise were recruited from Seoul, Korea, to participate in this study. All procedures were approved in advance by the Ethics Committee of the Korean Sports Medical Nutrition Institute and were in accordance

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with Helsinki Declaration of 1964, as revised in 2000. After a detailed explanation of this study, each subject gave her informed written consent. Except for obesity, it was required that the subjects were free of disease by a medical examination before the study. No subjects were using illegal drugs or taking medications that affect body weight. The day of the menstrual cycle at commencement and termination of the study was noted - this was not possible for menopausal women because fluctuations in metabolic parameters can occur during the cycle.[15] Subjects started the exercise program immediately after the pre-physical fitness tests. Because the experimental period was 12 weeks, most of the women were at about the same point of their cycle (mid-follicular phase) when physical fitness and body composition were remeasured at the end.

Dumbbell and rubber band exercises

All exercise programs were performed 3 days per week. Subjects wore pairs of wrist weights (sand bags) during dumbbell and rubber band exercises. The subjects performed a warm-up and cool-down of 10 min stretching before and after the exercise programs. The subjects performed dumbbell exercises with pairs of 500g-1kg dumbbells. The dumbbell exercises consisted of 12 movements which exercised the large muscle groups in the upper and lower body.[10-12,16] The exercises are shown in Table 1. The dumbbell exercise trained the chest, shoulders, biceps, triceps, back, thighs, and abdominals. Subjects performed 8-10 repetitions in 1-3 sets of each exercise, with 30 seconds of rest between the exercises. Subjects grasped the dumbbell bars firmly, and raised and lowered the weights slowly in a continuous motion. If subjects grew fatigued during the exercise, they performed a stretching exercise until they recovered their strength. Rubber band exercises consisted of 14 movements (Table 1) used to exercise large and small muscle groups.[13,14] The subjects performed rubber band exercises with 1-2 m of flexible rubber. This exercise was designed to strengthen inner muscles, which is difficult for general resistance training to accomplish. Subjects performed 12 repetitions in 1-2 sets of each exercise, with 30 seconds of rest between the exercises. Subjects stretched the rubber bands slowly in a continuous motion. Total exercise time each day was approximately 40 min.

Dietary control

The daily energy intake of the subjects was reduced by about 20% compared to their energy RDA, but protein intake met the RDA for Korean women. To get used to the restrictive diet, the subjects consumed the diet for 3 days prior to the commencement of the study started. The subjects were asked to record their complete food intake 3 days immediately before and after the study.

The daily intake of nutrients was calculated from these records. All alcoholic beverages were prohibited except on weekends and national holidays. Supper was consumed 1.5 h after the exercise training. When the subjects consumed more than the allowed amount, their energy intake was reduced accordingly for the subsequent days. Subjects were seen individually each week for nutritional counselling, with emphasis on behaviour modification.

Table 1. Program of light resistance exercise with dumbbells and rubber band

Dumbbell exercise		Rubber band exercise	
1	Shoulder press	1	Stretching
2	Standing pull	2	Side bend
3	Modified straight fly	3	Forward bend
4	Kick back	4	Over head press
5	Side lateral raise	5	Back triceps extension
6	Bent over rowing	6	Neck extension and side bend
7	Up right rowing	7	Stretching
8	Side bend	8	Back raise or hold up raise
9	Squat	9	Back trunk twist
10	Standing straight leg extension	10	Good morning
11	Standing leg curl	11	One arm French press
12	Arm curl	12	Stretching
		13	Straight arm lateral pull and down
		14	Forward trunk twist

Behaviour modification has been shown to improve long-term weight loss in association with a restrictive diet.[17,18] Subjects were asked to record and maintain their usual sedentary lifestyle during the study except for the exercise prescribed. Body weight and compositions were measured weekly in order to observe the progress of the experiment.

Measurement procedures

Subjects underwent several measurements before starting the experiment and again after the 12 weeks while still dieting. End measurements were conducted >24 h after the previous exercise session. The procedures were performed in the following order: physical fitness tests, then blood and plasma biochemical tests (hematological and iron-related measurements, white blood cell counts, leucocyte differential, and plasma immunoglobulin). Physical fitness tests (tunk flexion forward, grip strength, back strength, sergeant jump, sit up, and side step test) were performed by the standard methods described previously.[19] Evaluations of biochemical parameters of blood and plasma was requested from Green Cross Reference Laboratory Co., (Seoul, Korea).

Body composition

The subjects' height, weight and circumferences were measured by conventional methods. Skinfold thickness was determined by caliper. Percentage of body fat, fat mass and FFM were calculated from skinfold thickness (subscapular and triceps) as described previously.[20,21] Percentage body fat (%BF) was calculated with the following formula:

$$BS = W^{0.425} \times H^{0.725} \times 71.84 / 10000$$

BS, Body surface area (m^2); W, body weight (kg); H, height (cm)

$$BD = 1.0923 - 0.000514\,x$$

$$X = (SFt + SFs) \times BS/W \times 100$$

BD, Body density (kg/m^3); SFt, triceps skinfold thickness (mm); SFs, subscapular skinfold thickness (mm)

$$\%BF = (4.570 / BD - 4.142) \times 100$$

Statistical analysis
The mean and standard deviation (SD) were reported for all measurements. Data were analysed using Student's paired *t*-tests to show differences in variables from baseline to 12 weeks. A value of *P*<0.05 was considered to be significant.

Results

Body weight and body composition
Mean body weight, body mass index (BMI) and body fat weight were significantly reduced (*P*<0.05), but change in FFM was negligible for the 12 week experimental period (Table 2). Mean circumference size of waist, slim waist, hip, thigh, forearm, and upper arm significantly decreased (*P*<0.05) (Table 2). Waist to hip ratio did not change over the 12 week experiment period (pre- and post-experiment values: 0.86±0.07 and 0.85±0.07, respectively). Skinfold thickness for abdomen, biceps, chest, inside calf, midaxillary, subscapular, iliac, and thigh were significantly decreased (*P*<0.05) (Table 2).

Table 2. Pre- and post-experiment physical measurements

		Before	After	Difference
Age	years	49.5 ± 6.9	49.5 ± 6.9	-
Height	cm	157.1 ± 3.6	157.1 ± 3.6	-
Weight	kg	58.3 ± 8.8	57.3 ± 8.5*	-1.0 ± 1.2
Body mass index	kg/m^2	23.6 ± 3.5	23.2 ± 3.4*	-0.4 ± 0.5
Percentage of body fat	%	29.3 ± 3.0	28.1 ± 4.0	-1.2 ± 1.9
Body fat mass	kg	17.0 ± 3.1	16.1 ± 3.6*	-0.9 ± 1.2
Fat free mass	kg	41.3 ± 6.6	41.2 ± 6.3	-0.1 ± 1.5
Skinfold thickness				
Abdomen	mm	26.3 ± 5.7	24.9 ± 5.9*	-1.4 ± 0.5
Biceps	mm	18.9 ± 5.9	17.4 ± 5.7*	-1.5 ± 0.6
Chest	mm	18.9 ± 5.9	16.5 ± 6.8*	-2.4 ± 1.8
Inside calf	mm	21.1 ± 2.9	19.1 ± 3.4*	-2.0 ± 1.7
Midaxillary	mm	21.4 ± 5.4	20.0 ± 5.7*	-1.4 ± 0.4
Subscapular	mm	22.4 ± 5.5	20.4 ± 5.2*	-2.0 ± 0.6
Iliac	mm	24.0 ± 4.1	22.4 ± 4.4*	-1.6 ± 0.5
Thigh	mm	27.7 ± 4.7	26.6 ± 4.5*	-1.1 ± 0.5
Triceps	mm	21.8 ± 3.0	21.5 ± 4.1	-0.3 ± 3.4
Circumference				
Waist	cm	81.8 ± 9.8	79.9±10.0*	-1.9 ± 0.9
Slim waist	cm	80.5 ± 6.2	78.4 ± 6.1*	-2.1 ± 0.8
Hip	cm	95.4 ± 5.4	93.4 ± 5.1*	-2.0 ± 0.7
Thigh	cm	56.4 ± 3.5	54.6 ± 3.2*	-1.8 ± 0.6
Calf	cm	34.9 ± 3.8	33.0 ± 3.5	-1.9 ± 3.8
Forearm	cm	24.4 ± 1.8	23.4 ± 2.1*	-1.0 ± 1.1
Upper arm	cm	28.8 ± 2.4	27.0 ± 2.3*	-1.8 ± 0.5

Values are means±SD for 11 subjects; *P*<0.1, **P*<0.05 vs. pre-experiment values (Student's paired *t*-test).

Physical fitness parameters
Grip strength was shown in average of right and left strength values (Table 3). Grip strength and back strength increased significantly (*P*<0.05) by 25% and 16%, respectively (Table 3). Side step counts also increased (*P*<0.05), but trunk flexion forward, sergeant jump and sit up did not change over the 12 week experimental period (Table 3).

Blood and plasma biochemical parameters
All pre- and post-experiment blood and plasma biochemical test results were within the standard values for adult Korean women. Blood hemoglobin concentration, red blood cells, mean cell volume, mean cell hemoglobin concentration, and total iron binding capacity increased significantly (*P*<0.05), although plasma iron and ferritin concentrations did not change over the 12 week experimental period (Table 4). White blood cell counts and percentage of leucocyte differential did not change except for per-centage of eosinophil, which decreased 41% (Table 4). Plasma immunoglobulin was not different between pre- and post-experiment results (Table 4).

Table 3. Pre- and post-experiment physical fitness test results

		Before	After	Difference
Tunk flexion forward	cm	16.9 ± 8.7	17.8 ± 7.9	0.9 ± 3.9
Grip strength	kg	19.1 ± 4.3	23.8 ± 4.1*	4.7 ± 3.1
Back strength	kg	50.7 ± 14.2	59.0 ± 15.3*	8.3 ± 7.5
Sergeant jump	cm	20.4 ± 8.0	23.8 ± 4.8	3.4 ± 8.9
Sit up	counts	22.8 ± 9.9	23.7 ± 7.7	0.9 ± 4.9
Side step test	counts	19.6 ± 2.7	21.0 ± 2.8*	1.4 ± 0.8

Values are means±SD for 11 subjects; **P*<0.05 vs. pre-experiment values (Student's paired *t*-test).

Dietary intake
Daily nutrient intakes before and after the experiment are shown in Table 5 and their percentage of the RDA are shown in Table 6. Daily intake of energy and nutrients were not different before and after the experiment (Tables 5 and 6). Energy intake was about 80% of RDA and protein intake was over 100% of RDA for both before and after the experiment (Table 6). Calcium, iron, and vitamins A and B2 were insufficient compared to their RDAs (Table 6). Percentages of energy as protein, fat and carbohydrate were 15.7, 22.9 and 61.3% before the experiment and, 17.1, 22.4, and 61.3% after.

Discussion

The results show that light resistance exercise for 12 weeks with mild energy restriction significantly decreased body weight, BMI and body fat without reducing FFM. These results support our previous findings regarding the effects of dumbbell exercise.[10,11] To create an energy

Table 4. Pre- and post-experiment blood and plasma biochemical test results

		Before	After	Difference
Hematological and iron-related measurements				
Hemoglobin	g/dl	13.2 ± 0.9	13.7 ± 1.1*	0.5 ± 0.7
Red blood cells	x10^6/mm^3	4.4 ± 0.3	4.6 ± 0.4*	0.2 ± 0.3
Hematocrit	%	40.3 ± 2.6	41.7 ± 2.9	1.4 ± 2.1
MCV	fl	93.5 ± 3.0	86.4 ± 8.3*	-7.1 ± 10.3
MCH	pg	32.4 ± 0.5	32.4 ± 0.8	0.0 ± 1.1
MCHC	g/l	30.3 ± 1.3	29.1 ± 1.3*	-1.2 ± 1.3
Plasma iron	µg/dl	118 ± 32	114 ± 42	-4 ± 43
TIBC	µg/dl	374 ± 45	419 ± 49*	45 ± 25
Plasma ferritin	µg/l	94.2 ± 139	64.4 ± 95.3	30.2 ± 51.9
White blood cell counts and percentage of differential leucocyte				
White blood cells	x10^3/mm^3	6.8 ± 5.7	6.5 ± 1.6	-0.3 ± 6.5
Eosinophil	%	3.9 ± 1.6	2.3 ± 1.3*	-1.6 ± 0.2
Neutrophil	%	42.9 ± 12.8	48.8 ± 18.7	5.9 ± 8.7
Lymphocyte	%	44.5 ± 13.9	36.5 ± 9.2	-8.0 ± 6.1
Monocyte	%	6.9 ± 0.9	6.4 ± 0.8	-0.5 ± 0.4
Basophil	%	1.8 ± 1.2	1.2 ± 0.5	-0.6 ± 0.5
Plasma immunoglobulin				
IgG	mg/dl	1318 ± 282	1281 ± 295	-37 ± 124
IgA	mg/dl	308 ± 110	279 ± 97	-29 ± 73
IgM	mg/dl	155 ± 52	156 ± 34	1 ± 31

Values are means±SD for 11 subjects; *$P<0.05$ vs. pre-experiment values (Student's paired *t*-test); MCV, mean cell volume; MCH, mean cell hemoglobin; MCHC, mean cell hemoglobin concentration; TIBC, total iron binding capacity.

deficit, reduction of body fat and weight control have traditionally revolved around restricted energy intake and increased energy expenditure through physical activity of low to moderate intensity.[22] It can be argued that while such approaches result in weight loss, there is no compelling evidence that this approach has been effective for maintaining reduction of body fat beyond 3 to 6 months.[23] If the goal is loss of body fat, it can be argued from a metabolic perspective that this commonly used approach is not a very effective strategy. With continued and marked energy deficits, weight loss protocols indicate that FFM may be compromised and the resting metabolic rate may decrease markedly.[23] Further weight loss or maintenance becomes extremely difficult, and body fat is often regained. Given the loss of FFM, subjects may exhibit a higher percentage of body fat than before a diet.[23] Rather than merely a cosmetic problem, the additional body fat appears to appreciably increase risk for a number of diseases.[24]

Exercise, either aerobic or anaerobic, has been used with restricted diet programs in an effort to maintain FFM. Aerobic exercise is generally recommended in combination with restrictive diets, but aerobic exercise has shown equivocal results. Some researchers have suggested that FFM can be maintained[25,26] while others have reported contrary results.[27-29] Recently, many reports have described the effects of resistance exercise on reducing body weight and body fat mass. Kreamer *et al.,* reported that FFM did not change in response to resistance training in obese women with an 5.0 MJ-energy restrictive diets for 12 weeks.[30] Janssen *et al.*, also suggested that restricted diets (4.18 MJ) plus resistance exercise maintained skeletal muscle mass (-0.4±1.1 kg).[31] However, Fox *et al.*, reported a considerable loss of FFM through resistance exercise training combined with an energy deficit of 2.1 MJ below baseline caloric requirement.[32] Doi *et al.,* suggested that a 12-week light resistance exercise program with mild energy restriction (85% of RDA) decreased FFM by 2.0 kg.[33] The present study showed that FFM was not influenced by dumbbell and rubber band exercises with mild (80%) energy restriction. The discrepancies in the effects of resistance exercises combined with restrictive diets on FFM may be due to the quality or quantity of training and/or diet during the experimental period.

The values of the pre- and post-experiment blood and plasma biochemical test results for all subjects were normal compared with standard values[34] before and after the 12-week experimental period. These results suggest that the subjects were in good health (except for obesity) before commencing the exercise and diet program and that this study had been performed safely. In the haematological and iron-related measurements, blood haemoglobin concentration, red blood cells, mean cell volume, mean cell haemoglobin concentration, and total iron binding capacity increased significantly during the 12-week experimental period. We previously reported that voluntary resistance exercise improved blood haemoglobin concentration in iron-deficient rats.[35]

Strause *et al.,* demonstrated that resistance-exercised rats absorbed more iron than sedentary rats did in radio-iron tracer studies.[36] Resistance exercise may stimulate

Table 5. Pre- and post-experiment dietary intakes

		Before	After
Energy	kcal	1543±222	1623±197
Protein	g	61±9.7	65.5±10.8
Fat	g	39.5±14	35±14
Carbohydrate	g	234±38	253±27
Fibre	g	15.7±3.5	16.8±4.4
Calcium	mg	477±149	567±27
Phosphorus	mg	937±195	1035±187
Iron	mg	10.9±5.7	11.3±2.1
Sodium	g	3.4±0.9	4.0±0.9
Potassium	g	2.2±0.5	2.5±0.5
Vitamin A	mg RE	303±506	536±180
Vitamin B1	mg	1.1±0.3	1.1±0.3
Vitamin B2	mg	0.9±0.3	1.1±0.3
Niacin	mg NE	13.0±3.6	14.9±3.6
Vitamin C	mg	68.4±25.1	85.5±45
Cholesterol	mg	183±100	200±80

Values are means±SD for 11 subjects; RE, equivalent retinol weight; NE, equivalent niacin weight.

Table 6. Pre- and post-experiment dietary intake shown in percentage of RDA

		Before	After
Energy	%	77.5±11.6	81.8±9.2
Protein	%	101.3±18.7	109.2±18.1
Calcium	%	67.4±21.6	79.6±23.4
Phosphorus	%	132.1±27.7	144.9±29.6
Iron	%	75.2±54.4	83.9±26
Vitamin A	%	92.9±71.5	78.6±52.7
Vitamin B1	%	106.1±27	108.7±25.2
Vitamin B2	%	83±24.7	87.5±21.4
Niacin	%	101.3±27.6	114.7±27.9
Vitamin C	%	125.9±45.9	162.5±78.5

Values are means±SD for 11 subjects; RDA, recommended dietary allowance.

the distribution of haemoglobin iron rather than iron stored in the tissues, such as liver and spleen.[35] These mechanisms remain unknown, so further studies will be required.

Our data demonstrated that dumbbell and rubber band exercises increased grip and back strength during the 12-week experimental period. These results suggest that light resistance exercise can improve physical fitness in senior women, which requires maintaining their FFM. Muscular hypertrophy in women, as a result of resistance training, has been reported in previous studies.[37,38] These studies used multiple-set programs during resistance training. Acute increases in growth hormone have been reported during high-volume resistance exercise.[39,40] In particular, multiple-set programs were shown to be superior for rapid increases in growth hormone and decreases in cortisol in women.[41] Therefore, the volume of resistance exercise may be a significant determinant of hormonal alterations and, consequently to the maintenance of FFM in women during food restriction.

In conclusion, our study suggests that a combination of dumbbell and rubber band exercises decreases body weight and body fat without reducing FFM while improving physical fitness. A restricted diet (80% of base-line) did not influence FFM or physical activity, suggesting that mild energy restriction with light resistance exercise may be useful for long term dietary therapy.

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