



Effects of Combined Exercise Training on Body Composition and Metabolic Syndrome Factors

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Abstract

Background: Metabolic syndrome (MS) is emerging as a serious public health problem in Korea. The purpose of this study was to examine the effects of 12 weeks of combined exercise training on body composition and MS factors in obese Korean female college students.

Methods: Subjects were randomly assigned to exercise ($n = 7$) and control ($n = 9$) groups. The exercise group trained for 80 min/day, for 3 day/week for 12 weeks. Each exercise session comprised 3 phases: warm-up for 10 min, main exercise for 60 min (consisting of aerobic exercise for 30 min and resistance exercise for 30 min), and cool down for 10 min.

Results: The exercise intensity for aerobic exercise was 60–80% of the heart rate reserve (HRR) for 30 min, while the resistance exercises were 10–15 repetitions maximum (RM) for 30 min. Two-way repeated analysis of variance (ANOVA) was used for statistical analysis. There were no interaction effects (time \times group) on the MS-related factors of blood lipid composition such as triglycerides (TGs), high-density lipoprotein (HDL), glucose, total cholesterol (TC), and low-density lipoprotein (LDL). However, interaction effects were observed (time \times group) on percent body fat ($P = 0.006$), waist circumference (WC; $P < 0.001$), systolic blood pressure (SBP; $P = 0.010$), and diastolic blood pressure (DBP; $P = 0.007$).

Conclusions: A 12-week supervised combined exercise program could effectively reduce percent body fat, WC, SBP, and DBP. However, it was not effective on MS-related factors of blood lipid composition such as TG, HDL, glucose, TC, and LDL in a sample population of obese Korean female college students.

Keywords: Body composition, College student, Metabolic syndrome, Obesity, Korea

Introduction

Reaven (1988) was the first to report the concept of X syndrome for the cardiovascular (CV) disease risk factor cluster that includes factors such as impaired glucose tolerance, HDL deficiency, hypertriglyceridemia, and hypertension (1). This cluster of risk factors has been recently reported as insulin resistance syndrome, metabolic syndrome (MS), or CV syndrome (2-4).

Based on the National Health and Nutrition Examination Survey (NHANES) conducted in the United States from 2003 to 2006, and the National Cholesterol Education Program (NCEP)/

Adult Treatment Panel III (ATP III) guidelines, an estimated 34% of adults aged >20 years met the criteria for MS (5). The prevalence of MS in Korea has a pattern similar to that in the United States (6-7). For this reason, the prevalence of MS has emerged as a serious public health problem in Korea with time.

The therapeutic goals reported for MS management are reduced levels of abdominal obesity, sedentary lifestyle, atherogenic diet, smoking, pharmacotherapy (anti-obesity agents), and control of elevated blood pressure (8). Furthermore,

interestingly, increasing physical activity and fitness are considered to reduce the risk of MS and constitute important components of MS prevention (8).

Many studies have recommended aerobic exercises such as walking, jogging, swimming, biking, golfing, yoga, and team sports for preventing MS (8-10); furthermore, resistance exercise was also recommended (11). The results of many studies have confirmed that exercise is a good method for preventing MS as it increases muscle mass, decreases percent body fat and body weight, controls diabetes, reduces blood pressure, and reduces overall CV risk factors; however, only a few studies have examined the effects of combined exercise (12). Moreover, to our knowledge, none of the studies have focused on obese college students in Korea for the purpose of MS prevention. Therefore, the purpose of this study was to examine the effect of 12 weeks of combined exercise, consisting of aerobic and resistance exercises, on body composition and MS-related factors in a sample population of obese Korean female college students.

Materials and Methods

Subjects

Based on the 2×2 repeated ANOVA measures design and an anticipated statistical power of 0.80 (alpha error probability of 0.05) with an effect size of 0.4, it was determined that a sample size consisting of 16 subjects would be necessary (G-power program 3.1.3, Germany). We used a sample size consisting of 20 subjects to factor in the subjects who would be dropped from the analysis. The subjects were randomly classified into 2 groups: exercise ($n = 10$) and control ($n = 10$) groups. The subjects were obese female college students aged 20–26 years, who had $>30\%$ body fat, and exercised at the Dongguk University fitness center in Gyeong-Ju, Gyeongsangbuk-Do, Korea. They did not exercise regularly, and had not been previously diagnosed with abnormal glucose metabolism, or other health problems. The subjects were instructed to maintain a typical diet and a particular activity pattern throughout the

study, and compliance with this instruction was assessed via physical activity and food frequency questionnaires administered at the beginning, and end of the study (13,14). However, 3 subjects from the exercise group were excluded because they attended only part of the exercise program, and 1 from the control group was excluded because she did not participate in the test conducted at the end of the study. Thus, 7 subjects from the exercise group and 9 from the control group completed the pre- and post-study assessments.

All the subjects submitted a written consent form, and all the study procedures were approved by the Human Care and Use Committee of the Society of Sport Research Institute at Dongguk University. The characteristics of the subjects are shown in Table 1.

Table 1: Characteristics of the subjects (Mean \pm SD)

Variables	Control group (n = 9)	Exercise group (n = 7)	<i>t</i>	<i>P</i>
Age, years	20.78 \pm 1.99	21.14 \pm 1.57	-0.398	0.697
Height, cm	160.33 \pm 5.45	163.43 \pm 7.30	-0.973	0.347
Weight, kg	62.36 \pm 7.60	67.07 \pm 11.49	-0.989	0.340
BMI, kg/m ²	24.18 \pm 1.63	24.97 \pm 2.73	-0.718	0.484
WC, cm	76.61 \pm 4.78	81.29 \pm 6.02	-1.735	0.105
Body Fat, %	32.76 \pm 1.57	34.57 \pm 2.51	-1.780	0.097

BMI; Body Mass Index, WC; Waist Circumference

Tested by independent *t*-test

Experimental procedures

The exercise group participated in a 12 week supervised combined aerobic and resistance exercise program. The exercise group trained for 80 min/day, and the program was composed of 3 steps: warm-up for 10 min, combined exercises for 60 min, and cool down for 10 min. The exercise group trained for 3 day/week for 12 weeks, while the control group was asked to maintain their normal sedentary activities. All the variables pertaining to the parameters were measured 2 days before, and 2 days after the study: body composition (weight, body mass index [BMI], fat free mass [FFM], and percent body fat), MS-related factors (waist circumference [WC], triglyceride [TG] levels, high-density lipoprotein [HDL] levels, systolic

blood pressure [SBP], diastolic blood pressure [DBP], and glucose levels), and other blood lipid components (total cholesterol [TC] and low-density lipoprotein [LDL] levels).

Body composition

The BMI (kg/m^2) of each subject was calculated on the basis of their weight and height, and body composition (weight, FFM, and percent body fat) was assessed using an 8 polar bioelectrical impedance instrument (InBody 3.0, Biospace, Seoul, Korea).

This instrument measures the resistance of the arms, trunk, and legs at frequencies of 5, 50, 250, and 500 kHz and uses 8 tactile electrodes, 1 each in contact with the palm and thumb of each hand and with the anterior and posterior aspects of the sole of each foot (15).

Subjects were prohibited from consuming food/liquids for 4 h, performing exercises for 12 h, and urinating just before the impedance measurement. They were recommended to wear light clothing and to remove all metallic items, which could interrupt the electric current during the measurement. All the methods used for assessing body composition followed the recommendations from the book, *Applied Body Composition Assessment* (16).

MS-related factors and other blood lipid components

The WC was measured in the region of the trunk that is midway between the lower costal margin (bottom of the lower rib) and the iliac crest (top of the pelvic bone), while the subject stood with her feet placed ~25–30 cm apart. The person recording the measurements carefully wrapped the tape around the subject's trunk without compressing any underlying soft tissues. The circumference was measured at the end of a normal expiration and rounded off to the nearest 0.5 cm (17).

The TG, HDL, LDL, TC, and glucose concentrations were measured using the ADVIA 1650 automated analyzer (Bayer HealthCare Ltd. Tarrytown, NY, USA), with the Pureauto S TG-N (Daiichi, Japan), Cholestest N-HDL (Daiichi, Japan), Cholestest N-LDL (Daiichi, Japan), Pureauto S

CHO-N (Daiichi, Japan), and Hexokinase (Daiichi, Japan) kits, respectively.

The subjects rested for over 10 min in a sitting position. A specialist nurse then measured SBP and DBP at the right brachial artery by using a mercury sphygmomanometer (Alpk, Japan). Blood pressure was measured thrice separately over a 2-min interval. The specialist nurse determined the average blood pressure value (18).

Exercise program

All the subjects in the exercise group were asked to stretch their entire body before (warm up, 10 min) and after (cool down, 10 min) each training session. They performed a 60 min main exercise program, which consisted of treadmill running for 30 min at an intensity of 60–80% of their heart rate reserve (HRR), followed by resistance training for 30 min, which included the leg press, leg curl, chest press, lat-pull down, shoulder press, biceps curl, and sit-ups. The resistance exercise session consisted of 3 sets of 10–15 repetitions maximum (RM) for each of the exercises. Exercise intensity was monitored during the training sessions by using a Polar real time system (Polar S610, Finland).

Statistical analysis

All the descriptive data were expressed in terms of mean \pm standard deviation. Independent t-tests were used to examine the differences in subject characteristics between the groups at baseline. Two-way repeated analysis of variance (ANOVA) was used to evaluate significant changes in dependent variables in the exercise group before and after the exercise program and to compare these values with those for the control group before and after the study period. All the analyses were performed using SPSS version 12.0 (SPSS, Chicago, IL, USA). The statistical significance level was set at $P < 0.05$.

Results

The subjects' characteristics did not significantly differ between the groups at the baseline ($P > 0.05$) (Table 1). The changes in body composition, MS-related factors, and other blood lipid compo-

nents after combined exercise for 12 weeks are shown in Table 2 and 3. No interaction effects (time × group) were seen on MS-related factors of blood lipid composition such as TG, HDL, glu-

cose, TC, and LDL levels ($P > 0.05$). However, interaction effects (time × group) were observed on percent body fat ($P = 0.006$), WC ($P < 0.001$), SBP ($P = 0.010$), and DBP ($P = 0.007$).

Table 2: Changes in body composition after combined exercise for 12 weeks

Items	Exercise	Pre-exercise	Post-exercise	Interaction (Group X Time)	
				F	P
Weight, kg	Control	62.36 ± 7.60	62.88 ± 7.69	1.627	0.223
	Combined	67.07 ± 11.49	66.61 ± 12.53		
BMI, kg/m ²	Control	24.18 ± 1.63	24.38 ± 1.66	2.060	0.173
	Combined	24.97 ± 2.73	24.76 ± 3.01		
Muscle mass, kg	Control	38.13 ± 4.35	37.74 ± 4.40	3.125	0.099
	Combined	41.51 ± 8.02	42.01 ± 8.04		
Body Fat, %	Control	32.76 ± 1.57	33.60 ± 1.95	10.513	0.006**
	Combined	34.57 ± 2.51	33.16 ± 3.08		

BMI; Body mass index/** $P < 0.01$; Tested by two way repeated ANOVA.

Table 3: Changes in metabolic syndrome related factors and blood lipid composition after combined exercise for 12 weeks

Items	Exercise	Pre-exercise	Post-exercise	Interaction (Group X Time)	
				F	P
WC, cm	Control	76.61 ± 4.78	75.22 ± 5.22	17.550	<0.001***
	Combined	81.29 ± 6.02	75.00 ± 7.39		
SBP, mmHg	Control	114.33 ± 11.18	116.56 ± 8.82	8.787	0.010*
	Combined	113.71 ± 11.22	107.00 ± 9.40		
DBP, mmHg	Control	69.11 ± 5.40	69.56 ± 3.97	10.008	0.007**
	Combined	76.86 ± 6.09	69.71 ± 5.94		
TG, mg/dl	Control	105.22 ± 34.45	93.22 ± 33.47	3.632	0.077
	Combined	97.14 ± 32.49	50.43 ± 9.93		
HDL, mg/dl	Control	53.89 ± 7.66	50.89 ± 7.17	0.024	0.879
	Combined	48.71 ± 9.29	45.00 ± 4.51		
Glucose, mg/dl	Control	86.33 ± 3.08	89.44 ± 5.50	1.054	0.322
	Combined	85.86 ± 6.91	86.57 ± 7.00		
TC, mg/dl	Control	183.00 ± 26.125	178.89 ± 30.38	1.977	0.182
	Combined	180.29 ± 28.93	161.00 ± 20.58		
LDL, mg/dl	Control	99.56 ± 30.61	104.56 ± 34.86	3.259	0.093
	Combined	112.14 ± 26.25	103.57 ± 24.31		

WC; Waist circumference, SBP; Systolic blood pressure, DBP; Diastolic blood pressure, TG; Triglycerides, HDL; High density lipoprotein, TC; Total cholesterol, LDL; Low density lipoprotein

* $P < 0.005$ ** $P < 0.01$ *** $P < 0.001$; Tested by two way repeated ANOVA.

This study focused on the effectiveness of a 12 week combined aerobic and resistance exercise program on potential changes in MS-related factors and body composition. Significant improvements were observed in percent body fat, WC, and blood pressure, but not in any of the blood lipid components.

Traditionally, since aerobic exercise is associated with greater energy expenditure than resistance exercise, it is considered to be more effective in reducing body weight and fat mass (19). However, many studies have reported that resistance exercise is more effective in increasing FFM (20). In our study, combined exercise significantly decreased the percent body fat and WC, but did not increase the FFM.

Malina (2007) reported that young college students show a high correlation between BMI and FFM (21). Although the obese subjects in this study had high BMI, they also had higher FFM than that reported for adults. We felt that this was responsible for the observation that combined exercise did not affect their FFM. However, since combined exercise also represented increased energy expenditure, the percent body fat and WC decreased.

In a meta-analysis study by the American College of Sports Medicine (ACSM), the results showed that regular physical activity and exercise decreased SBP by 6 mm Hg and DBP by 5 mm Hg (22). Interestingly, our study also shows significant decrease in blood pressure; this result is supported by that from the ACSM report despite the subjects in our study being younger.

In our study, the MS-related factors of blood lipid composition were not affected. Obesity and MS have been known to be common and important clinical markers for early detection of CV disease and type 2 diabetes (23). Risk factors for MS include higher TG levels (≥ 150 mg/dl), lower HDL levels (< 50 mg/dl for women), high blood pressure ($\geq 130/80$ mm Hg), high fasting blood glucose levels (≥ 100 mg/dl), and a large WC (≥ 88 cm for women) (24).

Several previous studies have reported that combined exercise significantly improves MS-related factors of blood lipid composition (12, 25). We

agree with the results of the previous studies in which the subjects were middle-aged, or older adults. However, younger individuals are in better health compared to adults, and do not develop severe health conditions due to MS. Therefore, we believe that while combined exercise is effective in preventing MS in middle-aged and older adults, it might not be as effective in young adults. Furthermore, well-designed studies are required for comparing the effectiveness of combined aerobic and resistance exercise on young adults and middle-aged or older adults.

This study has a few limitations. Since the subjects were recruited from only 1 university at Gyeongju, Gyeongsangbuk-Do, Korea, and included only female students, the study population does not represent the entire Korean population. Furthermore, it comprised of a small number of students ($N = 16$). Our results show that combined exercise significantly decreases the percent body fat and WC, but does not increase FFM. This could be a result of our small study sample. Nevertheless, interaction effects (time \times group) were observed, with boundary statistical level significance on FFM ($P = 0.099$). Moreover, this study has an advantage in that it focuses on a young adult population, in contrast to previous studies that focused on middle-aged or older adults. Further studies are required to determine the effects of combined exercise on FFM.

We conclude that a 12 week supervised combined exercise program is effective in reducing percent body fat, WC, SBP, and DBP. However, it did not affect MS-related factors of blood lipid composition such as TG, HDL, glucose, TC, and LDL, in a sample population of obese Korean female college students.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors

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