Soft Comput (2012) 16:403–410
DOI 10.1007/s00500-011-0724-1

FOCUS

Effects of 12-week circuit weight training and aerobic exercise on body composition, physical fitness, and pulse wave velocity in obese collegiate women

Hyun-Joo Kang · Yang Sun Lee · Doo-Soon Park · Duk-Ho Kang

Published online: 27 May 2011

Abstract The purpose of this study was to study the effects of 12 weeks of circuit weight training and aerobic exercise on body composition, physical fitness, and pulse wave velocity in obese collegiate women. Twelve obese collegiate women were randomly assigned either to an exercise training group (TG) or control group (CG). The main exercise program was composed of an approximately 40–65 min session of circuit weight training (resistance training and aerobic exercise) as well as jogging at an intensity of 50–70% of the age-predicted heart rate reserve. The circuit weight training program was made by Korean Institute of Sport Science and was modified as needed for obese collegiate women. All analyses were performed using SPSS and all data was reported as mean ± standard deviation (SD). Significant differences between groups were determined using a two-way repeated measures analysis of variance (ANOVA) with a post hoc test (Tukey method). Statistical significance was accepted for all tests at a value of $p < 0.05$. The results indicated that after the 12-week intervention, there were no significant changes in body weight, % body fat, or WC in either group. There was a significant interaction of time by group with respect to body weight ($p < 0.05$), % body fat ($p < 0.01$), and WC ($p < 0.01$) and there was a significant change in back strength between the TG before beginning the program and the TG after having completed the program ($p < 0.01$). There was also a significant interaction of time by group with respect to back strength ($p < 0.01$), grip strength ($p < 0.05$), sit and reach ($p < 0.01$), sargent-jump ($p < 0.01$), and the one leg balance with eyes closed ($p < 0.01$); however, these differences were not statistically significant between groups. Further, there was a significant interaction of time by group with respect to the 1,200 m run for cardiopulmonary endurance ($p < 0.01$); however, this difference was not statistically significant between the TG pre and TG post. In addition, there was a significant in sit-ups ($p < 0.01$) and the 1,200 m run ($p < 0.01$) between the TG and CG. There was no significant difference in side-steps between the TG and CG. Further, there were no significant differences in the pulse wave velocity, RPP, SBP, DBP, and MAP between the TG and CG. In conclusion, circuit weight training and aerobic exercise had favorable effects on the occurrence of obesity and physical fitness in obese collegiate women.

Keywords Exercise · Body composition · Physical fitness · Pulse wave velocity · Obese

H.-J. Kang · D.-H. Kang (✉)
Department Sports Medicine, Soonchunhyang University, Asan, South of Korea
e-mail: kangdh@sch.ac.kr

Y. S. Lee
Department of Information Communication Engineering, Chosun University, Kwangju, South of Korea

D.-S. Park
Department of Computer Software, Soonchunhyang University, Asan, South of Korea

1 Introduction

Recently, obesity has become a serious worldwide issue due to a variety of causes including overeating and insufficient physical activity. While the health and fitness of Korean youth improved much over the years due to improvement in diets following economic growth, their physical fitness has worsened rapidly due to decreases in exercise and physical activity caused mainly by increases in the amount of time spent watching television and playing computer games.

The obesity caused by an imbalanced intake of calories and decreased exercise has led to related health problems including diabetes, hypertension, dyslipidemia, and arteriosclerosis, and has worsened the quality of life of young Koreans. In the past, the cause of obesity was thought to be over-intake of calories; however, in America and England, the occurrences of obesity has increased while the average intake of energy has decreased, emphasizing that a decrease in physical activity plays an important role in obesity (Bensimhon et al. 2006; Schrauwen and Westererp 2000).

Thus, the development of various exercise interventions has gained interest in an effort to counteract obesity. The recommended types of exercise to reduce obesity are walking, jogging, bicycling, and aerobic exercise (Carroll and Dudfield 2004; Cox et al. 2004; LeMura and Maziekas 2002; Watts et al. 2005). Resistance training is used to increase muscle mass and thus, increase the basic metabolic rate (Irwin et al. 2003; Manning et al. 1991). However, aerobic exercise such as jogging and walking have great effects on the prevention of diet-related diseases through its ability in improving circulation, it does not have very high effects on increasing and maintaining muscle strength and volume. On the other hand, weight training has a very important effect on maintaining and enhancing muscle strength, and preventing sarcopenia; however, it does not have an obvious role in improving circulation. It has been reported that in contrast, it has a negative effect on arterial stiffness (David et al. 1999). Thus, circuit weight training combining both aerobic exercise and resistance training can be much more effective on overall health and fitness. Recently, there has been interest in circuit weight training for the treatment of obesity. Circuit weight training involves the alternation of aerobic exercise and muscle resistance exercise, and is used for weight reduction. Thus, this study focused on the effects of a 12-week circuit weight training and aerobic exercise plan on body composition, physical fitness, and pulse wave velocity in obese collegiate women.

2 Methods

2.1 Selection of subjects

A group of 16 apparently healthy, obese collegiate women, aged 21–23 years, were recruited from S University in Chungnam. Other inclusion criteria were: (1) a percent body fat over 30; and (2) not previously engaged in any exercise or diet program 6 months prior to the start of the study. Based on information provided by a questionnaire, potential subjects who did not fit the criteria were excluded at that point. Additionally, four subjects dropped out of the study due to personal reasons. Therefore, values from six subjects in the training group and six subjects in the control group were included in the data analysis. Physical characteristics of subjects have been provided in Table 1.

2.2 Experimental design

Twelve obese collegiate women were randomly assigned to either the training group (TG) or control group (CG) to examine the effects of a 12-week circuit weight training and aerobic exercise program on body composition, physical fitness, and pulse wave velocity. Subjects in the CG were asked not to change their normal habit and in particular, their eating habits. They were also asked not to engage in any exercise throughout the control period except light activities (e.g., walking for commuting).

2.3 Exercise training program

Subjects assigned to the TG underwent a 12-week training program which consisted of circuit weight training and aerobic exercise. The combined program was performed for about 60 min per day, three times a week over a period of 12 weeks. Each training session consisted of a brief warm-up, followed by the main exercises at an individually prescribed intensity, and finally, a brief cool-down. The main exercise program was composed of an approximate 40–65 min session of circuit weight training (resistance training and aerobic exercise) as well as jogging at an intensity of 50–70% of the age-predicted heart rate reserve (ACSM 2006). Subjects were monitored using portable heart rate measuring device (Polar S610i, Finland). The circuit weight training program was created by the Korean Institute of Sport Science. The program was modified as needed for obese collegiate women. The circuit weight training program has been presented in Table 2.

2.4 Experimental methods

Height and body weight were taken in the morning after a 12-h overnight fast. At the same time body composition was measured. Body weight was measured to the nearest 0.1 kg with a balance beam scale and percent body fat was

Table 1 Physical characteristics of subjects

Group	*N*	Age (years)	Height (cm)	Body weight (kg)
TG	6	21.50	164.50 ± 4.42	61.57 ± 8.14
TG	6	23.00	162.50 ± 3.94	59.77 ± 6.69

TG training group, *CG* control group

Table 2 Circuit weight training program

	Type	Time (s)	Set (*N*)	Exercise
1	Walk or jog	30	3–6	Aerobic exercise
2	Push-up	30	3–6	Upper muscular strength
3	Jump	30	3–6	Aerobic exercise
4	Squat	30	3–6	Lower muscular strength
5	Jump	30	3–6	Aerobic exercise
6	Sit-Up	30	3–6	Abdominal strength
7	Step-up	30	3–6	Aerobic exercise
8	Crunch	30	3–6	Lower muscular strength
9	Jump up with raised arm	30	3–6	Aerobic exercise
10	Back exercise	30	3–6	Back muscular strength

measured using the BIA (Inbody 3.0, Biospace, Korea). Waist circumference was measured at the midpoint between the lower border of the rib cage and the iliac crest. Physical fitness factors consisted of the seven performance test items including grip strength (dynamometer. FE-001, Fi-Net, Korea) and back strength (back strength meter, FE-002, Fi-Net, Korea) for muscular strength, sit-up (N/30 s) for muscular endurance, sit and reach (cm) for flexibility, side-step (N/20 s) for agility, one leg balance with eyes closed (s) for balance, and a 1,200 m run (s) for cardiovascular endurance. Blood pressure was taken and recorded (SH-9600B) in the sitting position after a 5-min rest. Rate pressure product (RPP) which measured heart rate by systolic blood pressure and mean arterial pressure (MAP) was counted by diastolic blood pressure plus 1/3 pulse pressure. Pulse wave velocity (PWV) was measured in a supine position using a PWV 3.0 (model KM Tec, Korea).

2.5 Statistical analysis

All analyses were performed using SPSS (version 13.0 Windows; SPSS, Inc., Chicago, IL. USA) and all data were reported as mean ± standard deviation (SD). Significant differences with group were determined using a two-way repeated measure analysis of variance (ANOVA) with a post hoc test (Tukey method). Statistical significance was accepted for all tests at values of $p < 0.05$.

3 Result

Based on a 12-week circuit weight training and aerobic exercise program the following results were obtained with respect to body composition, physical fitness, and pulse wave velocity in obese collegiate women.

3.1 Body composition (Table 3)

After the 12-week intervention, there were no significant changes in body weight, % body fat, and WC in either group. There was a significant interaction of time by group with respect to body weight ($p < 0.05$), % body fat ($p < 0.01$), and WC ($p < 0.01$). Further, body weight, % body fat, and WC of the TG who exercised exhibited a decreasing tendency compared to the CG who had not undertaken the program.

3.2 Physical fitness (Table 4)

There was a significant change in back strength between the TG before beginning the program and the TG after having completed the program ($p < 0.01$). There was also a significant interaction of time by group with respect to back strength ($p < 0.01$), grip strength ($p < 0.05$), sit and reach ($p < 0.01$), sargent-jump ($p < 0.01$), and the one leg balance with eyes closed ($p < 0.01$); however, these differences were not statistically significant between groups. Further, there was a significant interaction of time by group with respect to the 1,200 m run for cardiopulmonary endurance ($p < 0.01$); however, this difference was not statistically significant between the TG pre and TG post. There was also a significant in sit-ups ($p < 0.01$) and the 1,200 m run ($p < 0.01$) between the TG and CG. There was no significant difference in side-steps between the TG and CG.

3.3 Pulse wave velocity

Table 5 provides the mean values for arterial pulse wave velocity and blood pressure. There were no significant differences in the pulse wave velocity, RPP, SBP, DBP, and MAP between the TG and CG.

4 Discussion

4.1 Body composition

Exercise in the treatment or prevention of obesity is important because it maintains or increases the amount of lean body mass and also reduces body fat as well as improving the cardiorespiratory function and lipid levels in the blood. In particular, combined program of aerobic exercise and resistance exercise training has been recommended for fat reduction since it is the most effective. Yoo (2005) had middle-aged women with extreme obesity,

Table 3 Change in body composition between TG and CG

Variables	Group	Pre	Post	*F* value	*P* value
Body weight (kg)	TG	61.57 ± 8.14	59.27 ± 5.42	a: 0.634	a: 0.444
	CG	59.77 ± 6.69		b: 0.001	b: 0.981
			60.88 ± 6.59	a × b: 5.286	a × b: 0.044*
Body fat (%)	TG	32.27 ± 4.85	30.62 ± 3.32	a: 1.943	a: 0.194
	CG	31.03 ± 2.09		b: 0.015	b: 0.904
				a × b: 10.214	a × b: 0.009**
			32.30 ± 1.84		
WC (cm)	TG	73.52 ± 3.67	70.08 ± 2.50	a: 1.943	a: 0.194
	CG	72.07 ± 3.31		b: 0.339	b: 0.573
			73.42 ± 2.73	a × b: 10.241	a × b: 0.009**

TG training group, *CG* control group, *WC* waist circumference, a: time, b: group, a × b: time × group interaction

* $p < 0.05$; ** $p < 0.01$

Table 4 Change in physical fitness between TG and CG

Variables	Group	Pre	Post	*F* value	*p* value
Back strength (kg)	TG	44.33 ± 13.14	56.67 ± 13.98	a: 11.967	a: 0.006**
	CG	36.17 ± 13.47	36.17 ± 12.20	b: 3.733	b: 0.082
				a × b: 11.967	a × b: 0.006**
Grip strength (kg)	TG	25.23 ± 3.81	27.00 ± 3.57	a: 0.031	a: 0.863
	CG	21.85 ± 8.65	19.78 ± 6.13	b: 0.140	b: 0.140
				a × b: 5.117	a × b: 0.047*
Sit and reach (cm)	TG	14.23 ± 4.62	18.45 ± 3.32	a: 2.628	a: 0.136
	CG	12.82 ± 5.04	11.40 ± 4.58	b: 3.079	b: 0.110
				a × b: 139.061	a × b: 0.009**
Sit-up (N/30 s)	TG	17.50 ± 2.95	19.83 ± 3.06	a: 0.749	a: 0.407
	CG	14.83 ± 1.72	14.00 ± 3.10	b: 10.027	b: 0.010**
				a × b: 3.336	a × b: 0.098
Sargent-jump (cm)	TG	33.33 ± 7.97	35.67 ± 9.03	a: 0.001	a: 1.000
	CG	29.50 ± 2.43	27.17 ± 2.56	b: 2.942	b: 0.117
				a × b: 28.824	a × b: 0.001**
Side-step (N)	TG	28.17 ± 8.91	32.00 ± 2.97	a: 0.302	a: 0.595
	CG	26.33 ± 4.59	24.50 ± 3.78	b: 3.120	b: 0.108
				a × b: 2.422	a × b: 0.151
One leg balance with eye closed (s)	TG	46.83 ± 25.89	62.33 ± 21.50	a: 1.726	a: 0.218
	CG	34.83 ± 13.83	26.50 ± 12.16	b: 4.965	b: 0.050
				a × b: 19.086	a × b: 0.001**
1,200 m running (s)	TG	443.83 ± 35.35	411.00 ± 23.84	a: 0.016	a: 0.902
	CG	458.50 ± 24.26	492.67 ± 15.71	b: 12.001	b: 0.006**
				a × b: 40.397	a × b: 0.001**

TG training group, *CG* control group, a: time, b: group, a × b: time × group interaction

* $p < 0.05$; ** $p < 0.01$

whose body fat was 35% or higher and who had previously exercised, do aerobic exercise together with resistance training for 16 weeks. Results indicated a significant reduction in body weight and body fat. Choi et al. (2006) had 24 middle-aged women, whose body fat was 30% or higher, do aerobic exercise and resistance training five times a week for 10 weeks and also reported a positive effect on body composition.

This study had obese collegiate women, whose body fat was 30% or higher, do circuit weight training and aerobic

Table 5 Change in pulse wave velocity between TG and CG

Variables	Group	Pre	Post	*F* value	*p* value
Left hand (ms)	TG	205.63 ± 13.83	211.79 ± 17.41	a: 0.172	a: 0.687
	CG	199.08 ± 15.08	196.96 ± 16.96	b: 1.892	b: 0.199
				a × b: 0.724	a × b: 0.415
Right hand (ms)	TG	208.74 ± 19.21	213.42 ± 17.30	a: 0.026	a: 0.875
	CG	197.44 ± 13.71	195.91 ± 44.63	b: 1.459	b: 0.255
				a × b: 0.101	a × b: 0.757
Left foot (ms)	TG	329.05 ± 40.31	333.95 ± 20.99	a: 1.179	a: 0.303
	CG	313.44 ± 29.30	333.15 ± 41.62	b: 0.259	b: 0.622
				a × b: 0.427	a × b: 0.528
Right foot (ms)	TG	334.27 ± 48.82	336.52 ± 24.72	a: 0.106	a: 0.752
	CG	319.31 ± 16.58	324.71 ± 44.41	b: 0.600	b: 0.456
				a × b: 0.018	a × b: 0.896
RPP (mmHg bpm)	TG	7,932.50 ± 1,585.80	7,641.33 ± 1,244.37	a: 0.137	a: 0.719
	CG	7,613.83 ± 1,073.46	8,350.83 ± 2,518.86	b: 0.064	b: 0.806
				a × b: 0.727	a × b: 414
SBP (mmHg)	TG	120.00 ± 13.39	112.67 ± 8.41	a: 0.049	a: 0.829
	CG	106.17 ± 3.66	112.00 ± 17.29	b: 1.483	b: 0.251
				a × b: 3.807	a × b: 0.080
DBP (mmHg)	TG	72.33 ± 10.80	68.33 ± 6.29	a: 0.867	a: 0.374
	CG	63.83 ± 3.97	64.17 ± 6.43	b: 2.887	b: 0.120
				a × b: 1.211	a × b: 0.297
MAP (mmHg)	TG	88.06 ± 11.52	82.96 ± 6.91	a: 0.482	a: 0.374
	CG	77.80 ± 3.53	79.95 ± 8.96	b: 2.414	b: 0.120
				a × b: 2.909	a × b: 0.297

TG training group, *CG* control group, *RPP* rate pressure product, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *MAP* mean arterial pressure, a: time, b: group, a × b: time × group interaction

* $p < 0.05$; ** $p < 0.01$

exercise for 12 weeks and resulted in positive effects on body composition with respect to body weight, body fat, and waist circumference. These results tend to demonstrate that the combination of aerobic exercise and resistance exercise increased lean body mass and thus, enhanced energy consumption in the body (ACSM 2000). Further these results may indicate enhanced use of fat as a source of energy through the activation of lipase in fat tissues (Gill 2007).

ACSM (2006) recommended the frequency of exercise to be 5–7 days per week, at an intensity of 40–75% of the maximum heart rate, duration of 45–60 min, and with a total amount of energy consumption of 300–400 kcal. Further, the Health Welfare Division and WHO set a consumption of 150–200 kcal (1,000–1,400 kcal/week) per day as the lower limit at which exercise, including physical activities, because it can prevent obesity and maintain reduced weight. And when considering that the type of exercise to prevent and improve obesity focuses on the total amount of energy consumption rather than the intensity of exercise (Saris et al. 2003), the combination of circuit weight training and aerobic exercise in alternation taken for 60 min per day, three times per week in this study represent the least amount of exercise required to prevent obesity. If this amount of exercise is enhanced by proper eating habits, it should result in stronger effects with respect to an improvement in body composition.

When exercising for weight loss, fats are mobilized more in the waist than in the hip and femoral areas (Gan et al. 2003). Further, the waist circumference shows a higher extent of expectation for intestinal fats than for BMI, % body fat, and WHR (Turcato et al. 2000). This study showed the effect of exercise because WC in the TG was reduced but increased in the CG. Decreased waist circumference will have effect on the prevention and improvement of cardiorespiratory diseases in the long run. So it has been concluded that the combination of circuit weight training and aerobic exercise in alternation conducted in this study brought positive effects on the reduction of waist circumference and has helped in the prevention of lifestyle diseases due to fact that this combination of exercises required movements of the whole body.

4.2 Physical fitness

The levels of physical fitness and physical function tend to vary greatly depending on the physical activities, even in people of the same age. The back muscular strength, which this study measured, increase markedly in the TG, but showed no change in the CG. Further, grip strength increased after exercising in the TG, but decreased in the CG, illustrating the push-up and back exercises of that exercise helped improve muscular strength. This outcome agrees with the results of a study by Yang et al. (2005) in which the combination of exercises for 8 weeks by collegiate men showed a noticeable improvement in grip strength and back muscular strength, and also agreed with the results of Kim (2002) where the circuit training of women in their 30s for 40 min per day, 5 days per week for 8 weeks resulted in a significant improvement in grip and back muscular strength.

Sit and reach resulted in improved flexibility in the TG but decreased in the CG. Kim and Kim (2000) had collegiate women and men do static stretching for 8 weeks for flexibility and as a result, they all showed noticeable improvements in the sit and reach. Yang et al. (2005) had average collegiate men do a combination of exercises for 8 weeks and showed considerable improvements in the sit and reach. These results agree with the outcome of this study. Thus, it is deemed that the stretching before and after the circuit weight training helped with flexibility increases. The sargent-jumps improved in the TG but decreased in the CG. Balance and cardiorespiratory endurance also improved in the TG but decreased in the CG. These results demonstrate that the TG benefitted by circuit training exercises such as jump with arms and legs outstretched, the squat, and skip. This also means that circuit weight training and jogging had a very positive effect on the improvement of cardiorespiratory endurance.

Studies by Lee et al. (1999) on cardiovascular disease-related mortality reported that people with stronger cardiorespiratory fitness showed decreased mortality regardless of obesity. A study by Kang et al. (2006) on collegiate men reported that the group with the lowest level of cardiorespiratory fitness had a three times higher risk of being exposed to a metabolic syndrome than the group at the highest level of cardiorespiratory fitness, claiming that cardiorespiratory fitness can be an independent factor for predicting metabolic syndromes. These results suggest that those who are obese but have a high level of cardiorespiratory fitness can prevent death caused by cardiovascular diseases or other diseases. Hence, physical activity is needed to prevent lifestyle-related diseases. Because physical activity has an effect on the occurrence of obesity and changes in physical fitness, college students should engage in regular exercise.

4.3 Pulse wave velocity

The pulse wave velocity is the velocity of pulse waves in the arterial vessels transmitted along at the time of heart contraction. As such, the extent of the arterial stiffness can be predicted. So, in order to measure the extent of atherosclerosis, a method of measuring the elasticity of blood vessels using the pulse wave velocity has been recently designed. In addition, pulse wave velocity has been used a lot as an index of the extent of sclerosis of an arterial vessel (Woodman and Watts 2003). Looking at preceding studies on exercise therapies and elasticity of blood vessels, Beak at al. (2009) reported that 6 weeks of training for obese women aged 30 and 50 years showed noticeable increases in the velocity of pulse waves in the upper and lower extremities. Further, Lee (2005) reported that after 12 weeks of treadmill exercise with 60–70% HRmax for 50 min per day, three times per week, hypertensive individuals showed significant increases in the pulse wave velocity, improving the elasticity of blood vessels. Additionally, Cheon (2006) reported that a 12-week exercise program for middle-aged women showed an increase in pulse wave velocity and reduction of the thickness of the carotid artery, meaning that exercise had a positive effect on the elasticity of the blood vessels.

Blood vessels repeatedly contract and relax, transporting nutrients to every part of human body. The elasticity of vessels reduces as we age. If the blood volume increases and blood pressure rises while the vessels do not experience a corresponding expansion, the result can be cardiovascular disease and arteriosclerosis (Cheon 2006). However, it has been reported that regular aerobic exercises increases blood volume in the artery. The adaptation of the main artery to increases in blood volume increases the intima media of the artery, thus improving the structure of the vessel (Prior et al. 2004). Thus, exercise is important in the improvement of the function of arteries. However, in this study, pulse wave velocity showed no significant difference. However, the velocity of pulse waves showed an increase from 205.63 ms before exercise to 211.79 ms after 12 weeks of exercise in the left upper extremities, from 208.74 to 213.42 ms in the right upper extremities, from 329.05 to 333.95 ms in the left lower extremities, and from 334.27 to 336.52 ms in the right lower extremities. Overall, there was no noticeable difference.

Moderate intensity aerobic exercise, low intensity resistance exercise, and stretching by aged people demonstrated that aerobic exercise had the highest increase, and that low intensity resistance exercise and stretching resulted in similar levels of increase (Jeon 2004). It seems that there are no claims opposing the conclusion that aerobic exercise increases the elasticity of vessels and decreases systolic blood pressure. Hence, the reports of athletes who have trained their muscles for a long time and show a lower elasticity of vessels than the average person (David et al. 1999). It is clear that the change of the elasticity of blood vessels is affected by the type, intensity, and duration of exercise.

Rate pressure product (RPP) is indicated by the heart rate times the systolic blood pressure (Jorgensen et al. 1977). A study on the characteristics of cardiovascular system according to differences in the % body fat in hypertensive patients showed that hypertension increases the volume of oxygen consumption in cardiovascular muscle due to the tension of contraction and if the patient is obese, such increases would be higher. Since RPP is the index reflecting their operation rate and pressure, changes in the RPP is significant with regard to the pressure of the heart and the coronary artery. Therefore, a reduction in the RPP by cardiovascular muscle caused by long-term endurance exercise can have effect on blood flow in the coronary artery and reduce the overload on the heart.

Mean arterial pressure is important as it is aides in determining the velocity of blood flow and the rate of blood flow throughout the circulatory system. Usually, since the diastolic period is longer than the systolic period, the average pressure of an artery can be estimated by adding one-third of the pulse pressure to the diastolic pressure, not the average of the diastolic blood pressure and systolic blood pressure.

Lee (2005) reported that the average artery pressure decreased by 5.49 mmHg after 6 weeks of exercise, by 11.47 mmHg after 12 weeks of exercise at the time of stability after an extended period of aerobic exercise, saying that decreases in the average artery pressure depended upon the automatic adjustment abilities of the artery, arteriole, and vein and changes in the enthetic adjustment abilities and the redistribution of venous blood. The current study showed no significant difference in the RPP by the exercise group but it did indicate a decrease from 7,932.50 ± 1,585.80 mmHg bpm before exercise to 7,641.33 ± 1,244.37 mmHg bpm after 12 weeks of exercise. In the control group, an increase from 7,613.83 ± 1,073.46 mmHg bpm before exercise to 8,350.83 ± 2,518.86 mmHg bpm was observed. The mean arterial pressure showed no noticeable difference at the time of stability, but in the training group a decrease from 88.06 mmHg before exercise to 82.96 mmHg after 12 weeks of circuit exercises was seen. In the control group, there was an increase from 77.80 to 79.95 mmHg.

Generally, changes in the thickness of the main artery and the structural and functional changes in blood pressure due to physical activity have positive effects on the reduction of blood pressure. Circuit training including resistance exercise in this study needs more investigation with respect to the elasticity of blood vessels. Exercise at a young age is effective in preventing increases in and maintaining blood pressure. Abnormal atrophy of the blood vessel walls has been shown to be accelerated as patient's age, and the effect of exercise on blood vessels seems to be independent from the risk factors of the traditional cardiovascular fitness such as lipids in the blood (Kelly et al. 2004; Deng et al. 2008). So, the importance of regular exercise by obese collegiate women is emphasized as a method to prevent a rise in blood pressure with age.

5 Conclusion

Results demonstrated that the combination of circuit weight training and aerobic exercise examined in this study brought positive effects on the reduction of waist circumference and helped in the prevention of lifestyle diseases due to the fact that the combination of exercises required movements of the entire body.

Physical activity has effects on the occurrence of obesity and changes of physical fitness and therefore, college students need regular exercise. In particular, exercise should be emphasized as a method to prevent hypertension and vessel stiffness in obese collegiate women.

References

ACSM (2000) ACSM's guidelines for exercise testing and prescription(6th edn), Lippincott Williams and Wilkins

ACSM (2006) ACSM's guidelines for exercise testing and prescription (7th edn). Lippincott Williams and Wilkins, pp 74

Beak YI, Nam SS, Sun WS (2009) Effects of 6 weeks of the whole body vibration training on vascular compliance, and vascular regulation substance in middle aged obese women. Exerc Sci. 18(2):151–162

Bensimhon DR, Kraus WE, Donahue MP (2006) Obesity and physical activity: a review. Am Heart J 151:598–603

Carroll S, Dudfield M (2004) What is the relationship between exercise and metabolic abnormalities? A review of the metabolic syndrome. Sports Med 34(6):371–418

Cheon WK (2006) Changes of pulse wave velocity and body composition after 12 weeks exercise program in middle-aged obese women's. Korean J Exerc Nutr 10(3):341–345

Choi JH, Yang JH, Han JP (2006) A comparative analysis of body composition and blood lipid profile during exercise and detraining in exercise type in the middle-aged obese women. Korean J Phys Educ 45:3

Cox K, Burke V, Morton A, Beilin L, Puddey I (2004) Independent and additive effects of energy restriction and exercise on glucose and insulin concentrations in sedentary overweight men. Am J Clin Nutr 80:308–316

David AB, Tamara KW, Christoph DG, James DC, Anthony MD, Bronwyn AK (1999) Muscular strength training is associated with low arterial compliance and high pulse pressure. Hypertension 33(6):1385–1391

Deng S, Youn CH, Liu Q, Kim HY, Yu T, Kim YH (2008) Policy adjuster-driven grid workflow management for collaborative heart disease identification system. J Inf Process Syst 4(3):103–112

Gan SK, Kridetos AD, Ellis BA, Thompson CH, Kraegen EE, Chisholm DJ (2003) Changes in aerobic capacity and visceral fat but not myocyte lipid levels predict increased insulin action after exercise in overweight and obese men. Diabetes Care 26(6): 1706–1713

Gill JM (2007) Physical activity, cardiorespiratory fitness and insulin resistance. Curr Opin Lipidol 18(1):47–52

Irwin M, Yasui Y, Ulrich C, Bowen D, Rudolph R, Schwartz R, Yukawa M, Aiello E, Potter J, McTiernan A (2003) Effect of exercise on total and intra-abdominal body fat in postmenopausal women: a randomized controlled trial. J Am Medical Assoc 289(3):323–330

Jeon YS (2004) Vascular compliance and blood pressure response on exercise types in aged men. Chungnam University, Master's thesis

Jorgensen CR, Gobel FL, Taylor HL, Wang Y (1977) Myocardial blood flow and oxygen consumption during exercise. Ann NY Acad Sci 301:213–223

Kang HS, Honh HR, Kang KH, Lee JY, Jin YS (2006) Effect of weekly exercise volume on obesity and its metabolic syndrome in centrally obese mid-life women. Exerc Sci 15(4):301–308

Kelly AS, Wetzsteon RJ, Kaiser DR, Steinberger J, Bank AJ, Dengel DR (2004) Inflammation, insulin, and endothelial function in overweight children and adolescents: the role of exercise. J Pediatr 145(6):731–736

Kim GG (2002) Influence of weight training and circuit training program participation on body composition and physical fitness. J Sport Leisure Stud 17(17):137–144

Kim KL, Kim TW (2000) The correlation between anaerobic threshold and muscle fatigue threshold during arm cranking. Korean J Phys Educ 39(2):285–293

Lee JH (2005) Effects of aerobic exercise on arterial pulse wave velocity and vessel pressure in patient with anti-hypertensive agents. Hanyang University, Doctoral dissertation

Lee CD, Blair NS, Jackson SA (1999) Cardiorespiratory fitness, body composition, and all-cause and cardiovascular disease mortality in men. Am J Clin Nutr 69(3):373–380

LeMura SM, Maziekas MT (2002) Factors that alter body fat, body mass and fat-free mass in pediatric obesity. Med Sci Sports Exerc 34(3):487–496

Manning J, Dooly-Manning C, White K, Kampa I, Silas S, Kesselhaut M, Ruoff M (1991) Effects of a resistive training program on lipoprotein-lipid levels in obese women. Med Sci Sports Exerc 32(11):1222–1226

Prior BM, Young HT, Terjung RL (2004) What makes vessels grow with exercise training? J Appl Physiol 97:1119–1128

Saris WHM, Blair SN, van Baak MA, Eaton SB, Davies PSW, Di Pietro L, Fogelholm M, Rissanen A, Schoeller D, Swinburn B, Trembly A, Westerterp KR, Wyatt H (2003) How much physical activity is enough to prevent unhealthy weight gain? In: Outcome of the IASO 1st stock conference and consensus statement

Schrauwen P, Westererp KR (2000) The role of high-fat diets and physical activity in the regulation of body weight. Br J Nutr 84:417–427

Turcato E, Bosello O, Di FV, Harris TB, Zoico E, Bissoli L, Fracassi E, Zamboni M (2000) Waist circumference and abdominal sagittal diameter as surrogates of body fat distribution in the elderly: their relation with cardiovascular risk factors. Int J Obes Relat Metab Disord 24(8):1005–1010

Watts K, Jones TW, Davis EA, Green D (2005) Exercise training in obese children and adolescents: current concepts. Sports Med 35(5):375–392

Woodman RJ, Watts GF (2003) Measurement and application of arterial in clinical research: focus on new methodologies and diabetes mellitus. Med Sci Monit 9:RA81–RA89

Yang JO, Kim YS, Park SM (2005) The effects of combined training on health-related fitness in college students. J Phys Growth Motor Dev 13(1):1–9

Yoo BK (2005) The change of severely obese middle aged women's body fat, cardiovascular strength and blood hormone on the combined exercise. Korean J Exerc Nutr 9(3):253–259