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The Effects of Circuit Weight Training Programs including Aquatic Exercises on the Body Composition and Serum Lipid Components of Women with Obesity

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Purpose: This study investigated the changes in body composition and serum lipid composition in obese women that were caused by a 12-week circuit exercise regime including both field and aquatic activities.

Methods: Subjects comprised a total of 36 women who had a BMI of more than 25 kg/m^2. The simple obesity group (n=17) had no current or past record of medical complications, whereas the group with complications (n=19) also suffered from hypertension and/or diabetes. The circuit exercise program consisted of 12 weeks of 60%HRmax exercise sessions, five days a week.

Results: While changes in every variable of body composition were significant, there was no statistically significant difference in the changes in serum lipid composition variables. With the exception of BMI, the correlation between the simple/complicated groups and exercising was statistically insignificant.

Conclusion: These findings suggest that while a complex circuit weight exercise program that includes aquatic exercises significantly and positively alters obese patients' body composition it does not create statistically significant changes in their serum lipid composition. It can still be concluded, however, that increasing the duration of the exercise program would be effective to influence this. Moreover, personalized exercise programs that fit the needs of the individual participants seem necessary, given that the effect of exercise on body composition and serum lipid composition was greater in patients with simple obesity than in those with complications.

Keywords: Aquatic exercise, Circuit weight training, Obesity

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I. Introduction

Obesity is now formally categorized as a disease and is both a dire threat to global health and a major source of various other chronic diseases.[1,2] In South Korea, obesity is defined as an individual being above 25 kg/m^2 on the body mass index, having a male waist measurement above 90 cm, or a female waist measurement above 85 cm (based on WHO Asia-Pacific Division and KSSO).[3] The causes of obesity are diverse and complex. Major causes include genetic predisposition, dietary habits, endocrine system abnormalities, and a lack of exercise.[4]

According to the 2009 National Health Survey (4th survey; 3rd year), the prevalence rate of obesity is 31.9% overall, broken down into 36.2% for men, and 27.6% for women.[5] Age-wise, males in their 50s and females in their 60s are the most likely to be obese. Aging causes various physiological changes, one of which is a decrease in an individual's amount of muscle.[6] Aging is also one of the factors related to increases in weight, body fat and intra-abdominal fat as well as in the accumulation of serum lipids.[7] As older people use their body less, high-calorie diets lead to excess fat composition and eventually to obesity. Such change can then weakens their muscles and limit their activity further, thus creating a negative cycle.[8,9] As a result, their daily activities may also be affected and they may experience a lower quality of life. For women, especially, due to the effects of menopausal hormones, abdominal obesity is rapidly becoming more common, with the prevalence ratio increasing faster than that for men, at an average annual rate of 3.3%.[2]

The main objective of obesity treatment is thus weight reduction.[10] Diet is the most common method of losing weight, but other methods include exercise, medication, surgery and behavioral correction. With the exception of exercise, these other methods all offer temporary results and have side-effects, which can include a loss of muscle structure, a decrease in BMR (basal metabolic rate), and lethargy.[11] Moreover, there is no medical consensus about the effectiveness of the above- mentioned methods of preventing and treating obesity.[12] However, there is general consensus that it is important to cultivate healthy lifestyles while implementing appropriate diet and workout plans to combat obesity.[11,13] In addition, Nelson and colleagues[14] have proposed that regular bodily exercise, including aerobic and muscular exercise, are imperative for healthy aging.

There have been several research papers that discuss the impact of exercising on obesity, with diverse conclusions having been presented.[1,10,15,16] The main objective of exercising in order to promote weight reduction lies in increasing the amount of energy consumption through increased body movement, and is focused especially on effectively reducing body fats. Usually, exercise is the most effective when it requires endurance. Muscular exercises do not directly affect weight but can reduce body fats.[17,18] Regular exercise creates changes in serum lipid levels, whereas the total cholesterol (TC) is either reduced or unchanged while triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C) are both reduced and high-density lipoprotein cholesterol (HDL-C) is increased.[1,7,15,19]

To treat obesity with exercise, the ASCM[20] recommends aerobic activities such as walking, cycling, and underwater exercise, all of which can burn calories steadily over a long period. Aerobic exercises increase energy consumption and use up body fats while also increasing BMR and decreasing body fat.[21] However, aerobic exercise alone has little effect muscle strengthening.[22] It has also been found that muscular exercises involving aerobic activity strengthen muscle, and that weight training, which is a muscular exercise, can create physiological effects equal to those provided by aerobic exercise.[10,23] Aerobic exercise and endurance exercise tend to have stronger effects on patients suffering from hypertension, diabetes, and obesity.[24] It has been found that regular exercise affects the serum lipid levels of obese patients with diabetes or high blood pressure.[25,26] Yet these exercise methods may impose pressure on the patients' joints, and may lead them to halt their exercise. Halting exercise has negative effects on improving patients' health-related measurements, including obesity index values and serum lipid levels.[4]

Underwater exercise, which utilizes the buoyancy of water, reduces the effects of gravity and the pressure on bone joints, and thus enables work-outs to be conducted with less pain. Therefore it is effective exercise for patients with arthritis or obesity, or even just for older people in general.[27] Compared to activities on ground, underwater exercise also reduces the stress caused by weight, while increasing energy consumption.[28] Wilder and Brannan[29] report that conducting underwater exercise greatly decreased weight and body fat content, as well as body mass index, and looking at a Korean population, Han[30] also found that underwater activities created positive effects on female body composition. In addition, underwater exercise coupled with music can promote positive psychological changes in participants, and as the exercise is often conducted in group settings, there may be additional positive psychological and social effects.[27]

Thus the purpose of this research was to examine the effects of a 12-week circuit weight training program that included aquatic exercise on the body composition and serum lipid components of obese females. Moreover, it aimed to explore the interactions in which the classification of subjects and the performance of exercise had an impact on the results.

II. Methods

1. Subjects

Subjects lived in City "S" in Gyunggi-do, Korea, and were participants in an obesity exercise class conducted by a municipal health center. The participants of the obesity exercise program comprised 60 obese women with a BMI higher than 25 kg/m.[2] These 60 were separated into those without a related medical history, and those with complications such as hypertension or diabetes. Of the 60 subjects, 36 participated in the 12-week exercise program. The other 24 participants dropped out due to personal reasons such as moving. The 36 research subjects were composed of 17 obese participants with no complications and 19 obese participants with complications.

Table 1. General characteristics of subjects

Subject group	Age (yr)	Height (cm)	Weight (kg)	BMI (kg/m^2)
Total (n=36)	43.0±10.6	158.0±4.1	71.2±6.9	28.5±2.3
Simple obesity group (n=17)	38.9±9.0	157.9±5.0	70.3±4.6	28.2±1.2
Complicated obesity group (n=19)	46.6±10.7	158.0±3.3	72.1±8.5	28.8±2.9

The subjects sufficiently understood the purpose of this study and voluntarily participated after providing written consent. The general characteristics of the subjects are as shown in Table 1.

2. Experimental methods

1) The program

The circuit exercise program included both field exercise and aquarobics, and aimed at carrying out resistive exercise. Exercise was scheduled five times a week, of which Mondays,

Table 2. Circuit exercise program that included both field and aquatic exercises

Stage	Exercise Program			Parameters		
	Step	Type	Contents	Time (min)	Frequency	Rest (sec)
Warm up	Dynamic stretching			5		
Main exercise	Introductory period	Field exercise	Air step box	1	4	60
			Step box kick			
			Leg kick back			
			Half push-up			
			Gymball legraise			
		Aquatic exercise	Aqua running	10	1	60
			Aqua jump	5	2	
			Aqua clapping	5	1	
			Aqua jeki	5	1	
			Aqua running	10	1	
	Developmental period	Field exercise	Chest press	1/2	3	40
			Run with open arm			
			Pec-deck flye			
			Step box kick			
			Lat pull-down			
			Lunge			
			Side step			
		Aquatic exercise	Aqua running	10	1	60
			Aqua jump	7	2	
			Aqua clapping	5	1	
			Aqua jeki	7	1	
			Aqua running	7	1	
	Maintenance period	Field exercise	Barbell press	2/3	3	40
			Lunge			
			Sit-up board			
			Step box kick			
			Barbell row			
			Run with open arm			
			Leg curl			
		Aquatic exercise	Aqua running	10	1	60
			Aqua jump	10	2	
			Aqua clapping	5	1	
			Aqua jeki	5	1	
			Aqua running	10	1	
Cool down	Static stretching			10		

Wednesdays, and Fridays were field exercise, and Tuesdays and Thursdays were aquarobics. Each daily program consisted of five minutes of warm-up, 40~60 minutes of the main exercise, and then ten minutes of cool-down. The first four weeks were the introductory period, the next four were then developmental period, and the final four weeks were a maintenance period, which lead to a 12 week total program. In each period, the main exercise time was gradually increased, and the type, frequency, and duration of each part of the program were also adjusted accordingly. Considering the fact that all research subjects suffered from obesity and that high blood pressure was present in some cases, 60%HR at max was set as the intensity level of the main exercise. The specifications of the 12 week circuit exercise program are detailed in Table 2.

2) Measurement categories and tools

Body composition and serum lipid levels were separately measured, once prior to the program and then again after the 12 week program had been completed.

Body composition was measured using Inbody 4.0 (Biospace, Korea). Specifically body weight (kg), body mass index, fat mass (kg), percentage fat (%), lean body mass (kg), muscle mass (kg), waist to hip ratio, arm circumference (cm), and ratio of intra-abdominal fat (cm^2) were measured. For research subjects with hypertension, blood pressure and blood sugar were also measured, each using a sphygmomanometer (Tm 2655, Biospace, Korea) and a blood sugar meter (HemoScan, Dasanmedical, Korea). Blood pressure and sugar levels were measured after two minutes of relaxation, at the height of their heart in a sitting position.

To measure serum lipid levels, the subjects' blood was taken after about five hours of zero food consumption. The blood was collected by a professionally trained nurse at the health center, who took a dose of about 5 ml from the subjects' lower-artery when they were in a sitting position. The collected blood was then run through a blood analyzer (Force 1618, LABNET, USA) to measure the total cholesterol (TC), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C). The low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedwald equation.

3. Statistical analysis

Study data were analyzed using SPSS for Windows (version 12.0). The average and standard deviation for each variable was calculated using technological statistics. Paired t-tests were conducted to confirm the differences (in body composition and serum lipid levels) before and after participation in the exercise program. 2-way repeated ANOVA was also used to examine the connections between the exercise and the characteristics of the research subjects. The statistical level of significance was set at 0.05.

III. Results

The results are shown in both averages and standard deviations in Table 3. Every body composition variable, including BMI, was very significantly decreased after the program, as shown in the results of using paired t-testing (p=0.00). For serum lipid components, however, only neutral fat showed a statistically significant decrease (p=0.01), while the total cholesterol, HDL-D, and LDL-C showed no significant decreases (p>0.05).

When dividing the participants into a simple obesity group (those who were suffering solely from obesity) and complicated group (those with either hypertension and/or diabetes), the simple obesity group showed a significant decrease in all body composition variables, while the group with complications showed changes in some variables, but not in their muscle mass and lean body mass (Table 4). Related to serum lipid composition, in the simple obesity group the total cholesterol and LCL-C were significantly decreased after the program (p=0.01). The group with complications, however, showed no statistically significant results in serum lipid composition variables (p>0.05).

Additionally, as a result of conducting analyses of variance between the simple obesity and complicated obesity groups and looking at the interactions that followed the implementation of the exercise program, body weight (F=4.52, p=0.04) and BMI (F=4.83, p=0.04) showed a correlation between the groups and before/after the exercise, but the other measuring variables did not show statistically significant correlations (p>0.05). For the non-interactive variables, analysis focused on the main effect on the group and time. In this respect, the fat mass, percentage fat, muscle mass, and lean body mass variables appeared indiscernible between the two groups, while statistically significant in terms of change before and after the exercise program. The main

Table 3. Mean and change score of all variables for all subjects before and 12 weeks after

Body composition	Pre-training (n=36) M±SD	Post training (n=36) M±SD	t-value	p-value
Wight (kg)	71.22±6.89	67.18±7.26	9.03	0.00*
BMI (kg/m^2)	28.53±2.27	26.91±2.46	9.18	0.00*
Fat mass (kg)	27.34±4.50	24.21±4.99	8.89	0.00*
% fat (%)	38.25±3.68	36.82±4.27	7.21	0.00*
Muscle mass (kg)	41.32±3.72	40.54±3.57	3.70	0.00*
Lean body mass (kg)	43.88±3.96	42.97±3.85	4.02	0.00*
Waist to hip ratio	0.92±0.05	0.90±0.05	5.32	0.00*
Intra-abdominal fa t(cm^2)	99.34±20.67	93.38±22.50	4.40	0.00*
Serum lipid components	**Pre-training (n=36) M±SD**	**Post training (n=36) M±SD**	**t-value**	**p-value**
Blood glucose	111.49±47.37	103.20±35.10	1.97	0.06
Triglyceride	104.75±53.13	85.94±51.36	2.65	0.01*
Total cholesterol	181.81±32.26	175.25±34.65	1.45	0.16
High-density lipoprotein cholesterol	50.78±6.83	51.36±7.25	-0.66	0.52
Low-density lipoprotein cholesterol	110.08±28.33	106.70±29.99	0.91	0.37

M±SD: Mean ± standard deviation
*$p<0.05$

effect of abdominal fat and intra-abdominal fat turned out to be statistically significant among both groups and before and after the exercise program. Because the serum lipid components also showed no interactive effects on all measuring variables, we looked at the main effect instead. This showed that only the changes in neutral fat content were discernable between the groups and before and after exercise, whereas all other variables showed no discernable differences.

IV. Discussion

Obesity is considered a disease in modern society, and causes or influences multiple health-related problems. Excessive fat content leads to obesity, and may cause hypertension and diabetes, while also being a psychological risk factor for mental instability, low self-esteem, or even depression.[6,10] Obesity management is receiving growing attention, and there have been consistent research results that point to regular body activities and exercises as being effective countermeasures.[15-17] In order to lose body weight while gaining stronger cardiovascular endurance, gross motor exercise is imperative, and aerobic and resistive exercises that are aimed at improving muscular strength and muscular endurance are effective.[10,23] Aquatic exercises, i.e. those that are carried out underwater, are also advantageous in the sense that they reduce the body load and are easy to imitate, and thus are ideal for women with weaker bone structure and thicker fat content.[9]

To achieve a healthy and strong body composition, muscle should be enhanced while fat should be burned off through exercise. When losing weight to counter obesity, it is important to reduce body fat while maintaining lean body mass. Exercising prevents the loss of BMI and lean body mass and is thus effective in obesity patients.[9]

This research study created a circuit exercise program that included both field and aquatic activities to compare the changes this program effected in the body composition and serum lipid composition of obese women. Body composition variables showed significant reductions: weight, BMI, fat mass, percentage fat mass, WHR and intra-abdominal fat were all reduced. The 12 week program reduced 4 kg of body weight on average, and also reduced fat mass and fat percentage.

This result largely corresponds to other research results that have shown that exercise can create positive changes in body

Table 4. Effect of interaction on circuit weight training and subject groups

Body composition	Subject group	Pre-training	Post- training	Paired t- test		ANOVA Group × Time	
		M±SD		t	p	F	p
Weight (kg)	SOG	70.29±4.60	65.29±4.79	8.08	0.00*	4.52	0.04*
	COG	72.05±8.48	68.87±8.70	5.41	0.00*		
BMI (kg/m^2)	SOG	28.20±1.24	26.19±1.43	8.23	0.00*	4.83	0.04*
	COG	28.83±2.90	27.55±3.01	5.23	0.00*		
Fat mass (kg)	SOG	26.17±2.47	22.49±2.37	8.79	0.00*	2.17	0.15
	COG	28.38±5.61	25.74±6.18	4.91	0.00*		
% fat (%)	SOG	37.24±2.63	34.48±2.87	7.30	0.00*	0.81	0.37
	COG	39.16±4.28	37.01±4.99	3.94	0.00*		
Muscle mass (kg)	SOG	41.55±3.25	40.46±3.43	3.45	0.00*	1.85	0.18
	COG	41.12±4.17	40.61±3.79	1.84	0.08		
Lean body mass (kg)	SOG	44.12±3.49	42.79±3.76	3.99	0.00*	3.25	0.08
	COG	43.67±4.43	43.13±4.03	1.85	0.08		
Waist to hip ratio	SOG	0.90±0.03	0.88±0.03	4.77	0.00*	1.51	0.23
	COG	0.94±0.06	0.92±0.05	3.00	0.01*		
Intra-abdominal fa t(cm^2)	SOG	89.31±15.79	82.55±16.96	3.53	0.00*	0.30	0.59
	COG	108.32±20.72	103.06±22.79	2.69	0.02*		
Body composition	**Subject group**	**Pre-training**	**Post-training**	**Paired t-test**		**ANOVA Group × Time**	
		M±SD		**t**	**p**	**F**	**p**
Blood glucose	SOG	113.44±56.84	109.50±50.00	1.01	0.33	0.89	0.35
	COG	109.84±39.25	97.89±13.40	1.70	0.11		
Triglyceride	SOG	81.94±34.85	65.18±26.31	1.82	0.09	0.07	0.79
	COG	125.16±58.97	104.53±61.18	1.91	0.07		
Total cholesterol	SOG	177.53±21.66	164.53±25.29	3.14	0.01*	1.87	0.18
	COG	185.63±39.67	184.84±39.50	0.10	0.92		
High-density lipoprotein cholesterol	SOG	53.06±4.83	52.71±5.57	0.21	0.83	0.99	0.33
	COG	48.74±7.78	50.16±8.45	-1.77	0.09		
Low-density lipoprotein cholesterol	SOG	108.08±21.44	98.79±23.21	2.93	0.01*	2.37	0.13
	COG	111.86±33.83	113.78±34.04	-0.31	0.76		

M±SD: Mean ± standard deviation
*p<0.05
SOG: Simple obesity group (n=17)
COG: Complicated obesity group (n=19)
ANOVA: Analysis of variation

composition. It can be suggested that a circuit exercise program including both field and aquatic activities will positively alter body composition. However, the results also showed that muscle mass and lean body mass decreased by about 1 kg on average. In another study, circuit weight training and jogging led to a reduction in BMI and percentage fat mass in women with metabolic disorders, but WHR and lean body mass also decreased.[23] Another similar study showed that after applying 10 weeks of aerobic exercise to an obese man with hypertension and diabetes, the exercise caused positive effects on body fat reduction while keeping lean body mass unchanged, which is consistent with other research results.[31]

However, when researchers carried out indoor and outdoor activities based on aerobic fitness with a group of obese adolescents, both the experimental and control groups showed significant drops in BMI and lean body mass increased to a statistically significant level in the experimental group.[16] As result of applying an aquatic exercise program to women, it was found that muscle mass increased, but not to a statistically significant level, which is comparable to the result in this research.[9] The differences in results seem to thus stem from the subjects' differing ages and genders. This research focused specifically on women with an average age of 42.97±10.55, while Wong et al.[16] examined boys aged between 13 and 14 and Oh[9] used older people over 60 as the subject population. Based on these studies and their results, it can be suggested that women and older people show a smaller increase in muscle mass and lean body mass after exercising than adolescent children do.

Looking at serum lipid composition, this study found that only the neutral fat level showed a statistically significant difference after an exercise program, and TC and LDL-C did decrease but not significantly while HDL-C increased but also not statistically significantly. Previous research has shown similar findings in relation to serum lipid composition.[32] In a study that implemented a PACE (programmed accommodating circuit exercise) with aerobic and resistive exercises, TC, TG, LDL-C decreased after the program but not to a statistically significant level, whereas HDL-C increased significantly, similar to the current study.[22] Likewise, Kersick et al.[33] reported that no statistically significant changes were shown in TC, TG and LDL-C as a result of a regular exercise program. Fett et al.[23] also reported that there were statistically significant decrease in TC and TG in a circuit weight training group and in glucose and HDL-C in a jogging group, and that the only difference between the two groups was in the LDL-C. In the previously mentioned study of obese adolescents it was found that TC increased while TG decreased, and that HDL-C and LDL-C were maintained but changes were statistically indifferent.[16] In Korea-specific research, TC, TG and LDL-C have usually decreased significantly as a result of exercise, and HDL-C has shown statistically significant increase.[9,34,35] Martin et al. [7] reported that in an experimental group who underwent aerobic and strength-based training, TC, TG and LDL-C decreased at a statistically significant level, while HDL-C increased significantly. Anderson et al.[1] also reported a decrease in serum lipid components in obese women after the application of a combination of dietary and lifestyle change alongside exercise, which is also a differing result from that found by the current study.

When comparing results, the findings from this research were similar to previous findings in that a 12-week circuit weight program decreased TC, TG and LDL-C while increasing HDL-C, but because there was no statistical significance except for in TG, it is difficult to propose that the exercise program in this study caused changes to the serum lipid component. Foreign research that was similar to this study has in the main considered circuit exercise training involving aerobic and resistive exercises (for 8 to 12 weeks, three days a week) and has reported no clear differences in the composition of serum lipids as a result of this exercise. It is likely that the durations involved in this research are the reason for similar findings to the current study. This suggestion is supported by the fact that foreign research that implemented 16-week exercise programs found different results. Therefore there seems to be a need to confirm and strengthen results by further studies that increase the duration of the exercise programs involved.

Research that has reported no clear differences in serum lipid composition after exercise program participation has used patients with complications (such as hypertension and diabetes) as the study population. In our study, nearly half of the participants had complications. Other Korean studies that have reported contrary findings to our own in terms of serum lipid composition have, by contrast, examined simple obesity patients as their subjects. Taken together, these two facts suggest that using complicated obesity patients is likely to affect findings related to serum lipid composition. It would therefore be meaningful to further compare the differences between simple and complicated obesity patients in future research that addresses Korean obese women and exercise.

This research used the simple/complicated groups and the before/after exercise results as fixed variables in the two-way ANOVA (Table 4). As a result, the simple obesity group showed similar results to the overall group, while the group with complications showed no statistically significant changes to their muscle mass and lean body mass. Regarding serum lipid components, TC and LDL-C decreased statistically significantly only in the simple obesity group, which leads us to believe that the 12 week period of exercise program was more effective for simple obesity patients. This result is consistent with the findings of another study which reported that when combined aerobic exercises were applied to older women with hypertension there was no difference in the serum composition at the before and after exercise stages or among different groups.[36] These results suggest that more extensive research that focuses on obese patients with complications is necessary. There has, however, been past Korean research related to the prevention of metabolic disease through lifestyle changes, and as a result of such work, the modification of lifestyle and diets as well as regular exercise are being increasingly emphasized as measures against obesity.[6,31,34]

This research is limited in that it could not make controlled comparisons among the groups because of the fact that the age range of the women was quite wide and that there were measured differences at baseline between the simple obesity patients and those with complications. Therefore, it can be suggested that follow-up research that uses wider subject ranges and varying exercise methods, intensities and durations should be carried out. Moreover, we concluded that increasing the duration of exercise in order to maintain regular exercise is effective; this needs to be further validated. Since changes in body composition and serum lipid composition were more positive in patients with simple obesity than in patients with complications, personalized exercise programs that fit the needs and characteristics of participants seem necessary.

Author Contributions

Research design: Hwang R
Acquisition of data: Hwang R
Analysis and interpretation of data: Kim GW
Drafting of the manuscript: Hwang R, Kim GW
Administrative, technical, and material support: Hwang R
Research supervision: Hwang R

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