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The effect of 4wk combine exercise on skeletal muscle mass, physical fitness and blood related parameters in perimenopausal women

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Abstract

This study analysed the influence of a 4 week combined weight bearing circuit exercise program in the body composition, physical fitness, and blood profile of an perimenopausal women (aged from 40 ~ 60, N = 29). Significant improvements were found in blood related parameters, fat-related parameters in body compositions and physical fitness parameters (P<0.01). As skeletal muscle mass (SMM) and lean % Dual-energy X-ray absorptiometry (DXA) considered as a standard for muscle mass in this study are used because each standard showed significant differences (P<0.01) and each standard significantly correlated with SMM, weight, time to exhaustion, fat-related parameters such as fa t% DXA, lean % DXA and free fatty acid in pre and post exercise. Blood-related parameters (creatinine, glucose, HDL-cholesterol, and total protein) significantly correlated with changes in each corresponding blood-related parameter after exercise (P=0.000). Exercise contributed to improving muscle mass-related parameters used as biomarkers in this study, which improved the positive changes of healthy indices are indispensable factors for evaluating the effects of exercise. These changes contribute to a virtuous cycle, which accelerates the capacity to perform exercise. It suggests that the weight-bearing circuit exercise can improve the quality of life of perimenopausal women.

Key words: weight-bearing circuit resistance training, perimenopause, skeletal muscle, body composition

Introduction

Perimenopause means ‘around the menopause’ and indicates a span of time before and after the final menstrual flow (Bener et al., 2014). Perimenopausal women (immediately before, during and after menopause) face decline in various physical or psychological factors. They are prone to hormonal changes, such as decreasing estrogen level (Maltais et al., 2009) or dramatic muscle mass and strength (Toivonen et al., 2013). In particular, decreased muscle mass caused by menopause is associated with a high possibility of decreased physical activity, which accompanies physiological abnormalities like insulin resistance, general obesity, cardiovascular disease (Katz et al., 2000; Lejskova et al., 2011) that reduces the probability of women changing physiologically for the better, which accelerates the vicious circle. Many alternatives for alleviating this phenomenon have been proposed, such as hormone replacement or exercise (Toivonen et al., 2013) to increase muscle plasticity (Jee et al., 2009), however, there is a paucity of studies associated with exercise in this particular type of subjects.

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Previous study reported that resistant exercise enhances physical function and improves muscle mass (Liu et al., 2009). Davidson et al. reported that aerobic and combined (resistant and aerobic exercise) exercise, not resistant exercise, improved insulin resistance. Recent studies have shown that the less fat mass and ameliorated endurance capacity were induced by aerobic and combined exercise, not by resistant exercise, and improved muscle quality (muscle mass and its strength), was obtained by resistant and the combined exercise (Davidson et al., 2009).

However, there are very few studies (from the aspect of skeletal muscle mass) about what kind of exercise can be a good measure of fitness in middle-aged women. In this study, we examined the effect of 4-week weight bearing circuit exercise training on perimenopausal Korean women to prolong or enhance the physiological health state in order to enhance their quality of life. Among the parameters, we emphasized parameters showing muscle mass and we set those as a standard biomarker to be an index for relationship with other parameters, because skeletal muscles cannot allow subjects to perform sports activities unless those parameters function. The muscle mass parameters thus are considered to be one of the main factors that accelerate the virtuous cycle: comparatively high muscle mass allows subjects to perform exercise that positively affects body composition; cardiac, metabolic, physical fitness and hematologically related factors improve and these in turn lead to positive effects on muscle mass (Katz et al., 2000; Lejskova et al., 2011).

The purpose of this study is to evaluate the effect of 4-week weight bearing circuit exercise training with low intensity on perimenopausal Korea women and to grasp the importance of muscle-related parameters as indices of the various ranges of other parameters such as body composition, physical fitness, and blood related parameters after exercise in perimenopausal women.

Methods

Participants

Women aged over 40-women who lived in a certain area of Incheon, an urban area, were invited to participate in this study. This group of subjects with more than 25 ~ 30% fat mass (body mass index, BMI) or nutritional supplements in the 3 months before this study had not participated in regular exercise activity. Study purpose and contents were explained and written informed consent was obtained from all before starting this study.

Methodology

Body composition, physical fitness and blood profile of all subjects were evaluated to the effect of understand the optimally programmed combined exercise effect on the health status of perimenopausal women. Body composition: Precise fat% and lean% Dual-energy X-ray absorptiometry (DXA) of all subjects were measured by using DXA (GE Lunar Prodigy, GE Medical Systems Lunar, Atlanta, USA) at a public health center in Incheon. Subject eligibility was confirmed after measuring Skeletal muscle mass (SMM), BMI, height, and weight (Inbody 720, Biospace, Cheonan, Korea). Physical fitness: Basic physical fitness parameters such as grip strength, body flexibility, muscular endurance, rapid reaction, quickness, and balance were measured by the physical fitness apparatus (NH 3000 series, Helmas Co. Seoul, Korea) before and after the above exercise program. The average grip strength between maximum and minimum value from 2 trials of right and left hand grip was decided. The sit-up test during 1 min was measured for muscle endurance. Body flexibility was measured by the sit and reach test. The Sargent test for rapid reaction was chosen. Response time to react to light was used for quickness. Balance was measured by the time standing on one leg with one eye open. Maximal oxygen consumption related factors such as maximal Heart Rate (max HR) was tested by using a treadmill (T 150 COSMED and Quark series, COSMED Co, Rome, Italy) with the Bruce protocol. The test was closed when the oxygen consumption of a subject plateaued, reached the maximal heart rate estimated by age of the subject, or the subject cannot try the test longer by the guideline of self-awareness. Hematology- related factors test: Whole parameters such as albumin, gamma glutamyl transpeptidase (GTP), Alkaline phosphatase (ALP), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), total bilirubin, blood urea nitrogen, calcium, total cholesterol, creatinine, free fatty acid, glucose, HbA1c-eAG, HbA1c-IFCC, HbA1c-NGSP, High density lipoprotein (HDL) cholesterol, Lactate dehydrogenase (LDH), phosphorus, protein total, and uric acid were screened by blood collecting process. All subjects were forbidden from alcohol and doing exercise 48 hours before blood collecting. The blood collecting was done at Seoul Medical Science Institute for overall blood analysis at 9 am after 12 hours of fasting before and after the exercise.

Exercise Program

A 4-week weight-bearing circuit exercise training was used and its intensity was set at a target heart rate of 55% according to the Karvonen Formula [9]. The 10-min warming-up, 40-min main training, and 10-min cooling down program was performed 3 times per week for 4 weeks. The program consisted of hip circles, push-ups, lateral squats, long lever crunches, squats, arm and leg raising, and calf raising in 2 repeated sets consisting of 20-30 times each (Table 1). All subjects were supervised by the same instructor for the 4 weeks and intermittent health consultations were held as necessary.

Statistics

All data are described as means ± standard deviation (S.D.). Each parameter value between prior and post exercise groups was statistically assessed by the Wilcoxon signed rank test. Statistical difference analyzed by the Wilcoxon signed rank test was executed between pre SMM and pre lean % DXA or post SMM and post lean % DXA, respectively, to emphasize that SMM and lean DXA were not used as the same standard parameter in this study. Whole parameters used between prior and post exercise groups were also evaluated by using Pearson's coefficient of correlation analysis if there was a significant positive or negative correlation. SPSS Version 18.0 was used for whole statistical analysis. A difference of $P<0.05$, or $P<0.01$ were taken to indicate statistical significance for all analyses.

Results

Physical characteristics

Physical characteristics exhibited each parameter before and after weight bearing circuit exercise training. The average age of all subjects is 50.62 ± 8.23 yr and average height was 156.35 ± 6.18 cm. There was a significant decrease in weight ($P<0.01$). max HR decreased about 1%, but this was not statistically significant. Time to exhaustion significantly increased ($P<0.01$).

Table 1. *Exercise Program*

Type	Intensity	Duration	Frequency	Contents
Weight bearing Circuit training	(HRmax − HRrest) x 55% + HRrest	4 wk	3 times/wk, 20-30 repetition, 2sets	Hip circles, Push up, Lateral squat, Long lever crunches, Squat, Arm & leg raise, Calf raise

Abbreviations: HR, heart rate.

The waist/hip ratio significantly decreased (P<0.01). Waist and hip were also significantly decreased (P<0.01). Blood pressure-related parameters, such as Blood pressure (BP), Systolic blood pressure (SBP), and Diastolic blood pressure (DBP), decreased approximately 6.5%, 2.9%, and 2.3%, respectively in Table 2.

Table 2. *Mean and standard deviation results for the Physical characteristic evaluated pre and post the exercise program.*

parameter	Pre	→	Post
Age (year)	50.62 ± 8.23		
Height (cm)	156.35 ± 6.18		
Weight (kg)	63.63 ± 8.42		62.90 ± 8.70 **
Max Heart Rate (max HR)	159.10 ± 11.15		156.90 ± 14.29
Exhausted Time	6.76 ± 1.15		7.49 ± 0.97 **
Skeletal Muscle Mass(SMM)	23.04 ± 5.80		21.95 ± 2.91
Fat Mass (FM)	23.38 ± 4.44		22.57 ± 4.72 **
BMI	26.00 ± 2.77		25.61 ± 2.96 **
BMR	1230.81 ± 100.64		1240.93 ± 105.26
Waist	82.38 ± 7.64		75.59 ± 7.86 **
Hip	96.45 ± 5.11		93.71 ± 5.02 **
WHR	1.03 ± 0.03		91.15 ± 6.86 **
Fat % DXA	37.33 ± 3.32		36.80 ± 3.78 *
FAT Volume	23.92 ± 4.89		22.68 ± 6.73 **
Lean % DXA	62.67 ± 3.32		63.20 ± 3.78 *
Lean Volume	39.71 ± 4.21		38.43 ± 8.46 *
Mean Blood Pressure	80.72 ± 10.40		75.46 ± 13.42
Systolic BP	130.00 ± 20.06		126.25 ± 18.15
Diastolic BP	77.07 ± 13.94		75.32 ± 12.29

*P<0.05, **P<0.01: statistical significances between Pre and Post. Values are mean ± S.D.

Physical fitness

We categorized the following as basic physical fitness parameters: grip strength, body flexibility, muscular endurance, rapid reaction, quickness, and balance. There were significant increases (P<0.01) in grip strength, flexibility of the body, muscular endurance, rapid reaction and balance (P<0.05) after the exercise study. Quickness improved 9%, However, this was not statistically significant in Table 3.

Table 3. *Mean and standard deviation results for the physical fitness parameters evaluated pre and post the exercise program.*

	PRE	POST
Grip strength (kg)	25.00 ± 5.52	27.40 ± 4.38 **
Flexibility (cm)	13.27 ± 8.39	15.67 ± 8.29 **
Muscular endurance	13.31 ± 4.30	15.90 ± 3.89 **
Rapid reaction (cm)	20.24 ± 4.01	22.59 ± 4.40 **
Quickness (sec/m)	325.28 ± 88.51	295.21 ± 113.94
Balance (sec)	15.86 ± 15.31	32.24 ± 36.34 *

Blood profile

Gamma-GTP, albumin, ALP, ALT, AST, bilirubin total, blood urea nitrogen, calcium (Ca), cholesterol total, creatinine, free fat acid, glucose, HbA1c-eAG, HbA1c-IFCC, HBA1c-NGSP, HDL cholesterol, insulin, LDH, phosphorus (Pi), protein total, triglyceride, and uric acid were grouped as blood related factors because they were measured during blood collection, described in Materials and Methods. ALT, AST, bilirubin total, calcium (Ca), creatine, free fatty acid, LDH, and triglyceride were significantly different in pre and post exercise (P<0.01 and P<0.05) in Table 4

Correlation of skeletal muscle mass and lean % DXA with other parameters

We selected muscle mass parameters, such as skeletal muscle mass (SMM) and lean % DXA as a standard for comparison with other parameters. SMM and lean % DXA were significantly different (P<0.01) in the post exercise and this means that the value of each parameter can be an independent standard for muscle mass composed within the body, even though those show muscle mass in the body. Thus, we choose SMM and lean % DXA as independent standard for other parameters in the pre and post exercise group. In Pearson's r correlation (Table 5), SMM significantly correlated with weight (P=0.002), insulin (P=0.047) and

Table 4. Mean and standard deviation results for the blood profile evaluated pre and post the exercise program.

	PRE	POST
r-GTP	20.67± 12.01	17.34± 10.24
Albumin	4.53± 0.25	4.67± 0.21
ALK . phosphatase	76.00± 18.25	68.52± 20.31
ALT	25.00± 12.29	21.83± 9.36 **
AST	33.00± 5.29	25.07± 4.81 **
Total Bilirubin	0.48± 0.24	0.80± 0.27
BUN	17.03± 4.28	14.71± 3.98
Calcium (Ca)	9.43± 0.38	9.49± 0.28 *
Total Cholesterol	191.33± 43.02	198.90± 23.97
Creatine	0.66± 0.07	0.66± 0.08 **
Free fatty acid	948.00± 274.99	883.31± 237.24 **
Glucose	82.33± 4.16	98.86± 29.11
HbA1c-eAG	123.67± 11.93	123.24± 22.92
HbA1c-IFCC	42.00± 4.58	41.69± 8.90
HbA1c-NGSP	5.93± 0.42	5.92± 0.80
HDL cholesterol	51.00± 3.00	54.66± 12.51
Insulin	6.53± 3.66	5.39± 1.83
LDH	491.33± 136.36	410.07± 63.24 **
Phosphorus (Pi)	6.50± 3.40	3.63± 0.57
Total Protein	8.13± 1.10	7.76± 0.48
Triglyceride	90.00± 43.09	86.41± 46.67 **
Uric acid	4.90± 0.46	4.88± 0.93

time to exhaustion (P=0.043) in pre-exercise and SMM (P=0.000), weight (P=0.002), and time to exhaustion (P=0.019) in the post exercise. Lean % DXA significantly related with insulin (P=0.042) in the pre exercise and with time to exhaustion (P=0.009), weight (P=0.001), fat % DXA (P=0.000), lean % DXA (P=0.000), and free fat acid (P=0.038) in the post exercise. Fat % DXA as pre-parameter in Table 5 statistically correlated with pre and post-exercise parameters. Pre-exercise lean % DXA (P=0.000) and insulin are significantly correlated (P=0.042) and pre-exercise lean % DXA is correlated with post exercise of fat % DXA, end T (P=0.009), weight (P=0.001), fat % DXA (P=0.000), lean % DXA (P=0.000), and free fat acid. (P=0.038)

Table 5. Correlation (Pearson's r) between Pre-Parameter and Pre or Post group

Pre-Parameter	Pre group	Post group
Skeletal Muscle Mass (SMM)	Weight (P=0.002) Insulin (P=0.047) End T (P=0.043)	SMM (P=0.000) Weight (P=0.002) End T (P=0.019)
Time to exhaustion (End T)	Glucose (P=0.01)	Glucose (P=0.001) Total protein (P=0.024)
Max Heart Rate (max HR)		End T (P=0.02) Max HR (P=0.000)
Weight	Fat % DXA(P=0.000) Lean % DXA (P=0.000)	SMM (P=0.000) Weight (P=0.000) Fat % DXA (P=0.000) Lean % DXA (P=0.000) Creatine (P=0.049)
Fat % DXA	Lean % DXA (P=0.000) Insulin (P=0.042)	End T (P=0.009) Weight (P=0.001) Fat % DXA (P=0.000) Lean % DXA (P=0.000) Free Fat Acid (P=0.038)
Lean % DXA	Insulin (P=0.042)	End T (P=0.009) Weight (P=0.001) Fat % DXA (P=0.000) Lean % DXA (P=0.000) free Fat Acid (P=0.038)
Creatine		Creatine (P=0.000) Free Fat Acid (P=0.046)
Glucose		Glucose (P=0.000) Insulin (P=0.004)
HDL Cholesterol		Max H (P=0.013) HDL Cholesterol (P=0.000)
Total protein		Total Protein (P=0.000)

Only Pre and Post groups that have statistically significances with Pre-Parameter are shown. P, *p* value

Body composition parameters before and after exercise and those correlation: We classified SMM, BMI, BMR, fat % DXA, fat volume, lean % DXA, and lean volume as body composition. As shown in Table 2, exercise for 4 weeks had no effect on SMM. However, lean % DXA significantly increased (P<0.05) during the same exercise training period. The BMI, fat % DXA, fat volume, and lean volume significantly decreased (P<0.01 and P<0.05). BMR increased approximately 8 % during the same period. In correlation analysis by

Pearson's r, time to exhaustion significantly correlated with glucose (P=0.01) in the pre exercise group and glucose (P=0.001) and protein total (P=0.024) in post-exercise. Max RH only significantly correlated with time to exhaustion (P=0.02) and max RH in post exercise group (P=0.02). Weight correlated with fat % DXA (P=0.000) and lean % DXA (P=0.000) in pre exercise and with SMM (P=0.000), weight (P=0.000), fat % DXA (P=0.000), lean % DXA (P=0.000), and creatinine (P=0.049) in the following exercise. Table 5 shows significant correlation ships among parameters, such as creatine, glucose, HDL cholesterol, and total protein total with other groups in the post exercise: creatinine with creatine (P=0.000) and free fat acid (P=0.046), glucose with glucose (P=0.000) and insulin (P=0.004), HDL cholesterol with max HR (P=0.013) and HDL cholesterol (P=0.000), and protein total with protein total (P=0.000).

SMM and lean % DXA as a marker for muscle mass

We chose SMM and lean % DXA as standard markers for muscle mass in the body. We consider those as each of different muscle mass parameters, because there are significantly different values between those two parameters (P<0.01) in Table 6.

Table 6. *Significant difference between Lean % DXA and Skeletal Muscle Mass (SMM)*

Pre	Lean % DXA	SMM	P = 0.000
Post	Lean % DXA	SMM	P = 0.000

Percentage; SMM, Skeletal Muscle Mass; P, *p* value

Discussion

We report hitherto unknown results of significant physical improvements in perimenopausal women by 4-week weight bearing circuit exercise training: time to exhaustion, waist and hip size, blood related parameters, fat related parameters such as BMI, fat % DXA, fat volume, and lean volume, and physical fitness parameters except quickness (P<0.01). SMM and lean % DXA, considered as a standard for muscle mass in this study, showed significant differences between each other. (P<0.01) We set those as independent standards and each standard significantly correlated with SMM, weight, time to exhaustion, and fat related parameters such as fat % DXA, lean % DXA and free fat acid pre and post exercise. Whole measured blood related parameters, except insulin, significantly correlated with each blood related parameter post exercise (P<0.05). The weight of subjects significantly correlated with fat % DXA (P=0.000) and lean % DXA. (P=0.000) The weight bearing circuit exercise induced a significant correlation ship between weight and SMM (P=0.000), weight (P=0.000), fat % DXA (P=0.000), lean % DXA (P=0.000) and creatine (P=0.049). We suggested that weight change is related with fat related factors described above and that exercise stimulates the weight changes, which lead to the changes of the fat related factors. We noted decreased visceral obesity in the post exercise group: waist, hip, and WHR. Visceral obesity might be a major contributor to a lower muscle mass and its quality, which shows increasing the risk of overall diseases. Increasing body fat is strongly associated with negative VO2max and this is related to muscle mass (De et al., 2009; Fleg et al., 1988 and Proctor et al., 1997).

Interestingly, we also find that creatinine is related with this procedure. We used creatinine as a biomarker for kidney disease. Sorensen et al reported that exercise declines the risk for incident of kidney stones in post menopause women and dietary intake increase the risk in post menopause women (Sorensen et al., 2014). Kidney disease and obesity are related with ventilatory controlled physical activity and it improves the function of kidneys in obese subjects with kidney disease (Aoike et al., 2012).

We select SMM and lean % DXA as a marker for muscle mass in the body. We consider those as each of different muscle mass parameters, because there are significantly different values between those two parameters (P<0.01). We suggested that a high muscle mass with comparatively low fat mass composition may be related with some factors such as physical fitness, or metabolically related factors generally consistent with health related indices. Exercise promotes higher muscle mass, cardiac function factors such as max HR, end time to exhaustion, metabolic related enzyme, and hematologically related factors. Doing exercise accelerates the virtuous circle of this process, as described above. We thus emphasized SMM and lean % DXA because these allow subjects to execute exercise, which has a positive effect on physiological and biochemical reaction-related factors within the body, which in turn positively influence the skeletal muscles. SMM has significant correlation with weight, insulin and end to exhaustion in the pre and post exercise. Lean % DXA and SMM are related with insulin in the pre exercise group and with end to exhaustion, weight, fat related parameters such as fat % DXA, lean % DXA, and free fat acid in the post exercise.

Insulin sensitivity and weight-bearing resistant circuit exercise: When glucose was measured as a marker for diabetic level the weight-bearing circuit exercise did not cause statistical differences pre and post exercise parameters, however, there was a significant correlation between end to exhaustion and glucose in pre and post exercise. This suggests that end to exhaustion is somehow related to glucose homeostasis. Exercise increases end time to exhaustion and the increased end to exhaustion is closely correlated with glucose. Lombarte et al (2013) suggested physical activity improves diabetes treatment and insulin sensitivity. Regarding the relation of insulin with SMM, Kimball et al reported that insulin acts as a strong regulator for protein anabolism via the PI(3)K and Akt pathways (Kimball et al., 2002). On the other hand, insulin resistant may promote skeletal muscle catabolism (Kim et al., 2014). Accumulating fat mass especially visceral fat by less physical activity enhances insulin resistant that negatively contributes to less skeletal muscle mass, in turn contributing to lower skeletal muscle and higher fat mass (Schrager et al., 2007).

The optimal choice for aged women: There are many sorts of adult exercise training. Combined exercises are more beneficial to insulin resistance, visceral obesity decrease and improve endurance capacity rather than resistant exercise, which is likely to be effective in enhancing muscle quality, such as its strength and mass (Davidson et al., 2009). We chose weight-bearing circuit exercise because we consider that this exercise includes all aspects. The advantage of each exercise is one of options for perimenopausal women to improve physical function of the body. Intensity is also an important factor to maximize the effect of exercise. We set 55% among the range of 50%/maximal intensity following the Karvonen formula, as described in the Methods and Materials, which agreed with the study by Ryu et al (2007) that intense exercise causes reduced low muscle mass and obesity in older Korean adults. Our study also showed that not only high intensity, but also low intensity weight-bearing circuit training induced muscle mass increase and decreased obesity.

As a whole, this study revealed that 4-week weight bearing circuit exercise training induced significant improvement in end time to exhaustion, waist and hip (decreased), hematologically-related factors, fat-related factors (decreased), physical fitness parameters, except Quickness. Muscle mass parameters in this study such as SMM and lean % DXA significantly differed from pre and post condition. Those muscle mass-related parameters have significant relations with other parameters such as weight, end time to exhaustion, fat related parameters pre and post exercise. We found that multi-faceted parameters were positively changed after exercise in the perimenopausal women. The parameters used in this study can be representative indices for the health status of the perimenopausal women.

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