Effect of Blood Flow Restriction during Low-intensity Resistance Training on Bone Markers & Physical Functions in Postmenopausal Women with Osteopenia or Osteoporosis

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ABSTRACT

BACKGROUND/PURPOSE: The aim of this study was to investigate effects of 12-week low intensity resistance training(RT) with blood flow restriction(BFR) on bone mineral density, bone turnover markers, physical functions, and blood lactate concentration in postmenopausal women with osteoporosis or osteopenia. METHODS: 26 postmenopausal women(56±1.8yrs) with osteoporosis or osteopenia(T-score: −2.5±0.7) were randomly assigned into a Moderate-to- High-Intensity RT(MHIRT, n=7), BFR combined with Low-Intensity RT(LIBFR, n=7), Low-Intensity RT (LIRT, n=6), or Control group(CON, n=6). Exercise group performed leg press, leg extension, biceps curl, and triceps extension exercise 3 times a week for 12 weeks. The BFR pressure on upper limb was 151±5mmHg, and187±8mmHg on lower limb. Initial intensity were set at 60% of 1-repetition maximum(1-RM) for MHIRT, and at 30% of 1-RM for LIBFR and LIRT, and reset every 4 weeks for gradual intensity increment. Two-way repeated ANOVA used to identify difference between and within groups. RESULTS: Lower, and upper limb maximal muscle strength only increased in MHIRT(65%, p<0.001), and LIBFR(40%, p<0.05), while LIRT only showed increment on lower limb muscle strength(28%, p<0.05). All exercise groups demonstrated significant increment on blood lactate concentration after training session(p<0.001). However, LIBFR showed 2.7 fold higher increment compare to LIRT(Δ4.39mmol/L, p<0.001). Although no changes were observed in MHIRT, LIBFR, and LIRT, CON showed significant decrease in bone mineral density(0.04g/cm², p<0.05) after 12 weeks. However, in particular of interest, both bone resorption(CTx), and formation markers(P1NP) showed significant changes in MHIRT (0.098 & 9.2ng/ml respectively, p<0.05). While, LIRT showed no responses on any bone turnover markers. LIBFR significantly increased bone formation marker(P1NP) about 7.05ng/ml(p<0.05). Lastly, improvement in balance was only found in MHIRT, and LIBFR(p<0.05). CONCLUSION: 12-week LIBFR can be implied as a safe, and effective method to improve muscle strength, lactate concentration, bone formation markers, and balance similar to MHIRT in postmenopausal women with osteoporosis or osteopenia.

Introduction

Blood flow restriction (BFR) training works by occluding venous flow yet allowing partial arterial inflow with manual or pneumatically inflated cuff on the most proximal site of limb during exercise.19, 20 A number of studies reported low-intensity resistance training with BFR (LIBFR) increased both muscle size, and strength in healthy adult.21-23 In elderly, LIBFR also has beneficial in muscle strength,24-26 bone markers,27, 28 and hormonal responses.29, 30 Several studies showed positive effects of LIBFR on bone metabolism, formation, and resorption in adult healthy men.31 Moreover, study with middle age women reported LIBFR effectively increased growth hormone (GH), and insulin like growth factor-1 (IGF-1).32 Also, study in elderly women with osteoporosis showed similar increase in muscle strength on LIBFR, and HIRT group.33 However, the advance understanding in the role of LIBFR on Bone mineral density (BMD), Bone turnover markers (BTMs), physical function, etc in postmenopausal women with osteoporosis or osteopenia has shown to be still unclear. Most of the postmenopausal osteoporotic women studies focus on BMD or BTMs without investigate the other related variables, such as muscle strength, balance, and lactate concentration comprehensively, despite the lactic acidosis is the primary factor influencing GH release.34 Therefore, the aim of this study was to investigate the effects of blood flow restriction during low-intensity RT on BMD, BTMs, blood lactate concentration, and physical functions in postmenopausal women with osteoporosis or osteopenia.

Methods

Study Participants: We screened 37 postmenopausal women aged from 50-60 years old. 11 of them did not meet the criteria, thus only 26 participated in this study. Among 26 participants, 12 had osteopenia, and 14 had osteoporosis, which were diagnosed by physician through T-score. T-score ≥ -1 indicates normal bone mass, T-score between -1 and -2.5 indicates low bone mass or osteopenia, and T-score below -2.5 indicates osteoporosis.

Blood flow restriction: BFR cuffs were applied on the most proximal site of the upper and lower limbs using BFR cuffs (The EDGE mobility system, USA). Personalized pressure were applied during whole training program including resting time based on following formula; LOP=67+c/0.06W mmHg.37-39 However, lower limb cuffs did not apply while performing upper body workout, and vice versa. LIBFR group mean occlusion pressure for upper limbs and lower limbs were 152±6 mmHg and 188±9 mmHg respectively.

12-week resistance training : Training program held 3 times a week for 12 weeks with a 48-hour interval between each session. All participants were randomly assigned into 4 groups, moderate to high-intensity resistance training (MHIRT), low-intensity RT with blood flow restriction (LIBFR), low-intensity RT (LIRT), and control (CON) group.

Each group performed 10 minutes' warm-up exercise using treadmill with speed of 3km/h followed by basic stretching. As a RT all participants performed bilateral leg press, leg extension, dumbbell biceps curl, and triceps extension. Training intensity for MHIRT were set from 60% to 80% of 1-RM (60%1-RM at 1st & 2nd week, 70%1-RM at 3rd & 4th week, 80%1-RM at 5th-12th week). MHIRT group performed 10 repetitions of 3 sets for each workout with 60 seconds of rest between sets (Table 1). LIBFR, and LIRT group training intensity were set at 30% of 1-RM, and each workout was performed for 20 repetitions of 3 sets with 30 seconds rest between sets. All group had 90 seconds rest between each workout.

Workout	MHIRT	LIBFR	LIRT
Warming-Up		10min	
Basic stretching		5 min	
Leg press	60~80% 1RM	30% 1RM	30% 1RM
Leg extension	10 reps	20 reps	20 reps
Biceps curl	3 sets	3 sets	3 sets
Triceps extension	60 second rest	30 second rest	30 second rest

Note. MHIRT (Moderate to High-Intensity Resistance Training group), LIBFR (Low-Intensity resistance with Blood Flow Restriction group), LIRT (Low-Intensity Resistance Training group).

Measurement of dependent variables: One repetition maximum (1-RM) was measured to determine change in muscle strength based on ACSM procedure. BMD was measured before and after intervention by using dual-energy X-ray absorptiometry (DEXA; BMtech, South Korea). Serum concentration of P1NP, and CTx assessed as marker for bone formation and resorption respectively. Blood lactate level was assessed before and after the training at week 4th, 8th, and 12th. Accutrend (Roche Diagnostics, USA) was used to evaluate capillary blood lactate level. Dynamic balance was assessed by using timed backward tandem walk test over a 6-meter course

Results

1. 1 repetition maximum (1-RM)

		MHIRT (n=7)	LIBFR (n=7)	LIRT (n=6)	CON (n=6)
Unilateral Biceps Curl (Kg)	pre	6.29±0.18	6.00±0.44	6.50±0.43	5.83±0.40
	post	7.43±0.20*†	6.86±0.34*	6.83±0.40	5.67±0.42
Triceps Extension (Kg)	pre	26.86±1.28	24.43±1.02	24.67±1.26	22.83±0.98
	post	32.00±1.57*†‡§	27.71±0.81*†	26.00±1.59	23.33±0.49
		MHIRT (n=7)	LIBFR (n=7)	LIRT (n=6)	CON (n=6)
Leg Press (Kg)	pre	97.43±8.45	82.86±3.76	94.17±9.61	91.67±10.78
	post	165.71±18.50*†‡§	124.29±4.93*†	118.33±10.14*	84.17±10.83
Leg Extension (Kg)	pre	24.29±2.00	26.00±1.27	25.67±1.23	26.67±2.58
	post	39.43±3.24*†	33.71±1.21*	32.83±1.33*	26.00±2.58

Note. *: represents significant between pre and post within group (p<0.05). †: represents significant group difference with CON (p<0.05). ‡: represents significant group difference with LIRT (p<0.05). §: represents significant group difference with LIBFR (p<0.05).

2. Total lumbar bone mineral density and T-score

		MHIRT (n=7)	LIBFR (n=7)	LIRT (n=6)	CON (n=6)
Total Lumbar BMD (g/cm²)	pre	0.89±0.04	0.88±0.01	0.86±0.03	0.94±0.04
	post	0.88±0.04	0.86±0.02	0.85±0.02	0.90±0.03*
Total Lumbar T-score	pre	-2.51±0.34	-2.66±0.11	-2.80±0.27	-2.15±0.36
	post	-2.61±0.36	-2.83±0.18	-2.82±0.18	-2.45±0.28*
Femur neck BMD (g/cm²)	pre	0.87±0.04	0.84±0.06	0.78±0.03	0.90±0.06
	post	0.88±0.03	0.84±0.03	0.78±0.04	0.93±0.08
Femur neck T-score	pre	-0.84±0.32	-1.04±0.49	-1.58±0.28	-0.54±0.53
	post	-0.74±0.24	-1.04±0.27	-1.58±0.34	0.04±0.70

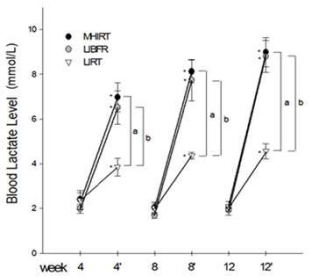
3. Bone turnover markers

		MHIRT (n=7)	LIBFR (n=6)	LIRT (n=6)	CON (n=5)
s-CTx (ng/ml)	pre	0.46±0.10	0.52±0.07	0.40±0.05	0.58±0.10
	post	0.56±0.10*	0.46±0.06	0.40±0.05	0.56±0.07
s-P1NP (ng/ml)	pre	59.47±10.32	60.48±10.21	57.65±10.71	66.48±7.65
	post	68.70±12.24*	67.53±9.85*	57.50±8.70	76.76±8.69*
P1NP/CTx ratio	pre	139.01±14.09	130.56±8.48	115.87±7.19	112.18±11.81
	post	131.28±15.30	153.94±7.23	120.98±12.35	140.76±13.05

4. Balance

		MHIRT (n=7)	LIBFR (n=7)	LIRT (n=6)	CON (n=6)
Static eyes open (sec)	pre	93.21±27.76	83.88±14.60	80.68±20.49	86.01±26.92
	post	121.46±35.84*	130.25±22.50*	107.91±21.13	83.45±31.89
Static eyes closed (sec)	pre	10.55±4.21	5.95±1.29	15.61±7.00	9.05±3.37
	post	10.03±2.05	11.30±2.86*	16.36±8.16	7.44±3.81
Dynamic (sec)	pre	34.19±5.95	32.34±5.87	30.12±1.96	33.32±2.60
	post	27.15±2.39*	29.05±5.99	31.28±2.14	33.64±3.01

5. Blood lactate concentration



Note. *: represents significant between pre and post within group (p<0.05). a: represents significant group difference with CON (p<0.05). b: represents significant group difference with LIRT (p<0.05). c: represents significant group difference with LIBFR (p<0.05).

Conclusion

Blood flow restriction during low-intensity resistance training (LIBFR) revealed to be more effective to increase muscle strength, lactate concentration, bone formation markers, and balance in low bone density postmenopausal women compared to traditional low-intensity resistance training (LIRT). Even though moderate to high-intensity resistance training (MHIRT) showed greatest improvement in muscle strength, and bone turnover markers (BMT), however, the higher risk in injury also can not be neglected.