

The effects of resistive exercise with low intensity-high frequency on essential mild hypertension in men

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Abstract. Five sedentary middle-aged men with mild hypertension were studied to determine the effects of a low-to moderate-intensity resistive exercise program (RE group) on resting systolic and diastolic blood pressures. Another group of five mild hypertensive men was also examined to determine the effects of a moderate aerobic exercise program (AE group) on the resting blood pressures. Besides blood pressures, effects of respective training programs were studied on aerobic capacity, muscle strengths, and serum lipid and lipoprotein concentrations.

Resistive exercise consisted of 10 stations of weight training machines for 12 weeks. Workloads were set at 40-50% maximum and the subjects performed 10 repetitions for each station with 2-3 sets, 3 times per week. The subjects in the aerobic exercise group performed 30-min brisk walking or jogging with intensities of 60-75% their predicted maximum heart rates.

The following changes occurred in the resistive exercise group: (1) resting systolic blood pressure dropped significantly (from 150 to 143mm Hg) after training and diastolic blood pressure dropped significantly (from 91 to 88mm Hg) after training; (2) VO_{2max} significantly increased 2.3 ml/kg/min or 6.9% (from 33.3 to 35.6 ml/kg/min) after training; (3) increases of muscle strengths were profound, 17.9% and 23% in lower and upper body strengths, respectively; (4) body weight and body fat decreased 2.6% ($P < 0.05$) and 8% ($P < 0.005$),

respectively. However, no significant changes were observed in lipid and lipoprotein concentrations. Thus, low intensity with high repetition resistive exercise may lower blood pressures in middle-aged men with mild hypertension, but the underlying mechanism are unclear.

As compared to the RE group, AE group elicited marked improvements in resting blood pressures (decreased 11.8mm Hg=7.9% and 7.8mm Hg=8.2% in systolic and diastolic, respectively) and cardiovascular endurance (increased 6 ml/kg/min=17% in VO_{2max}) as well as body composition. Serum lipid lipoproteins included total cholesterol (TC), high-density cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG). Significant ($P < 0.01$) increase was noted for HDL-C while significant decreases were seen in TC, LDL-C, and TG.

Hypertension, an established independent risk factor for coronary heart disease, stroke and cardiovascular disease^(1,40) is observed in approximately 48% of Japanese male adults aged 30 yr or old⁽²⁶⁾. In view of this, successful efforts to lower elevated blood pressures could be expected to have a profound impact on population morbidity and mortality statistics.

In 1986 the World Health Organization (WHO) and the International Society of Hypertension (ISH)⁽³⁴⁾ stated that "increased physical activity is likely to reduce the risk of cardiovascular disease and is appropriate in mildly hypertensives". In 1992 the WHO/ISH recommended lifestyle interventions such as weight reduction in the overweight, reduction of alcohol consumption, regular mild exercise in sedentary subjects, and salt restriction in the primary prevention of hypertension⁽³⁰⁾. In 1993 this was followed by a memorandum of the WHO/ISH⁽¹¹⁾ which stated that "it appears reasonable to advise that efforts to lower blood pressure by lifestyle modifications, including exercise, should normally precede any decision about the necessity of drug treatment of mild hypertension".

Persons with mild hypertension (diastolic blood pressure between 90 and 104 mmHg and/or systolic blood pressure between 140 and 159 mmHg) represent the overwhelming majority of hypertensive individuals in the general population⁽²⁰⁾. The Framingham Study⁽³⁹⁾

reported that mild hypertension accounts for most of the excess cardiovascular disease morbidity and mortality that can be attributed to high blood pressure. Therefore, the achievement of long term blood pressure control in persons with mild hypertension is of most important concern in the prevention of hypertension-related diseases and death.

Pharmaceutical antihypertensive therapy for individuals with hypertension has contributed to a dramatic reduction in cardiovascular diseases and death rate. Since pharmaceutical drugs, however, cause a number of unfavorable side effects, non-pharmacological therapy is recommended for control the blood pressure better. This idea is more suitable especially for mild hypertensive individuals.

Exercise training has emerged as one of the few potentially effective and physiologically desirable non-pharmacological approaches that can be used both as definitive intervention and as an adjunct to pharmacological therapy for patients with mild hypertension. Hagberg⁽¹⁴⁾ performed a meta-analysis of 25 longitudinal studies examining the antihypertensive effects of aerobic exercise conditioning on patients with high blood pressure. The major findings regarding the efficacy of exercise training in controlling hypertension were that the average sample-size weighted reductions in resting systolic and diastolic blood pressures with exercise training were 10.8 and 8.2 mmHg, respectively.

Mild exercise training has also often been proposed as a non-pharmacological therapy for mild and moderate essential hypertension^(3, 23, 27, 32, 33) while Blumental et al.⁽²⁾ failed to observe lowering effects of aerobic training on mild hypertensives.

Thus, aerobic exercise training has generally been shown to lower blood pressure in men and women with moderate to high elevations in blood pressure.

Muscle contractions by weight training raise both systolic and diastolic pressure, and heavy resistive exercise training can raise intra-arterial blood pressure to 400/300mm Hg⁽³⁰⁾. Furthermore, there is a common misconception that resistive training is directly responsible for hypertension seen among some strength-power athletes.

Consequently, many people have tended to avoid weight training because they are afraid that resistive exercise will adversely affect blood pressure. However, the training effects of regular resistive exercise on resting blood pressure are controversial. It has been previously suggested that the long-term effect of weight training may be to increase resting blood pressure⁽¹⁴⁾. Furthermore, no significant reduction in resting blood pressure among healthy males after 16-week weight training program has been reported⁽⁴¹⁾. Most of the studies above mentioned, however, used high-intensity loads for their weight training programs. More likely causes of resting hypertension include chronic overtraining⁽¹⁶⁾, gaining large amounts of body mass⁽⁴⁵⁾. On the contrary, some investigators^(15,17) found significant decreases in diastolic pressure in middle-aged men and in groups of moderately hypertensive cardiac rehabilitation patients as a result of 16 weeks of resistive circuit training.

The purpose of this investigation was to determine if moderate-intensity and relative high repetition, resistive exercise training had an effect on reduction in resting systolic and/or diastolic blood pressure among mild hypertensive middle-aged males.

METHODS

Subjects

Ten (10) male subjects between the ages of 42 and 56 yr (mean = 48.3 yr), who were diagnosed as mild hypertensives at medical clinic, volunteered for this investigation. All subjects had normal resting electrocardiograms, had not participated in a regular exercise program for at least 5 years prior to the start of the study. Five of 10 subjects were randomly assigned to a resistive exercise training (RE) group, the remaining 5 were assigned to an aerobic exercise training (AE) group. The subjects were not allowed to participate in any other exercise during the experimental period. Although no dietary records were taken, all subjects were instructed to adhere to their established eating and drinking habits.

Table I.—Classification of hypertension by resting blood pressure level

	SBP (mmHg)		DBP (mmHg)
Normotension	< 140	and	< 90
Mild hypertension	140–180	and/or	90–105
Subgroup: borderline	140–160	and/or	90–95
Moderate and severe hypertension	≥ 180	and/or	≥ 105
Isolated systolic hypertension	≥ 140	and	< 90
Subgroup: borderline	140–160	and	< 90

(Joint National Committee)

Assessments

All assessments were taken the week before training and the final week of the exercise program.

Blood pressure. Blood pressure measurements were taken at the right brachial artery by the auscultatory method using a standard sphygmomanometer. Resting blood pressure measurements were taken following 10 min of seated rest at our laboratory. Systolic blood pressure (SBP) measurements were recorded at the moment the first sounds were heard (First Korotkoff phase) and diastolic pressure (DBP) were measured during the fifth Korotkoff phase. Mean value of 3–5 trials was used as blood pressure scores.

Work capacity. A modified Balke treadmill test⁽⁶⁾ was used to measure maximal aerobic power. Subjects walked on a level treadmill (Quinton Model Q4000) at 3.3 mph (90 m/min) for the first one min. The treadmill grade was elevated by 2.0% for the second one min. Thereafter, the speed was held constant and the grade increased 1% every minute. Expired gases were measured at 30-s intervals using an automated system (Meta Max, Biophysik GmbH) calibrated with standardized gases. Heart rate was monitored with an ECG using a CM5 lead. The test end point was subjective exhaustion, and attainment of age-predicted maximal heart rate or a respiratory exchange ratio of 1.0 or greater was used to determine whether maximal effort was reached in the absence of a plateau in oxygen consumption (VO_2).

Strength tests. Bench press and leg press strengths were recorded as the maximum amount of weight lifted during one full range of

motion (one repetition maximum) by using resistance weight machines manufactured by Universal Gym, Inc. These tests were achieved by increasing the load by one plate after each successful lift until the maximum load was obtained. After a brief warm-up consisting of stretching exercises, the bench press lift was performed by each subject in a supine position on the bench. A very light weight was selected for the first repetition, and the bar was raised vertically until the arms were fully extended. After approximately 15s of rest the subject lifted an increased amount of weight for one repetition. This procedure was graduated in such a manner that the person lifted the maximum amount of weight on approximately the fifth repetition. The same guidelines were used for the leg press test.

Body composition. The %body fat (%FAT) was obtained using an electric impedance equipment (Tanita Bodyfat Analyzer, Tokyo). All measurements for %FAT were conducted in the post-absorptive state in the laboratory in the morning.

Blood sampling. Blood samples were taken at medical clinic after an overnight fast. The subjects rested in a seated position for 15min prior to sampling. Blood was drawn from an antecubital vein into a 10ml vacutainer and allowed to clot at room temperature prior to centrifugation. Serum was separated, stored at 4°C, and analyzed within 24 hours of collection by a certified biomedical laboratory. Serum was analyzed for total cholesterol (TC), high density lipoprotein cholesterol (HDL-C), and triglycerids (TG). Low density lipoprotein cholesterol (LDL-C) was calculated⁽⁷⁾.

Training prescription

Resistance training program. The training program for the RE group consisted of resistive exercise of weight conditioning machines, 3 days a week, for a duration of 12 weeks. Each session consisted of 2 sets of upper and lower body exercises, 10-station circuit with 15 to 20 repetitions for upper body, and 20–25 for lower body during the first half duration (6 weeks) of the training period. The set number was increased to 3 for the second half of training period. Workload was set initially at 40% 1 RM at each station. Work load was

increased by 50% 1 RM after 6-week duration was completed. The subjects were always encouraged to work with their possible highest repetition and set. Each training session lasted approximately 30–40 minutes. The 10 exercise stations consisted of biceps curl and triceps extension, chest press, shoulder press, lat pull, leg extension, leg curl, quadriceps press, calf-raise, abdominal curl, and back extension.

Walking-jogging regimens. Thirty (30) min-brisk walking programs were offered to AE group. As walking intensities, a target heart rate zone corresponding to 60–75% of predicted maximal heart rate was established for each subject. The subjects were provided with a heart rate monitor (Polar heart rate monitor, Polar Electro Oy, Finland). They were asked to walk briskly, keeping their heart rate within the designated zone. Training was performed athletic track. After they completed 6-week duration, the subjects were allowed to jog with heart rates within target zone.

Statistical analysis

Dependent variables were analyzed using a two by two analysis of variance (ANOVA) with repeated measures on the second factor. The first factor, Group, had two levels (RE and AE). The second factor, Time, had two levels (PRE and POST). The 5% level of significance was adopted.

RESULTS

Physical parameters

Physical characteristics are presented in Table II. There were no statistically significant differences between the two groups in the baseline features of the subjects, including age, height, body weight and %FAT. Both groups exhibited significant decreases in BW (RE: $P < 0.01$, AE: $P < 0.001$), %FAT ($P < 0.01$) and BMI (RE: $P < 0.01$, AE: $P < 0.0001$). The reduction of BW was greater in AE than in RE demonstrating 3.9kg (5.3%) and 1.9kg (2.6%) for AE and RE groups, respectively. These values corresponded to reductions of 3.1kg and 1.8kg in body fat for respective groups.

Table II.—Age and physical characteristics

Variable	RE Group				AE Group			
	Pre	Post	Δ	% Δ	Pre	Post	Δ	% Δ
Age	48.0				48.6			
(yrs)	(5.3)				(5.3)			
Height	169.6				170.2			
(cm)	(5.0)				(4.5)			
WT	73.4	71.5*	-1.9	2.6	73.1	69.2*	-3.9	5.3
(kg)	(6.0)	(5.4)			(6.0)	(5.5)		
%FAT	23.4	21.5*	-1.9	(8.0)	22.4	19.2*	-3.2	16.6
(%WT)	(1.7)	(2.0)			(2.4)	(2.0)		
BMI	25.5	24.8*	-0.8	3.1	25.3	23.9*	-1.4	5.5
(kg · m ⁻²)	(1.0)	(1.0)			(1.4)	(1.3)		

All values are means \pm SD. No significant difference were observed between groups. (*)=significant difference between Pre and Post time points. Significance was accepted at the $P < 0.05$ level.

RE and AE are resistive and aerobic exercise groups, respectively.

Baseline value of maximal oxygen consumption (VO_{2max}) for both RE (33.3 ± 3.1 ml/kg/min) and AE (35.1 ± 3.4 ml/kg/min) groups was in the "fair" (slightly below average) aerobic fitness range⁽¹⁹⁾.

The mean baseline clinic blood pressures were comparable between the two groups: $149.8 \pm 6 / 91.2 \pm 4.5$ mm Hg in the RE group and $148.8 \pm 6.7 / 94.6 \pm 4.5$ mm Hg in the AE group. No statistical difference was seen in both systolic and diastolic blood pressures between the two groups.

Changes in Blood Pressure

Both groups showed a significant decrease between baseline and follow-up in systolic and diastolic blood pressures (Fig. 1). The AE group showed an 11.8 mm Hg (7.9%) decrease in systolic blood pressure ($P < 0.005$), from 148.8 ± 6.7 mm Hg to 137 ± 4.2 mm Hg, and a 7.8 mm Hg (8.2%) decrease in diastolic blood pressure ($P < 0.001$), from 94.6 ± 4.5 mm Hg to 86.8 ± 3.7 mm Hg, while the RE group showed a 7.2 mm Hg (4.6%) decrease in systolic blood pressure ($P < 0.05$), from 149.8 ± 6.0 mm Hg to 142.6 ± 4.6 mm Hg, and a 3.6 mm Hg (3.9%) decrease in diastolic blood pressure ($P < 0.005$), from 91.2 ± 4.5 mm Hg to 87.6 ± 5.4

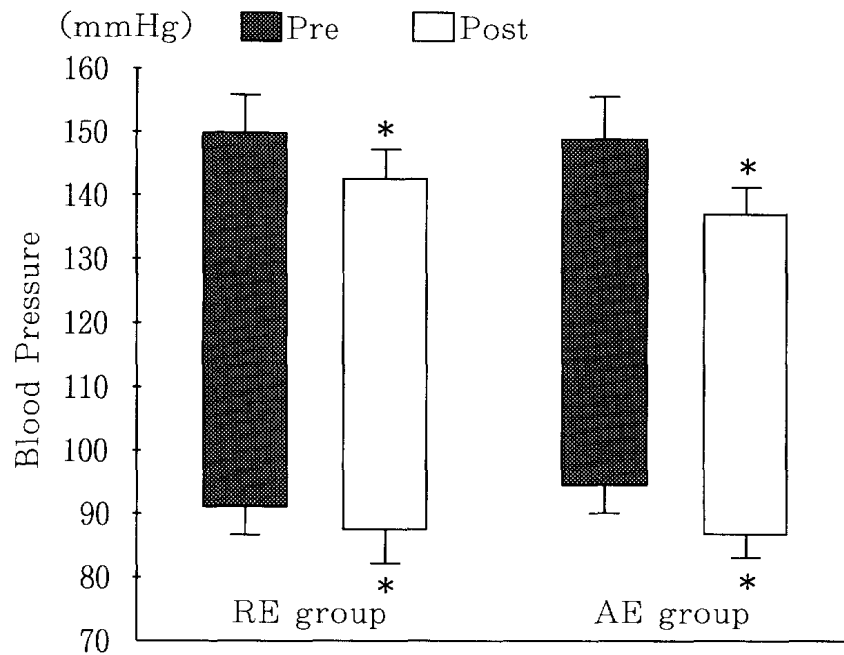


Fig. 1. Mean (\pm SD) systolic and diastolic blood pressures measured at pre-and post-training. RE (resistance exercise) and AE (aerobic exercise) groups are displayed separately. (*)=significant difference between Pre and Post time points. Significance was accepted at the $P < 0.05$ level.

mm Hg. However, there were no statistically significant differences between the two groups in blood pressure at follow-up (systolic blood pressure, $P = 0.109$, diastolic blood pressure, $P = 0.812$).

Changes in aerobic capacity and muscle strengths

Both groups demonstrated significant increases in VO_{2max} after respective training programs (Fig. 2). The AE group showed a 17% increase between Pre and Post ($P < 0.01$) of 6 ml of oxygen per kilogram per minute, which was significantly greater than the RE group's 6.9% increase of 2.3ml of oxygen per kilogram per minute ($P < 0.05$). Follow-up value of VO_{2max} for both RE (35.6 ± 3.1 ml/kg/min) and AE (41.1 ± 3 ml/kg/min) groups was in the "average" aerobic fitness range.

The RE group significantly increased their muscle strengths by 17.9% or 21kg (from 117 to 138kg) ($P < 0.005$) and 23% or 8kg (from 34kg to 42kg) ($P < 0.005$) in leg press and bench press, respectively,

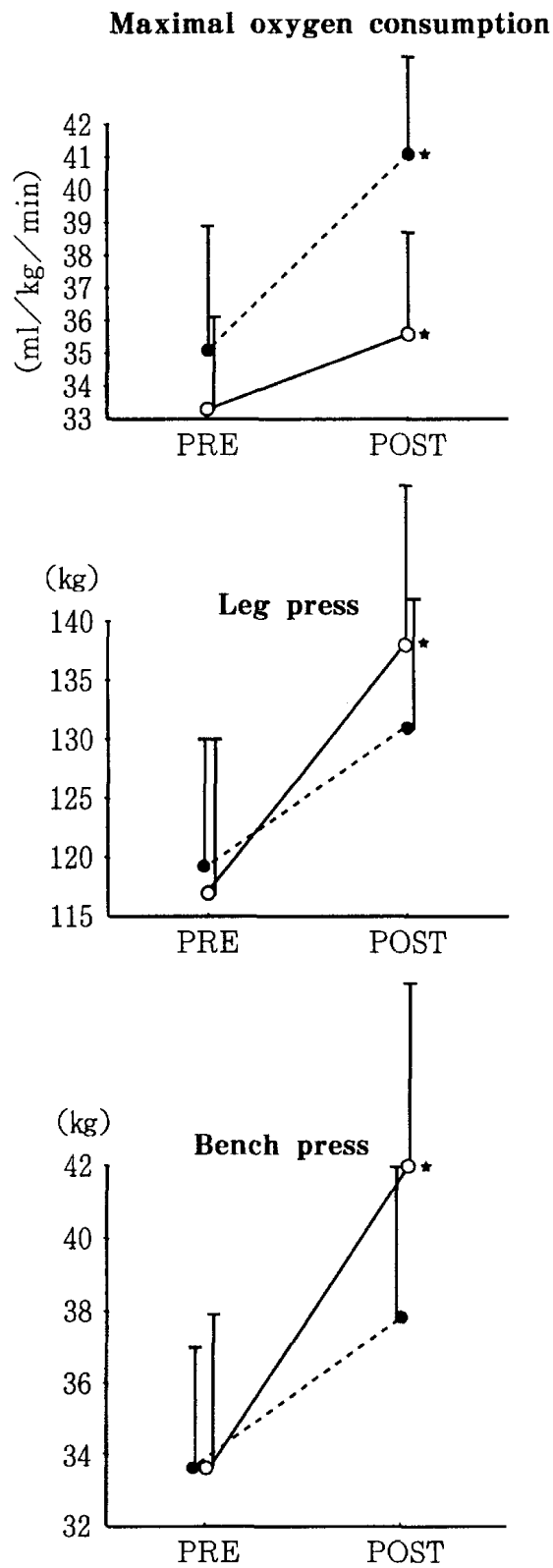


Fig. 2. VO_{2max} , leg press and bench press at pre-and post-training for RE group (solid line) and AE group (broken line).
(*)=significant difference between Pre and Post time points.
Significance was accepted at the $P < 0.05$ level

while the AE failed to show statistical significance for their increases in both strength tests (Fig. 2).

Lipid and lipoprotein concentrations

Lipid and lipoprotein concentrations are presented in Table III. A statistical significant effect for Time was observed in the AE group only. TC, LDL-C and TG concentrations in the AE group decreased 18.2 ($P < 0.05$), 19.3 ($P < 0.005$) and 15.8 mg/dl ($P < 0.05$), respectively over the 12 weeks, while HDL-C increased 4.2mg/dl ($P < 0.05$) over the training period. However, the RE group showed the identical trend on the changes in lipid and lipoprotein, but did not reach statistical significance.

A significant relationship was found between the change in % FAT and the change in HDL-C concentrations ($r = 0.72, P < 0.05$). No statistically significant relationships were found between the changes in HDL-C and the changes in blood pressures.

Table III.—Lipid and Lipoprotein concentrations.

Variable	RE Group				AE Group			
	Pre	Post	Δ	% Δ	Pre	Post	Δ	% Δ
TC (mg/dl)	202.4 (13.9)	192.0 (12.9)	-10.4	5.0	201.8 (19.7)	183.6* (14.8)	-18.2	9.0
LDL-C (mg/dl)	132.8 (13.2)	122.9 (9.7)	-9.9	7.5	134.8 (9.8)	115.5* (8.1)	-19.3	16.7
HDL-C (mg/dl)	46.2 (5.7)	48.2 (3.3)	+2.0	4.3	44.8 (5.7)	49.0* (4.8)	+4.2	9.3
TG (mg/dl)	117.0 (22.9)	109.6 (17.0)	-7.4	6.3	111.4 (26.0)	95.6* (22.1)	-15.8	14.2
TC/HDL-C	4.5 (0.6)	4.0 (0.1)	-0.5	11.1	4.5 (0.1)	3.7* (0.1)	-0.8	21.6

All values are means \pm SD. No significant difference were observed between Groups. (*)=significant difference between Pre and Post time points. Significance was accepted at the $P < 0.05$ level.

RE and AE are resistive and aerobic exercise groups, respectively.

DISCUSSION

Many studies have examined the effects of aerobic conditioning on patients with primary and secondary hypertension. It has been well documented that regular aerobic exercise is associated with decreases in systolic and diastolic blood pressures in hypertensive men and women. However, training effects of regular resistive exercise on resting blood pressure are controversial. In the present study, the AE group with mild hypertension also significantly decreased 11.8 and 7.8mm Hg in resting systolic and diastolic blood pressures, respectively over the 12-week period. Furthermore, the present study showed that low to moderate intensity resistance high repetition training was associated with a significant reduction in resting systolic and diastolic blood pressures of mild hypertensive middle-aged men although the rate of reduction was small as compared to that of the aerobic exercise group (7.2 and 3.6mm Hg in systolic and diastolic pressures, respectively).

The findings obtained from RE program in this study were in agreement with previous studies in which moderately hypertensive adults⁽¹⁷⁾, normotensive middle-aged adults⁽¹⁷⁾, and females⁽²¹⁾ were investigated. Hurley et al.⁽¹⁷⁾ observed a 5mm Hg decrease in resting diastolic blood pressure in middle-aged adults after 16 weeks of circuit weight training (CWT) where workloads were set at 40% of maximum capacity, although resting systolic blood pressure remained unchanged. Harris and Holly⁽¹⁵⁾ also reported an approximately 5mm Hg decrease in resting diastolic blood pressure (95.8 to 91.3mm Hg) in moderately hypertensive men following 9 weeks of CWT.

Blumenthal et al.⁽²⁾ reported a 7mm Hg decrease in systolic (143 to 136mm Hg) and 6mm Hg decrease in diastolic (95 to 89mm Hg) blood pressure following 16 weeks of strength and flexibility training in mild hypertensive adults. However, since the control group showed similar change, the investigators concluded that resistive exercise did not favourably alter resting blood pressure in these participants.

Other investigators have shown no change in resting blood pressure following resistive training in male college athletes⁽²⁹⁾, college women⁽³⁵⁾, male bodybuilders⁽⁴⁾, hypertensive adults⁽³⁸⁾ and old individuals with normal or somewhat elevated blood pressures⁽⁵⁾. Smutok et al.⁽³⁸⁾ found no change in resting blood pressure following 20 weeks of Nautilus training in either normotensive or hypertensive men although there was a trend toward a reduction in systolic blood pressure in the hypertensive group. Thus, although resistive exercise appears to have the potential to lower blood pressure, conflicting results have been presented.

Favorable effect by resistive exercise has not been noted in all cases as mentioned above. It has been well documented that weight training is directly responsible for the hypertension seen among some strength-power athletes. More likely causes of resting hypertension include essential hypertension, chronic overtraining, perhaps gaining large amounts of body mass. Therefore, training prescription must be considered. In the present investigation, we set training intensity at 40–50% 1RM, but high repetition of 20–25 with 2–3 sets. It appears that such a moderate load and high repetition program could produce beneficial blood pressure alterations concomitant with reducing with body fat and with increases in lean body mass as seen in regular aerobic exercise. Hagberg et al.⁽¹²⁾ found significant decreases in systolic blood pressure after 5 months of weight training in borderline hypertensive adolescents. In the study, the investigators found that the weight-training produced a reduced peripheral resistance at rest.

Myocardial hypertrophy is an adaptive mechanism that develops in response to increased haemodynamic loading of the heart. Theoretically, chronic heavy resistance training, which also results in pressure overloading of the left ventricle, could be expected to contribute to develop thick walls but small cavities of the heart, and consequently, could bring either no effect or a slight enhancement of systolic function at rest^(8,9). Thus physiological adaptation of the heart to the eccentric hypertrophy (hearts with walls that are thicker than normal, but relatively thin due to cavities that are larger than normal) that often results from the volume overloading induced by aerobic

exercise training is physiologically more desirable than the concentric hypertrophy that may result from work intensity overloading. Therefore, resistance training could be expected to result in a beneficial effect on blood pressure if training program is prescribed in aerobic fashion, that is low intensity and high repetition. In the present study in which resistive exercise training was conducted in a manner of aerobic type like as circuit weight training, our subjects of the RE group showed a small ($2.3\text{ml/kg/min}=6.9\%$), but a significant increase in $\text{VO}_{2\text{max}}$ over a 12-week period (see Fig. 2). Even in aerobic exercises such as walking and jogging, high intensity is not as effective as in low intensity for improvements of hypertension. Kouame et al.⁽²⁸⁾ suggested that an attenuation of the cardiopulmonary baroreflex control of skeletal muscle vascular resistance after training at 70% $\text{VO}_{2\text{max}}$ compared with training at 50% $\text{VO}_{2\text{max}}$ may contribute to the less pronounced hypotensive efficacy of higher intensity training compared with lower intensity training. Several other studies using endurance exercise with 40 to 60% $\text{VO}_{2\text{max}}$ ^(13,43) demonstrated significant reductions in blood pressures. These investigators^(13,14,43) stated the notion that the magnitude of blood pressure reduction elicited by exercise training is not directly related to the magnitude of the increase in $\text{VO}_{2\text{max}}$ after training. This also suggests that the training-induced adaptations responsible for the increase in $\text{VO}_{2\text{max}}$ are different from those involved in the reduction of blood pressure. Indeed, it appears from these studies that moderate intensity exercise may be just as effective in controlling hypertension, if not more so, than high intensity exercise. It is of some interest that circuit resistance training (generally low intensity and high repetition) can even be performed with a high level of safety by select patients with coronary artery disease^(22,39).

A discrepancy of the findings between the RE and the AE groups was seen in serum concentrations of lipid and lipoprotein (Table II). No significant changes in serum lipid and lipoprotein were found in the RE group while significant favorable changes were observed in the AE group after a 12-week training. It has been well established that the risk for cardiovascular diseases is directly related to plasma

levels of TC and LDL-C and inversely related to HDL-C concentrations (American Heart Association, 1990). There are some studies that reported that resistive exercise may favorably alter blood lipid and lipoprotein levels. Reductions in TC⁽⁴⁴⁾, LDL-C^(17,44) and TC/HDL-C ratios⁽¹⁷⁾ have been reported following chronic resistive training in healthy subjects as well as following 14 w of intensive resistance training (85%-RM, 45–50min) in premenopausal women⁽³⁶⁾ although no differences were seen in TG and HDL-C. Increases in HDL-C have also been observed following up to 16 weeks of CWT^(17,44). However, conflicting data have been also presented^(25,31). Longitudinal studies of the effects of training on serum lipids have not always shown significant alterations in blood lipids with either aerobic^(10,18) or resistive training^(18,24,37). Several factors may account for the inability of some training studies to demonstrate beneficial alterations in lipid profiles; these factors include subject age, initial serum lipid concentrations, exercise selection and the volume and intensity of the training program^(18,24). Resistive training may produce positive changes in serum lipids, with the volume of training being the dependent factor⁽⁴²⁾. The training volume with low intensity in the present study might not be enough to elicit favorable changes in lipid and lipoprotein concentration levels.

In summary, there was a significant reduction in resting blood pressures with a low to moderate intensity (40–50% 1RM)-high repetition (20–25 at each station, for 10 stations) resistive exercise program which was conducted in a manner of circuit training (2–3 sets). The reduction in blood pressures was smaller than that observed in a moderate intensity aerobic exercise (30-min walking, 3 times a week) program. The resistive exercise training in this study was a sufficient stimulus to favorably modify cardiorespiratory endurance, body composition in middle-aged men whereas was an insufficient stimulus to favorably modify serum lipids and lipoproteins in the subjects.

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中年男子軽症高血圧改善に及ぼす低強度 高頻度レジスタンス運動の効果

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要 約

高血圧症は心筋梗塞, 脳卒中, 動脈硬化の独立した危険因子になっている。日本人 30 歳以上の成人男子の約 48% が軽症を含めた高血圧症とされている。高血圧関連疾患や死亡の予防として軽症高血圧症時の血圧コントロールは重要な関心点である。薬物による高血圧治療は著しい効果をあげているが, 好ましくない副作用の発現も見逃せない。薬物療法に対して運動療法が近年広く処方されるようになってきた。これまでに多くの研究が有酸素運動の降圧効果を報告しているが, レジスタンス運動による降圧効果については異なる知見が出されている。そこで本研究においては, 有酸素運動の様式に似た低強度—高頻度レジスタンス運動を用いて中年軽症高血圧男子に対する降圧効果を検索した。

方法。42 歳—56 歳 (平均 48.3) の男子 10 名が被検者として参加し, 内 5 名がレジスタンス運動群 (RE) に他の 5 名がウォーキング群 (AE) に区分された。RE 群は 10 種目のウェイト運動を最大筋力の 40—50% 強度, 20—25 レペティションで 2—3 セット, 週 3 回の形で 12 週間行った。一方の AE 群は同様に予測最大心拍数の 60—75% 強度の 30 分速歩を週 3 回, 12 週間行った。

結果。安静時血圧において RE 群は AE 群より程度は低いものの有意な ($P < 0.05$) 下降を示し (RE が収縮期圧 7.2, 拡張期圧 3.6mm Hg の下降に対して AE はそれぞれ 11.8, 7.8mm Hg), その結果安静時血圧は 149.8/91.2mmHg から 142.6/87.8mmHg に改善された。同時に全身持久性の増加 (VO_{2max} 値 2.3ml/kg/min = 6.9%) と身体組成の改善 (体脂肪 1.5kg

= 8.8% 減) が見られ, その改善率は AE 群に比べて小さいがいずれも有意であった (AE 群: $6\text{ml/kg/min}=17\%$, $3.1\text{kg}=18.9\%$)。また, 体重もしくは体脂肪の減少量と降圧値との間には有意差が得られなかったが相関傾向が見られた。しかし, AE 群と異なり, RE 群では血清総コレステロール, 高比重リポ蛋白コレステロール, 低比重リポ蛋白コレステロール, トリグリセライド (中性脂肪) の血清脂質・リポ蛋白濃度の有意な改善は見られなかった。

結語。これまで血圧や身体組成もしくは有酸素性体力の改善, 向上に対するレジスタンス運動の効果については意見の一致をみていない。考えられる要因の一つに運動の処方の違いが挙げられる。血圧や身体組成の改善に対しては低強度・高頻度による運動量負荷 (Volume loading) の処方が好ましく, 高強度による過重負荷 (Over-weight loading) は至適処方とは言えないであろう。今回の研究においてレジスタンス運動による血清脂質の有意な改善が見られなかったのは総運動量が十分な刺激とならなかったものと考えられる。本研究は低強度高頻度のレジスタンス運動の習慣化が軽症高血圧患者の健康改善に効果的であることを示唆するものである。