CLINICAL AND EXPERIMENTAL HYPERTENSION
Vol. 26, No. 3, pp. 255–265, 2004

The Beneficial Effect of Regular Endurance Exercise Training on Blood Pressure and Quality of Life in Patients with Hypertension

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ABSTRACT

Regular aerobic exercise can reduce blood pressure and is recommended as part of the lifestyle modification to reduce high blood pressure and cardiovascular risk. Hypertension itself, or/and pharmacological treatment for hypertension is associated with adverse effects on some aspects of quality of life. This study was performed to evaluate the effects of regular endurance exercise training on quality of life and blood pressure. Patients with mild to moderate hypertension (systolic blood pressure 140–180 or diastolic blood pressure 90–110 mm Hg) were randomized to a moderate-intensity aerobic exercise group training for 3 sessions/week over 10 weeks or to a non-exercising control group. Health-related quality of life was assessed with the Short Form 36-item Health Survey (SF-36) at baseline and after 6 and 10 weeks. In the 102 subjects (47 male, mean age 47 years) who completed the study, reductions in

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DOI: 10.1081/CEH-120030234 1064-1963 (Print); 1525-6006 (Online)

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blood pressure in the exercise group at 10 weeks (−13.1/−6.3 mm Hg) were significant ($P < 0.001$) compared to baseline and to the control group (− 1.5/+6.0 mm Hg). Unlike the control group, the exercise group showed an increase in exercise capacity from 8.2 ± 1.6 to 10.8 ± 2.2 METS ($P < 0.01$) and showed higher scores on 7 out of 8 subscales ($P < 0.05$) of the SF-36. Improvement in bodily pain and general health sub-scores correlated with reduction in systolic blood pressure. Regular endurance training improves both blood pressure and quality of life in hypertensive patients and should be encouraged more widely.

Key Words: Hypertension; Quality of life; Aerobic exercise; Endurance training.

INTRODUCTION

Hypertension is still the most common and major risk factor for developing cardiovascular disease (1). Clinical evidence suggests that in patients with blood pressure more than 180/100 mm Hg, the risk of developing coronary heart disease is about 5 fold higher than those with blood presure less than 120/80 mm Hg (1). The Treatment of Mild Hypertension Study (TOMHS) has shown that lifestyle modification including weight loss and increased physical activity contributes significantly to blood pressure control (2).

Large number of well-controlled studies support the notion that regularly performed aerobic exercise will decrease blood pressure in patients with hypertension, compared to non-exercising control subjects (3,4). The reduction is about 8 to 10 mm Hg for systolic and 7 to 8 mm Hg for diastolic blood pressure (3,4).

Consequently, it is widely accepted that a sedentary lifestyle increases the risk for hypertension, whereas increased occupational or leisure time physical activity is associated with lower levels of blood pressure (1,2). Increased physical activity is now strongly recommended as part of the lifestyle modification along with or as an adjunct to pharmacological therapy as proposed by the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC VII).

Epidemiological studies, after allowing for conventional confounding factors, suggest that reported habitual physical activity is associated with lowered blood pressure (5,6). Similar findings have also been reported from studies in which physical activity was assessed by an exercise treadmill test (5,7).

Furthermore, patients with hypertension may experience adverse effects on well being and health-related quality of life. In some studies, hypertension has been associated with headache, dizziness, and tiredness (8,9). Besides, hypertensive individuals always have lower health status compared with normotensives (10,11). The Medical Outcome Study in the United States also found lower general health perception in hypertensive patients compared with those patients without chronic illness (12).

In recent years, the measurement of health-related quality of life (HRQOL) has become popular for evaluating additional effects of antihypertensive treatments in clinical practice. Although the effects of antihypertensive medications on HRQOL have been extensively investigated, there has been little unification of the research finding

(13). Results from different studies were also frequently inconsistent due to a wide variety of methodological designations and instruments used (13,15).

The aims of this study were to evaluate the effectiveness of regular endurance training on blood pressure and HRQOL in patients with mild to moderate hypertension.

METHODS

Subjects

Hypertensive patients were recruited from hospital outpatient clinics. Patients were eligible if they were between 20 and 60 years old, weighed less than 120% of their ideal weight according to Metropolitan Life tables, had a history of essential hypertension, were not currently performing regular aerobic exercise, and had not taken antihypertensive medications within 6 weeks of being screened for the study. Patients were excluded if they had coronary artery disease or other organic heart disease, asthma, arthritis of knee joints, chronic obstructive pulmonary disease, white coat hypertension, or secondary hypertension. Informed consents were obtained from all subjects. The local investigation and research ethnic committee has approved this study.

Baseline Blood Pressure

All patients had three blood pressures taken in a clinic setting by a pre-trained nurse or research assistant 5 minutes apart on three separate occasions with a random zero sphygmomanometer. They were blinded to the randomized subjects. Patients were included if either their mean systolic blood pressure was between 140 and 180 mm Hg or their mean diastolic blood pressure was between 90 and 110 mm Hg. All patients underwent a physical examination by a physician to rule out obvious secondary causes of hypertension and contraindications to exercise. Then, on separate days, ambulatory blood pressure monitoring and exercise testing were performed.

Ambulatory Blood Pressure Monitoring

Ambulatory blood pressure (ABP) monitoring was performed using an Accutracker monitor (Suntech Medical Instruments, Raleigh, NC, USA). Monitoring was done on a typical workday and subjects were encouraged to pursue a variety of routine activities. Ambulatory monitors were placed on subjects at approximately 8:00 AM and were removed by a research assistant the following day. Blood pressures were recorded on a fixed schedule every 60 minutes. At each cuff inflation, subjects used a diary to record their posture (standing, sitting, lying), location (home, work, other), activities (physical activity, talking, eating, sleeping), use of caffeine, alcohol, or medications.

To test the calibration of the monitor, seven auscultatory and ambulatory monitor blood pressure measurements were performed simultaneously on a subset of subjects ($n = 25$) using a Y-adapter. Ambulatory monitor blood pressures were on average 0.2/3.0 mm Hg below auscultatory blood pressures. When mean ambulatory blood pressure readings were adjusted for this calibration difference, classification as white coat or persistent hypertensive remained unchanged for 90% of subjects. In view of this high degree of agreement, unadjusted ambulatory blood pressures were used to classify subjects as white coat or persistent hypertensive patients. According to 2003 European Society of Hypertension–European Society of Cardiology (ESH/ESC) guidelines (16), we defined 24 h ABP less than 125/80 mm Hg as white coat hypertension (WCH) and excluded subjects with WCH because some evidence revealed WCH is different from established hypertension in clinical characteristics and underlying mechanism (17). The present study was designed to evaluate the effect of exercise focused on patients with pure established essential hypertension.

Health-Related Quality of Life

Health-related quality of life was assessed at baseline and after 6, and 10 weeks in both groups with the Chinese-version Short-Form 36-item Health Survey (SF-36) (18). The SF-36 consists of 8 subscales including physical functioning, role limitation because of physical problem, bodily pain, general health perceptions, vitality, social functioning, role limitation because of emotional problem, and mental health. Each domain of these scales are scored from 0 (poorest health) to 100 (optimal health) (18,19). Respondents were asked to evaluate their own health during the past 30 days (18). The psychometric properties of the SF-36 have been examined extensively and support its validity and reliability (18,20). It has been shown to distinguish healthy from chronically ill individuals and patients with different types of chronic condition (20).

Exercise Tests

One week before the experimental study began, blood biochemical examination was performed for each subject after having fasted for 8 h. Subjects then reported for a graded exercise test using the Balke protocol on a Schiller Treadmill (Cardiovit CS-100) fitted with a Schiller electrocardiogram monitor and controller (Schiller AG, Basel, Switzerland). The Balke protocol was selected due to its moderate intensity increases per stage (21). Briefly, during the Balke/Ware protocol the subjects start to exercise at 4.8 km/h, 0% gradient with the percentage gradient increasing by 2.5% every 2 min. Each subject was fitted with a 12-lead electrocardiogram system. A licensed physician was present during all tests. Blood pressure and rate of perceived exertion were measured every 2 min. Heart rate and 12-lead electrocardiogram strips were printed every 2 min. The exercise test was terminated if any subject exhibited $\geq$ 1 mm ST-segment change, significant arrhythmias, an inappropriate blood pressure response to increasing workloads, angina pectoris or exercise-induced bundle branch block. All subjects had data collection at baseline, 6-weeks, and 10-weeks during the 10-week exercise program.

Experimental Groupings and Trials

Every subject completed the exercise tests based on Balke protocol. Prior to initial exercise testing, subjects were assigned randomly to one of two experimental groups: a non-exercising control group and a moderate-intensity aerobic exercise training group [60–70% maximal heart rate reserve: average about 6–7 metabolic equivalent (METs), 1 MET = 3.5mL O_2/kg body weight/min]. The exercise-training program consisted of

10 min warm up, 30 min of treadmill walking/jogging, and 10 min cool down three times per week. Resting blood pressure was calculated by averaging the blood pressure measurements following at least 10 min seated rest by the subject before each of the exercise training. To ensure compliance with the exercise prescription, exercise heart rate for each subject were continuously monitored by staff members. In addition, subject's blood pressures were taken every 10 min during exercise to ensure the safety of the subject. After 2-week run-in period until blood pressure stabilizes by exercise training, the 10-week exercise program started.

Statistical Analysis

Values are expressed as mean ± SD. Pretraining versus post-training and between group differences in heart rate, blood pressure, body weight, maximal METs, and HRQOL scores at 6-week and 10-week were analyzed using analysis of variance for repeated measures and the least square means post-hoc test. All other comparisons were analyzed using one-way analysis of variance and Dunnett's post-hoc test. $P < 0.05$ was considered statistically significant.

RESULTS

Based on the results of the ABPM, 22 patients with WCH were classified and excluded from the study. A total of 120 eligible subjects with essential hypertension were recruited from July 1998 to August 2001 but only 102 (47 male) subjects completed the study within 10 weeks. Eighteen of the 120 subjects, 10 in the exercise group and 8 in the control group, were not able to complete the study for non-medical reasons and were not included in the data analysis. The mean age of the subjects was 47 years. The baseline data of both control and exercise groups were shown in Table 1.

Table 1. Baseline characteristics of hypertensive subjects in control and exercise groups.

	Control (n = 50)	Exercise (n = 52)	P value
Age (years)	49.3 ± 7.2	48.8 ± 6.3	NS
Male (n)	23	24	NS
Female (n)	27	28	NS
BMI (kg/m^2)	23.8 ± 2.2	23.6 ± 1.8	NS
Mean clinic SBP (mmHg)	141.2 ± 10.9	144.4 ± 11.2	NS
Mean clinic DBP (mmHg)	94.9 ± 6.6	95.2 ± 7.0	NS
Mean 24-h ASBP (mmHg)	135.6 ± 7.6	136.2 ± 8.2	NS
Mean 24-h ADBP (mmHg)	88.6 ± 5.8	90.2 ± 6.4	NS
Mean resting HR (bpm)	76.6 ± 12.4	76.8 ± 10.2	NS
Exercise capacity (METs)	8.4 ± 1.4	8.2 ± 1.6	NS

NS, non-significant; BMI, body mass index (kg/m^2); SBP, systolic blood pressure; DBP, diastolic blood pressure; 24-h ASBP, 24 hours ambulatory systolic blood pressure; 24-h ADBP, 24 hours ambulatory diastolic blood pressure; METs, metabolic equivalent; bpm, beats per minute.

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Table 2. Comparisons of blood pressure between control and exercise groups at baseline, 6-week and 10-week of the study.

		Baseline	6-week	10-week
Mean clinic SBP	C	141.2 ± 10.9	136.2 ± 13.6	137.6 ± 18.4
	E	144.4 ± 11.2	137.9 ± 11.0[a]	131.3 ± 12.4[c]
Mean clinic DBP	C	94.9 ± 6.6	96.2 ± 4.6	98.9 ± 4.7
	E	95.2 ± 7.0	92.0 ± 6.9[a]	88.9 ± 8.2[c]
Mean resting HR	C	76.6 ± 12.4	78.2 ± 10.8	78.8 ± 10.6
	E	76.8 ± 10.2	78.6 ± 11.8	74.6 ± 8.8
Exercise capacity (METs)	C	8.4 ± 1.4	9.2 ± 1.8	9.2 ± 2.2
	E	8.2 ± 1.6	9.8 ± 2.0[a]	10.8 ± 2.2[b]

Abbreviations as in Table 1; C, control group; E, exercise group; [a]$p < 0.05$, [b]$p < 0.01$, [c]$p < 0.001$ for the difference from the baseline value compared with that of the control group.

Biochemical parameters were also measured at every visit but are not shown in this paper. Subjects' body mass index did not show any significant change in both groups.

The average attendance rate of the exercise sessions was 90.2% in the exercise group. On the completion of this study, the exercise group showed a dramatic reduction of blood pressure especially the systolic pressure. The blood pressure showed significant reductions even at the first follow-up visit. The maximal mean reduction of systolic blood pressure reached 9% at a value of 13.1 mm Hg, whereas the maximal

Table 3. Comparisons of scores on the SF-36 between control and exercise group at baseline, 6-week and 10-week of study.

		Baseline	6-week	10-week
Physical functioning	C	85.6 ± 15.9	83.9 ± 26.8	85.6 ± 25.1
	E	86.3 ± 14.9	94.3 ± 8.4[a]	92.3 ± 8.2[a]
Role function/physical	C	64.0 ± 48.0	63.3 ± 33.1	66.7 ± 50.0
	E	76.7 ± 34.7	95.0 ± 14.0[b]	83.3 ± 32.3[a]
Bodily pain	C	68.8 ± 40.7	74.9 ± 32.5	68.2 ± 31.0
	E	73.3 ± 17.8	88.0 ± 14.8[b]	83.6 ± 17.6[a]
General health	C	54.4 ± 27.7	57.7 ± 29.3	61.7 ± 27.4
	E	58.5 ± 19.1	70.4 ± 18.9[a]	69.9 ± 18.0[a]
Vitality	C	54.4 ± 26.5	60.6 ± 25.7	58.3 ± 25.4
	E	60.7 ± 16.5	69.3 ± 12.1[a]	72.2 ± 10.5[a]
Social functioning	C	66.7 ± 33.1	65.0 ± 20.7	67.8 ± 24.8
	E	74.2 ± 19.8	86.7 ± 15.3[b]	83.3 ± 15.4[a]
Role function/emotional	C	59.3 ± 49.4	63.0 ± 42.3	63.0 ± 38.9
	E	60.0 ± 40.2	84.5 ± 30.5[c]	84.5 ± 30.5[c]
Mental health	C	58.1 ± 29.1	56.4 ± 24.7	58.2 ± 24.5
	E	69.1 ± 9.9	72.3 ± 9.4	73.1 ± 9.6

C, control group; E, exercise group; [a]$p < 0.05$, [b]$p < 0.01$, [c]$p < 0.001$ for the difference from the baseline value compared with that of the control group.

Table 4. Correlations between the change of scores on the SF-36 and blood pressure reduction at the 10-week in the exercise group.

	SBP	DBP
Physical functioning	0.09	0.52*
Role function/physical	0.03	0.14
Bodily pain	0.55*	0.21
General health	0.53*	0.23
Vitality	0.17	− 0.01
Social functioning	0.26	0.27
Role function/emotional	0.13	0.09
Mental health	0.08	0.14

SBP, systolic blood pressure; DBP, diastolic blood pressure; *$p < 0.05$.

reduction of diastolic blood pressure reached 6.6% at a value of 6.3 mmHg. A significant increase in exercise capacity was also observed in the exercise group (Table 2).

On average, the hypertensive subjects scored the highest on the physical functioning subscale and the lowest on the general health perceptions. There were no significant differences in all sub-scores of the SF-36 between exercise and control groups at baseline ($p > 0.05$). In comparison with the baseline data, the exercise group showed significant higher scores on 7 subscales of the SF-36 following the 10-weeks exercise-training program (Table 3). The changes in the bodily pain and general health sub-scores of the SF-36 paralleled the degree of systolic blood pressure reduction in trained patients ($r = 0.55$, $p = 0.03$; $r = 0.53$, $p = 0.04$ respectively) (Table 4). In contrast, no significant changes were observed in any of the sub-scores of the SF-36 in control group (Table 3).

DISCUSSION

Previous investigations have demonstrated that low- to moderate-intensity exercise (35% to 79% of age-predicated maximum heart rate) is effective in lowering blood pressure (22,23). Our recent studies also reconfirmed this finding in Taiwanese hypertensive patients and even in subjects with white coat hypertension (24,25). The magnitudes of mean blood pressure reduction were −18/−10 mmHg and −10.8/−5.3 mmHg, respectively (24,25). In studies designed to compare the effects of different exercise intensities, low-intensity exercise was more effective in lowering blood pressure than was high-intensity exercise (22,23). The findings of the Trial of Hypertension Prevention also support this observation (26).

Therefore, the reduction of blood pressure by moderate- to low-intensity exercise intensities is particularly important for hypertensive patients. When compared to high-intensity exercise, low-intensity exercise carries a lower risk for cardiac event (27). This important factor considered along with the low-cost, lack of pharmacological side effects, and additional cardiovascular benefits associated with exercise (28), are likely

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to increase patients' participation in exercise programs and lead to a better control of hypertension.

Several experimental studies also show that exercise training positively modifies coronary heart disease risk factors including resting blood pressure in hypertensive patients (1,28,29). Although the concept that increased physical activity protects against cardiovascular disease is now widely accepted, the underlying mechanisms mediating the hypertensive response of exercise training remain obscure and controversial. Several mechanisms accounting for the antihypertensive effects of mild exercise have been proposed. It may arise from the decrease of plasma norepinephrine, decrease of endogenous ouabain-like substance, or the increase of prostaglandin E (30,31). The decrease of plasma renin activity (PRA) was also proposed to play a role (30,31). However, PRA and aldosterone levels of the subjects remained unchanged during our study period; this phenomenon is compatible with the previous study (25). Our previous study has shown that serum catecholamines did not reveal any significant changes (unpublished data). Other factors such as decreased sympathetic nervous system activity and increased sensitivity of the baroreceptor reflex after exercise training may exert beneficial influences on the blood pressure reduction.

The HRQOL of hypertensive patients was significantly lower than that in normotensives (10,11). Variables which significantly retained their negative impact on quality of life included: gender (female), greater organ damage, and higher heart rate and weight (11). In addition, deterioration of HRQOL in patients with hypertension is assumed from three factors, i.e., hypertension itself/hypertension complication, treatment (pharmacological and/or non-pharmacological), and the so-called labeling effect following diagnosis (32). In a recent general population-based study, the patients with known hypertension presented lower scores on four SF-36 sub-scales, including physical function, vitality, mental health and general health than those scores of general population. However, patients with known hypertension reported more bodily pain than subjects with unknown hypertension reported, while there were no differences between patients with unknown hypertension and the nomotensive subjects (32). So, this deterioration of the subjective state of HRQOL (SF-36) was not observed in patients who have not yet been diagnosed hypertension in this population-based survey.

The present data show that endurance exercise training improved exercise capacity, HRQOL and induced a significant reduction of blood pressure in hypertensive patients. The improvements in 3 domains of HRQOL (bodily pain, general health, and role function/emotional) were most apparent. Previous studies have shown that increase of physical activity improves quality of life in hypertensive patients (33,34). It is likely that the improved exercise capacity and better blood pressure control following exercise training contributed to improvement in the quality of life. We think there were the favorable effects of exercise per se on quality of life in our subjects with regularly moderate intensity exercise training. Results from a randomized controlled trial suggested a significant improvement in quality of life in patients with chronic heart failure after 2 months exercise training program. The changes in the total score of quality of life paralleled an increase in peak VO_2 (35). In a study by Michalsen and colleagues they reported an improvement of quality of life among elderly hypertensive patients treated with quinapril, mainly due to better mood and lower depression scores (14). It is unclear whether the effects of exercise training on quality of life are different from those effects of antihypertensive medications. Further studies are

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needed to confirm the impact and mechanism of physical training on quality of life in hypertension.

The change in bodily pain and general health scores of the SF-36 were also associated with the degree of blood pressure reduction. However, it is generally accepted that most hypertension is asymptomatic, even headache, the most common symptom of hypertension is also considered not related to the level of blood pressure (36). In our study, the subjects in exercise group might have aware of the changes in blood pressure after regular exercise. The exercise group reported lower bodily pain after exercise probably because that they observed significant blood pressure reduction. Results from a study by Hortega (32) also suggested that patients with known hypertension reported more bodily pain than that in unknown hypertensive subjects. In addition, SF-36 is a subjective statement by patients themselves and pain is also a subjective perception. We cannot define whether the decreases of bodily pain and changes in general health scores were directly resulted from blood pressure reduction or not. It still needs further studies to define the relationships among exercise, blood pressure and quality of life.

In conclusion, regular endurance exercise training may play an important role on the improvements in exercise capacity, quality of life as well as better blood pressure control in hypertensive patients, which can also reduce the likelihood of cardiovascular complications.

REFERENCES

1. Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Seventh report of the joint national committee on detection, evaluation, and treatment of high blood pressure. JAMA 2003; 289:2534–2573.
2. World Hypertension League. Physical exercise in the management of hypertension: a concensus statement by the world hypertension league. J Hypertens 1991; 9:283–287.
3. American College of Sports Medicine. Physical activity, physical fitness and hypertension: position stand. Med Sci Sports Exerc 1993; 25:i–x.
4. Hagberg JM. In: NIH Consensus Development Conference: Physical Activity and Cardiovascular Health. Office of Director National Institute of Health. Physical activity, physical fitness and blood pressure, Publication NIH: Bethesda, MD, 1996:69–71.
5. Gibbons LW, Blair SN, Cooper KH, Smith M. Association between coronary heart disease risk factors and physical fitness in healthy adult women. Circulation 1983; 67:977–983.
6. Palatini P, Graniero GR, Mormino P, Nicolosi L, Mos L, Visentin P, Pessina AC. Relation between physical training and ambulatory blood pressure in stage 1 hypertensive subjects: results of the HARVEST trial. Circulation 1994; 90:2870–2876.
7. Kokkinos PF, Holland JC, Pittaras AE, Narayan P, Dotson CO. Cardiorespiratory fitness and coronary heart disease risk factor association in women. J Am Coll Cardiol 1995; 26:358–364.
8. Kjellgren KI, Ahlner J, Dahlof B, Gill H, Hedner T, Saljo R. Perceived symptoms

among hypertensive patients in routine clinical practice—a population based study. J Intern Med 1998; 244:325–332.
9. Moller L, Kristensen TS, Hollnage H. Self-rated health as a predictor of coronary heart disease in Copenhagen, Denmark. J Epidemiol Community Health 1996; 50:423–428.
10. Wang J, Kang D, Hong Q. Health-related quality of life in hypertensive patients. Zhonghua Yixue Zazhi 1999; 79:599–602.
11. Roca-Cusachs AD, Antoni B, Badia X, Aristegui I, Roset M. Relation between clinical and therapeutic variables and quality of life in hypertension. J Hypertens 2001; 19:1913–1919.
12. Stewart AL, Greenfield S, Hays RD, Wells K, Rogers WH. Functional status and well-being of patients with chronic conditions. JAMA 1989; 262:907–913.
13. Coyne KS, Davis D, Frech F, Hill MN. Health-related quality of life in patients treated for hypertension: a review of the literature form 1990 to 2000. Clin Ther 2002; 24:142–169.
14. Michalsen A, Wenzel RR, Mayer C, Matthias B, Philipp T, Dobos GJ. Quality of life and psychosocial factors during treatment with antihypertensive drugs: a comparison of captopril and quinapril in geriatric patients. Herz 2001; 26:468–476.
15. Rake EC, Breeze E, Fletcher AE. Quality of life and cough on antihypertension treatment: a randomized trail of eprosartan, enalapril and placebo. J Hum Hypertens 2001; 15:863–867.
16. Guidelines Committee. 2003 European Society of Hypertension–European Society of Cardiology guidelines for the management of arterial hypertension. J Hypertens 2003; 21:1011–1053.
17. Bidlingmeyer I, Burnier M, Bidlingmeyer M, Waeber B, Brunner HR. Isolated office hypertension: a prehypertensive state? J Hypertens 1996; 14:327–332.
18. Fuh J, Wang SJ, Lu SR, Juang KD, Lee SJ. Psychometric evaluation of a Chinese (Taiwanese) version of the SF-36 health survey among middle-aged women form a rural community. Qual Life Res 2000; 9:675–683.
19. Ware JE Jr, Sherbourne CD. The MOS 36-Item Short-Form Health Survey (SF-36) I: conceptual framework and item selection. Med Care 1992; 30:473–483.
20. McHorney CA, Ware JE, Raczek AE. The MOS 36-Item Short-Form Health Survey (SF-36) II: psychometric and clinical tests of validity on measuring physical and mental health constructs. Med Care 1993; 31:247–263.
21. Blumenthal JA, Rejeski WJ, Walsh-Riddle M, Emery CF, Miller H, Roark S, Ribisl PM, Morris PB, Brubaker P, Williams RS. Comparison of high and low intensity exersice training early after acute myocardial infarction. Am J Cardiol 1988; 61:26–30.
22. Hagberg JM, Montain SJ, Martin WH III, Ehsani AA. Effect of exercise training in 60- to 69-years-old person with essential hypertension. Am J Cardiol 1989; 64:348–353.
23. Motoyama M, Sunami Y, Kinoshita F, Kiyonaga A, Tanaka H, Shinodo M, Irie T, Urata H, Sasaki J, Arakawa K. Blood pressure lowering effect of low intensity aerobic training in elderly hypertensive patients. Med Sci Sports Exerc 1998; 30:818–823.
24. Tsai JC, Chang Wy, Kao CC, Lu MS, Chen YJ, Chan P. Beneficial effect to blood

pressure and lipid profile by programmed exercise training in Taiwanese patients with mild hypertension. Clin Exp Hypertens 2002; 24:315–324.
25. Tsai JC, Liu JC, Kao CC, Tomlinson B, Kao PF, Chen JW, Chan P. Beneficial effects on blood pressure and lipid profile of programmed exercise training in subjects with white coat hypertension. Am J Hypertens 2002; 15:571–576.
26. Borhani NO. Significance of physical activity for prevention and control of hypertension. J Hum Hypertens 1996; 10(suppl II):7–11.
27. Friedewald VE Jr, Spence DW. Sudden cardiac death associated with exercise: the risk-benefit issue. Am J Cardiol 1990; 66:183–188.
28. Fletcher G, Blair SN, Blumenthal J, Caspersen C, Chaitman B, Epstein S, Falls H, Froelicher Es, Froelicher VF, Pina IL. Benefits and recommendations for physical activity programs for all americans. A statement for health professionals by the Committee on Exercise and Cardiac Rehabilitation of the Council on Clinical Cardiology, American Heart Association. Circulation 1992; 86:340–344.
29. National High Blood Pressure Education Program Working Group. National high blood pressure education program working group on prevention of hypertension. Arch Intern Med 1993; 153:186–208.
30. Arakawa K. Exercise, a measure to lower blood pressure and reduce other risks. Clin Exp Hypertens 1999; 21:797–803.
31. Koga M, Ideishi M, Matsusaki M, Tashiro E, Kinoshita A, Ikeda M, Tanaka H, Shinodo M, Arakawa K. Mild exercise decreases plasma endogenous digitalis-like substance in hypertension individuals. Hypertension 1992; 19(suppl II):II231–II236.
32. Mena-Martin FJ, Martin-Escudero JC, Simal-Blanco F, Carretero-Ares JL, Arzua-Mouronte D, Herreos-Fernandez V. Health-related quality of life of subhects with know and unknown hypertension: results from the population-based Hortega study. J Hypertens 2003; 21, pp. 1283–1289, 5–272.
33. Dubbert PM, Martin JE, Cushman WC, Meydrech EF, Carroll RG. Endurance exercise in mild hypertension: effects on blood pressure and associated metabolic and quality of life variables. J Hum Hypertens 1994; 8:265–272.
34. Shephard RJ. Exercise and relaxation in health promotion. Sports Med 1997; 23:211–217.
35. Belardinelli R, Georgiou D, Cianci G, Purcaro A. Randomized, controlled trial of long-term moderate exercise training in chronic heart failure: effects on functional capacity, quality of life, and clinical outcome. Circulation 1999; 99:1173–1182.
36. Primary hypertension: natural history and evaluation. In: Kaplan NM, Ed. Kaplan's Clinical Hypertension, 8th ed. Philadelphia: Lippincott Williams & Wilkins, 2002, 163.

Received June 10, 2003
Accepted December 9, 2003