Influence of a 10-Week Controlled Exercise Program on Resting Blood Pressure in Sedentary Older Adults

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ABSTRACT

Objective: The objective of this study was to determine the efficacy of a 10-week controlled aerobic exercise program on resting blood pressure (BP) and magnitude of BP change response to such training in sedentary elderly individuals.

Methods: Previously sedentary participants aged 75 years and older were randomized to either a control or one of two exercise groups. Subjects in exercise groups performed aerobic exercise at moderate or high intensity, 3 days per week for 40 minutes per session. Resting BP was measured in sitting position at pre- and post-intervention.

Results: The high-intensity exercise group showed a significant reduction in resting systolic BP (–7.8 mmHg) and diastolic BP (–9.6 mmHg). Significant BP decreases for the moderate-intensity exercise group were only observed on diastolic BP (–8.4 mmHg) but not systolic BP (–5.2 mmHg, $P = 0.25$).

Conclusion: The data suggest that the lowering effect of a 10-week aerobic exercise program on resting systolic BP may be closely related to the training intensity. However, other regimens may have influence on the reduction of resting diastolic BP.

INTRODUCTION

High resting blood pressure (BP) and its complications remain a major public health problem today. Hypertension affects approximately 50 million individuals in the United States and approximately 1 billion worldwide.[1] The risk of cardiovascular disease doubles with each increment of 20 mmHg in systolic blood pressure (SBP) or 10 mmHg in diastolic blood pressure (DBP) over 115/75 mmHg.[2] Aging is associated with changes in resting BP, especially an increase in SBP,[3] with hypertension being reported in more than two-thirds of individuals after age 65.[1] The prevalence of hypertension will increase even further in the older population unless broad and effective preventive measures are implemented. Recent data suggest that individuals who are normotensive at age 55 have a 90% lifetime risk for developing hypertension.[4] This is also the population with the lowest rates of BP control.[5]

Aerobic exercise training has been documented to produce a reduction of resting BP among sedentary normotensive and hypertensive adults.[1,6-8] However, the rate of reduction found has been inconsistent or equivocal, both in general and among subgroups of the population.[9-11] This is the case especially in the elderly population. One narrative review,[7] for example, reported a weighted average reduction of 7.6 and 8.8 mmHg in resting SBP and DBP, respectively, among hypertensive adults aged 60 years and older, while a recent meta-analysis suggested that aerobic exercise only slightly reduced resting SBP (approximately 2 mmHg), but not DBP, in adults aged 50 years and over.[9]

One possible reason for the divergent results is a wide range in the age of participants in the published studies.[7] Age is an important factor related to the prevalence of elevated BP and hypertension in the general population. This variability among investigations may be problematic when attempting to derive conclusions about the effect of exercise training on BP in different age populations. Thus, it is meaningful for the investigation to use a relatively narrow age segment of the older population to determine the BP-lowering effects of endurance training.

In addition, the influence of important exercise parameters (ie, length, frequency, intensity, duration) on change in resting SBP and DBP in older adults remains unclear. A wide range of exercise training programs were used in previous studies,[7] and thus, the results have presented different directions and a variety of magnitude of BP changes. Furthermore, most intervention trials have tested the effect of vigorous exercise with longer length on resting BP.[12,13] Few controlled interventions have explored necessary and optimal training intensity in short-term exercise programs that may induce resting BP change in elderly people. Limitations of older adults often keep them from vigorous exercise. It is also difficult to retain older adults in a long-term exercise program. Obviously, providing supervised or community-based exercise programs with relatively short length and optimal intensity is cost effective and greatly beneficial to elders and society if health benefits of the programs can be determined.

Therefore, the purpose of this randomized community-based intervention was to determine if and to what extent the resting SBP and DBP would be changed in previously sedentary persons aged 75 years and older after a 10-week controlled aerobic exercise program at two different intensities. Heart rate (HR) responses at rest after the training were also of interest.

METHODS

Subjects

Participants were recruited from among elderly residents in three community living facilities at different locations. The residents at these sites had similar socioeconomic status, ethic background, and resident conditions. Information sessions at three sites were held that addressed the objectives of the study, the nature of the exercise program, the schedule and procedures of assessments, and all other physical aspects of the program. Subjects eligibility criteria were sedentary but otherwise healthy and ambulatory; age ≥75 years; able to participate in moderate or upper levels of physical activity; not smoking; and no antihypertensive medications taken currently. All interested volunteers were interviewed and gave their written informed consent. A screen evaluation was administered including medical history and physical activity questionnaires, an approval for the exercise program from subjects' personal physicians, and a physical examination for documenting the absence of significant medical abnormalities. Sixty participants were then identified from the facilities.

The subjects were randomly assigned into 1 of 3 groups: a control group, a moderate-intensity exercise group, and a high-intensity exercise group. All subjects were instructed to maintain their usual diet and salt intake during the intervention. Fifty-two participants constituted the final sample for the analysis. An additional eight subjects were not included due to incompletion of the test measures and/or failure to attend more than 80% of the training sessions. Baseline physical characteristics of the subjects who were excluded in the final sample were not significantly different than those of the subjects who were included in the analysis. The study was conducted during the months of March, April, and May. The Advisory Committee on Human Experimentation of the University of Kansas approved this study.

Measurements

Physical tests were administered before the exercise program and again in the week immediately after the conclusion of the training program. All measures were conducted at normal indoor temperature and humidity. Height and weight were measured without hats and shoes, using a wall stadiometer and a calibrated triple-beam scale, respectively. Body mass index (BMI, kg/m^2) was calculated from the values of height and weight. Resting HR was measured by the 2001 CardioSport Heart Rate Monitor (Sports Beat, Inc., Floral Park, NY). The same device was also used for monitoring HR during exercise training. Resting SBP/DBP was measured in sitting positions. The brachial artery auscultation technique was used with a random zero mercury sphygmomanometer. The measurement procedures followed the criteria of the American Society of Hypertension.[14] Three resting HR and BP measurements were recorded after the participants had spent at least 5 minutes sitting in a quiet room. Systolic BP was measured as the point of appearance of the Korotkoff sounds (phase I) and diastolic BP as the point of disappearance (phase V). All of the pre- and post-testing were performed by trained technicians who were retrained to measure HR and BP prior to testing. Technicians were masked to the intervention status of subjects and did not provide participants with HR and BP information. The test and re-test procedures were conducted to determine reliability under the same conditions.

Interventions

The elderly participants in two exercise groups performed 10-week aerobic exercise training at two different intensities, 3 days per week for a total of 30 exercise sessions, and 40 minutes in duration. A 2-week control period was used to adjust physical function of subjects adapted to exercise training. Each exercise session was conducted by a post baccalaureate exercise physiologist who had good knowledge of physical activity and older adults as well as of the guidelines for exercise instructions established by The American College of Sports Medicine. The class attendance of each participant was documented.

The moderate-intensity group was

Table 1. Physical characteristics of the subjects at baseline

Subjects	Age (year)	Height (cm)	Weight (kg)	BMI	Resting HR (bpm)
Control (n = 14)	83.4 ± 2.8	155.6 ± 7.5	63.4 ± 9.0	26.2 ± 1.6	79.6 ± 7.9
Moderate intensity (n = 22)	83.8 ± 3.1	158.6 ± 9.2	61.0 ± 11.5	24.2 ± 1.5	83.8 ± 12.0
High intensity (n = 16)	84.8 ± 2.6	154.8 ± 5.1	57.4 ± 9.6	24.0 ± 2.2	79.6 ± 7.9

Values are expressed as mean ± standard deviation
BMI=body mass index
HR=heart rate
bpm=beats per minute

progressed to an exercise intensity of 65-70% of maximal heart rate (HRmax) and continued exercising at this training level to the end of program. The exercise intensity was monitored by HR measures immediately after the exercise bouts three times during each aerobic exercise session. The training routine included a warm-up period with stretching, a main period of moderate impact aerobic activities, and a cool-down and relaxation period. The aerobic exercises are as follows: sitting in chair to do moving feet in marching fashion and leg kicks, sitting in chair and standing, slow marching, speed-up marching, marching with alternating body positions, high knee raising while marching, swaying arms side to side, rocking weight back and forth, lateral stepping while moving body parts, and double stepping sideways with back and forth arm sway.

The high-intensity group was progressed to a vigorous aerobic exercise with the intensity at 85-90% of their HRmax. The exercises included warm-up and stretching, a major period of aerobic exercise and cool-down activities. The aerobic activities include as follows: stepping (side to side, polka steps, bus stop steps, etc.), side bending, marching with alternating body positions (knee lifts, heel lifts, etc.), swaying with moving body parts, walking in circle with swing arms, walking in circle with arm variations, fast walking towards different directions, and squatting with arms moving. Exercise HR was also closely monitored in the same way as for the moderate-intensity group.

Subjects in the control group were advised to continue with their usual activities of daily living. They were also organized to participate in a very light-intensity stretching program. The goal was to improve flexibility as well as stimulate enjoyment so as to keep adherence of the subjects. The stretching activity, plus relaxation techniques, focused on all major joints (neck, shoulders, arms, hands, fingers, trunk, hips, legs, ankles, and feet). They were similar to active daily living of the elderly but elicited little increase in HR. Exercise HR was also monitored at each stretching session for the group in order to make sure there was no effect of aerobic training.

Statistical analysis

Descriptive statistics were calculated for all independent and dependent variables. Differences between the values at pre- and post-exercise training were compared using a repeated measures analysis of variance. Analysis of covariance was also performed to control the possible differences among the mean changes and to statistically eliminate the possible affects of confounding variables. The level of statistical significance was set at $P \leq 0.05$. Descriptive statistics were expressed as mean ± SD.

RESULTS

The physical characteristics of the subjects in the 3 groups are presented in Table 1. The groups did not differ with respect to mean age, height, weight, and BMI at baseline. Exercising for 10 weeks did not significantly change body weight or BMI results in any of the groups. The initial resting HR was similar in all groups. Mean differences of resting HR after the 10-week intervention were –0.4 beats per minute (bpm) in the control group, –1.6 bpm in the moderate-intensity group, and –0.5 bpm in the high-intensity group; all were not significant.

The initial SBP at rest was not different among the 3 groups. After the 10 weeks of aerobic training, resting SBP significantly decreased by 7.8 mmHg (148.3 ± 22.8 mmHg pre-exercise vs. 140.5 ± 27.2 mmHg post-exercise; $P<0.05$) in the high-intensity group. Following the 10-week intervention, the moderate-intensity group had a SBP decrease of approximately 5.2 mmHg (145.8 ± 17.7 mmHg pre-exercise vs. 140.6 ± 23.6 mmHg post-exercise), whereas the control group demonstrated an increase of approximately 2.6 mmHg (133.1 ± 23.9 mmHg pre-intervention vs. 135.7 ± 4.8 mmHg post-intervention) in the resting SBP. The changes in these two groups were not statistically significant.

The initial DBP at rest did not differ among the groups. After the 10-week study, resting DBP decreased significantly in all groups with the reduction of 9.6 mmHg (76.5 ± 13.8 mmHg pre-exercise vs. 66.9 ± 12.4 mmHg post-exercise, $P<0.001$) in the high-intensity group, 8.4 mmHg (75.2 ± 11.5 mmHg pre-exercise vs. 66.8 ± 9.7 mmHg post-exercise, $P<0.001$) in the moderate-intensity group, and 8.7 mmHg (74.7 ± 11.4 mmHg pre-intervention vs. 66.0 ± 9.3 mmHg post-intervention, $P<0.01$) in the control group, respectively. These changes (Δ) in SBP and DBP at different conditions after the 10-week study are shown in Figure 1.

DISCUSSION

The overall results of this study suggest that a 10-week controlled aerobic exercise program can influence on resting BP in the individuals aged 75 years and older. However, the current study only demonstrated a significant effect on resting SBP with high-intensity aerobic training. The 10-week aerobic training with intensity at 85-90% of HRmax can result in a resting SBP reduction by approximately 7.8 mmHg or a change of about 5.3%. Although subjects in the moderate-intensity group did have a SBP decrease of approximately 5.2 mmHg or a 3.6% improvement, the change was not statistically significant ($P=0.25$). These results imply that the effect of short-term aerobic exercise on lowering SBP among the elderly individuals appears to be related to the training "dose." For a relatively short-term training program, exercise intensity plays an important role and must reach a certain level or threshold so as to elicit a substantial SBP reduction for older adults. Based on our investigation, if the length of an aerobic exercise program is about 10 weeks, with 40-minute duration, 3 times per week, the intensity should reach or attain 85-90% of HRmax to significantly elicit the lowering effect of resting SBP. Light- to moderate-intensity (less than 65-70% of HRmax) seems to be unable to induce significant SBP-lowering benefits in sedentary older adults

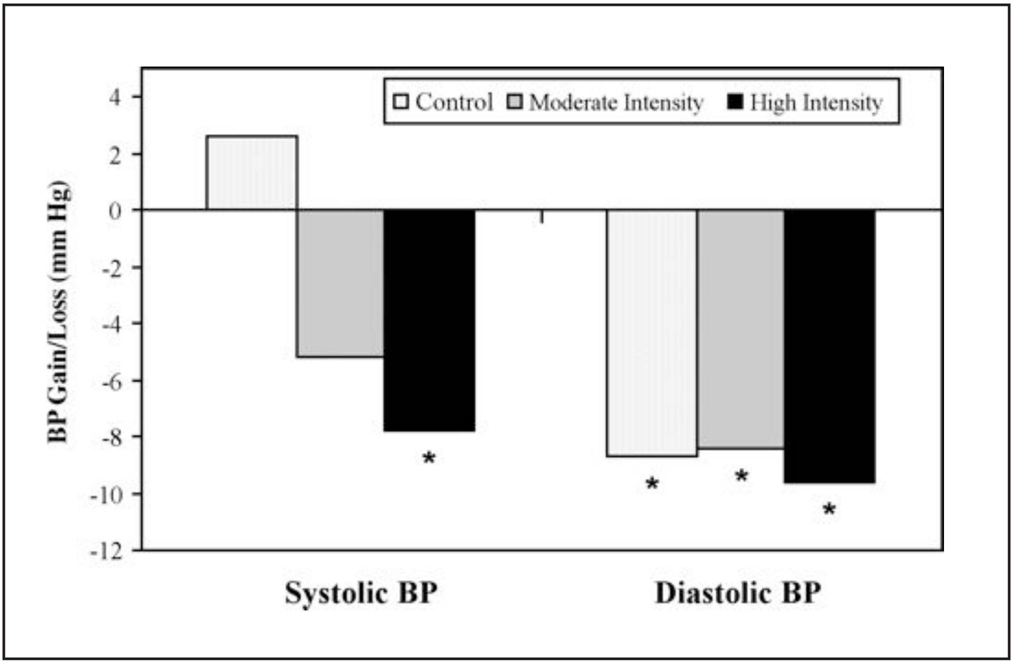

Figure 1. Changes (Δ) in resting systolic/diastolic blood pressure (BP) after 10 weeks of endurance exercise training

if the exercise length is around or less than 10 weeks. However, as long as exercise intensity reaches a certain point or level, a relatively short-length of aerobic exercise training, such as 10 weeks, may have a similar effect to lower resting SBP as long-term training. Given the fact that it appears difficult to retain older adults in a long-term exercise program, our findings have practical value in exercise prescriptions and the design of systematic and cost-effective exercise programs for older populations to promote cardiovascular health.

Significant changes in resting DBP were observed in both exercise groups. In the high-intensity group, the mean DBP change was approximately 9.6 mmHg, a 12.5% reduction. For the subjects with moderate-intensity training, an average DBP reduction was approximately 8.4 mmHg, a decrease of 11.2%. However, subjects in the control group also experienced changes of resting DBP, an 11.6% reduction after the 10-week study. A possible explanation was that this group was organized to participate in stretching exercises, though these activities were very light without eliciting HR increase. Stretching activities have been documented to reduce muscle tension, increase relaxation, and improve circulation and air exchange.[15] These physiological changes may contribute to a decrease in anxiety, blood pressure, and breathing rate.[16] It is difficult, however, to propose an underlying mechanism for the DBP-lowering effects of flexibility exercise showed in this study. Thus, it may be inappropriate at this point to make a conclusion from the results of this investigation regarding the aerobic exercise effect on resting DBP of older people. More prospective studies are needed to determine if the relatively shorter exercise program would have a significant influence on resting DBP in sedentary older people.

One potential confounding variable in exercise and BP studies is the concomitant changes that often occur in body mass. However, recent review articles suggest that exercise training induced reductions in SBP and DBP do not appear to be the result of the small and highly variable changes in bodyweight that occur with endurance exercise training.[7,8] The results of our study suggest that weight changes as a possible explanation may be precluded for observed changes in resting SBP and/or DBP as a result of the 10-week aerobic training. In addition, we did not find a significant decrease in resting HR after this short-term aerobic training. This result is consistent with the findings in our previous study that longer training time of aerobic exercise may have greater impact on lowering HR at rest among older adults.[17] This result also implies that the changes of resting BP consequent to the 10-week aerobic exercise appear to be independent of the HR change. Thus, the observed reductions in resting BP may result from reductions in peripheral vascular resistance, which may be contributable to an overall change of autonomic nervous system activity, and/or some changes in stroke volume.

The present study, however, has limitations. These include the relatively small sample size, the similar ethnic background of the participants, the fact that the control condition was possibly confounded with the light stretching activities, and the lack of measurement in aerobic fitness. Therefore, caution should be used in generalizing from these findings. More research is warranted to confirm the effectiveness of this type of exercise program and clarify the association between exercise paradigms and changes of resting BP in an older population.

Despite these limitations, this study has demonstrated the trainability of octogenarians and provides support for health promotion aimed at re-activating very old individuals. Importantly, the value of exercise training with adequate volume and intensity is established as having a positive effect upon resting BP reductions in elderly persons with the mean age of 84 years. Promoting the relative short length of endurance exercise programs with adequate intensity among elderly adults can have practical meaning and substantial benefits to public health as a means to reduce blood pressure. The prevalence of hypertension increases with age, with more than 1 of every 2 adults older than 60 years of age having hypertension.[3] It has been reported that the relative risk of stroke and coronary heart disease is directly related to the level of both SBP and DBP throughout the normotensive and hypertensive range.[18] MacMahon and Rodgers[19] found that the greatest number of strokes occurred in those subjects with a DBP in the upper range of normal (80-89 mmHg). Systolic BP has stronger association with risk of cardiovascular and renal disease.[18] In light of such knowledge, the magnitude of decrease in resting BP responding to the intervention in this study is clinically important. These improvements may influence the outlook for independent living and decrease cardiovascular risk factors for older adults and thus provide a cost-saving benefit to the community.

CONCLUSIONS

The lowering effect of a 10-week controlled aerobic exercise program on resting BP may closely be related to the training "dose." Training at intensity between 85-90% of HRmax can induce a significant reduction of resting systolic BP in sedentary elderly individuals. Moderate-intensity exercise at 65-70% of HRmax did not elicit a statistically significant change in SBP. However, the average decrease of 5.2 mmHg might have clinical meaning if compared to the results in the other studies. The 10-week exercise induced effect on resting DBP remains to be confirmed. Other regimens or variables may have influence on the reduction of resting DBP.

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