RESISTANCE EXERCISE TRAINING IS MORE EFFECTIVE THAN INTERVAL AEROBIC TRAINING IN REDUCING BLOOD PRESSURE DURING SLEEP IN HYPERTENSIVE ELDERLY PATIENTS

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ABSTRACT

Bertani, RF, Campos, GO, Perseguin, DM, Bonardi, JMT, Ferriolli, E, Moriguti, JC, and Lima, NKC. Resistance exercise training is more effective than interval aerobic training in reducing blood pressure during sleep in hypertensive elderly patients. J Strength Cond Res 32(7): 2085–2090, 2018—An appropriate fall in blood pressure (BP) during sleep is known to be related to a lower cardiovascular risk. The objective of this study was to compare the effect of different types of training on hypertensive elderly patients under treatment in terms of pressure variability assessed by the nocturnal decline in BP. Hypertensive elderly subjects under pharmacological treatment were randomly assigned to the following groups: 12 weeks of continuous aerobic training, interval aerobic training (IA), resistance training (R), or control (C). All subjects underwent ambulatory BP monitoring before and 24 hours after the last exercise session. The results were assessed using the mixed effects model. A greater nocturnal decline in diastolic BP compared with the wakefulness period was observed in R in comparison with C (11.0 ± 4.1 vs. 6.0 ± 5.7 mm Hg and ρ = 0.01) and with IA (11.0 ± 4. vs. 6.5 ± 5.1 mm Hg and ρ = 0.02). No fall in BP during a 24-hour period was observed in training groups compared with C, perhaps because the subjects were mostly nondippers, for whom the effect of training on BP is found to be lower. In conclusion, resistance training promoted a greater nocturnal fall in BP among hypertensive elderly subjects under treatment compared with IA subjects.

INTRODUCTION

The regular practice of physical exercise has been recommended to older individuals with various chronic comorbidities to reduce cardiovascular risk and to maintain functional capacity. Several physical training protocols have been tested on various groups to determine the magnitude of the benefits of exercise and to determine which protocol would be more effective in promoting beneficial changes in the elderly. More recently, some studies have included interval aerobic training (IA), which permits variations in intensity during the sessions, alternating more-intensive and less-intensive periods (7,15,25).

The nocturnal fall in systolic and diastolic blood pressure (BP) is considered to be physiological when the reduction is 10–20% compared with BP during wakefulness. Blood pressure falls of less than 10% (attenuated decline) or of more than 20% (exacerbated decline) are associated with greater cardiovascular risk (2,3,13).

Despite the evidence of the beneficial effects of various exercise modalities on BP variability (4,6), a literature review did not reveal any comparative studies on elderly persons that would include continuous aerobic training (CA), interval aerobic training (IA), and resistance training. Thus, the objective of this study was to compare the effects of these different types of training on hypertensive elderly subjects under treatment in terms of BP variability assessed by the nocturnal BP decline.

METHODS

Experimental Approach to the Problem

This was a nonblind, controlled study consisting of groups randomly assigned to different interventions. The different types of physical training represented the independent variable and BP plus its fall during sleep represented the dependent variables.

Subjects

The study was conducted on 70 preselected subjects of both sexes aged 60-78 years, residing in the city of Ribeirão Preto,
SP, Brazil, and followed up at the Teaching Health Center of the Ribeirão Preto Medical School, University of São Paulo (FMRP-USP). The subjects were hypertensive, were regularly taking prescribed medications, and had no experience with aerobic or resistance training.

The Research Ethics Committee of the Teaching Health Center, FMRP-USP, approved the study (number 1.092.824), and all subjects gave written informed consent to participate. The volunteers were previously submitted to an electrocardiogram and to a treadmill stress test in addition to routine laboratory tests for the determination of thyroid stimulating hormone, creatinine, urea, sodium, potassium, glycemia, and blood count. Exclusion criteria were as follows: a positive test for ischemia, moderate or severe left ventricular hypertrophy, left ventricular systolic dysfunction of any degree, moderate or severe left ventricular diastolic dysfunction, presence of arrhythmias, alcohol intake of more than 7 doses per week, renal insufficiency (creatinine >1.5), diabetes, uncontrolled hyperthyroidism or hypothyroidism, anemia with hemoglobin <12 g·dl⁻¹, limiting pneumopathy, musculoskeletal conditions that would limit the execution of aerobic or resistance exercises, and basal systolic blood pressure (SBP) ≥160 and diastolic blood pressure (DBP) ≥100 mm Hg (Omron—HEM 4031). After exclusion of 2 subjects because of changes in the ergometric test and of 7 subjects who dropped out of the study prematurely by being unable to train at the standardized time, 61 subjects were randomized to the various groups and completed the study.

**Procedures**

The subjects were randomly assigned to 4 groups: CA, IA, resistance training (R), and control group (C), with each group consisting of 15 participants except for R, which consisted of 16 participants. Mean age was similar for all groups (CA: 67.3 ± 5.4 years; IA: 68.1 ± 5.8 years; R: 67.7 ± 5.8 years; and C: 66.6 ± 5.2 years; p > 0.05). Sex distribution also did not differ among groups (p > 0.05), with a total of 41 women and 20 men.

The CA and IA groups were managed with intensities previously calculated by means of

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### Table 1. Twenty-four-hour systolic (S) and diastolic (D) blood pressure during wakefulness and sleep before (Pre) and after (Post) a period of training.*

<table>
<thead>
<tr>
<th></th>
<th>CA (n = 15)</th>
<th>IA (n = 15)</th>
<th>R (n = 16)</th>
<th>C (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Pre 24 h (mm Hg)</td>
<td>129.5 ± 7.4</td>
<td>131.6 ± 14.7</td>
<td>126.9 ± 10.0</td>
<td>130.9 ± 10.4</td>
</tr>
<tr>
<td>S Post 24 h (mm Hg)</td>
<td>125.5 ± 12.3</td>
<td>128.9 ± 12.4</td>
<td>128.2 ± 10.3</td>
<td>128.0 ± 11.7</td>
</tr>
<tr>
<td>S Pre Wake (mm Hg)</td>
<td>130.7 ± 8.2</td>
<td>134.1 ± 15.0</td>
<td>129.1 ± 10.7</td>
<td>134.7 ± 10.6</td>
</tr>
<tr>
<td>S Post Wake (mm Hg)</td>
<td>127.7 ± 13.1</td>
<td>131.5 ± 12.0</td>
<td>131.9 ± 10.1</td>
<td>130.2 ± 12.8</td>
</tr>
<tr>
<td>S Pre Sleep (mm Hg)</td>
<td>126.8 ± 10.4</td>
<td>126.5 ± 15.0</td>
<td>121.9 ± 11.3</td>
<td>123.3 ± 12.8</td>
</tr>
<tr>
<td>S Post Sleep (mm Hg)</td>
<td>120.9 ± 12.7</td>
<td>124.0 ± 14.4</td>
<td>121.2 ± 11.8</td>
<td>123.7 ± 12.2</td>
</tr>
<tr>
<td>D Pre 24 h (mm Hg)</td>
<td>75.5 ± 7.6</td>
<td>78.6 ± 10.8</td>
<td>73.6 ± 8.3</td>
<td>77.2 ± 10.0</td>
</tr>
<tr>
<td>D Post 24 h (mm Hg)</td>
<td>71.9 ± 8.2</td>
<td>76.6 ± 10.9</td>
<td>74.3 ± 8.2</td>
<td>76.3 ± 11.5</td>
</tr>
<tr>
<td>D Pre Wake (mm Hg)</td>
<td>77.3 ± 7.4</td>
<td>81.2 ± 10.8</td>
<td>76.3 ± 9.1</td>
<td>80.5 ± 10.6</td>
</tr>
<tr>
<td>D Post Wake (mm Hg)</td>
<td>74.5 ± 8.7</td>
<td>78.9 ± 11.3</td>
<td>78.1 ± 7.9</td>
<td>78.3 ± 12.3</td>
</tr>
<tr>
<td>D Pre Sleep (mm Hg)</td>
<td>72.1 ± 9.3</td>
<td>73.3 ± 11.3</td>
<td>69.1 ± 7.9</td>
<td>70.2 ± 11.1</td>
</tr>
<tr>
<td>D Post Sleep (mm Hg)</td>
<td>67.3 ± 8.0</td>
<td>72.5 ± 11.2</td>
<td>67.1 ± 9.8</td>
<td>72.3 ± 10.9</td>
</tr>
</tbody>
</table>

*CA = continuous aerobic training group; IA = interval aerobic training group; R = resistance training group; C = control group.

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### Table 2. Fall in systolic (S) and diastolic (D) arterial pressure during sleep compared with wakefulness before (Pre) and after (Post) a period of training.*

<table>
<thead>
<tr>
<th></th>
<th>CA (n = 15)</th>
<th>IA (n = 15)</th>
<th>R (n = 16)</th>
<th>C (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S Pre (mm Hg)</td>
<td>4.0 ± 10.3†</td>
<td>7.5 ± 5.8</td>
<td>7.2 ± 9.1</td>
<td>11.5 ± 9.8</td>
</tr>
<tr>
<td>S Pre (%)</td>
<td>3.0</td>
<td>5.6</td>
<td>5.5</td>
<td>8.5</td>
</tr>
<tr>
<td>S Post (mm Hg)</td>
<td>6.8 ± 8.8</td>
<td>7.5 ± 8.0</td>
<td>10.8 ± 6.2</td>
<td>6.5 ± 10</td>
</tr>
<tr>
<td>S Post (%)</td>
<td>5.3</td>
<td>5.7</td>
<td>8.2</td>
<td>5.0</td>
</tr>
<tr>
<td>D Pre (mm Hg)</td>
<td>5.2 ± 5.4†</td>
<td>7.9 ± 3.8</td>
<td>7.2 ± 6.1</td>
<td>10.3 ± 8.5</td>
</tr>
<tr>
<td>D Pre (%)</td>
<td>6.7</td>
<td>9.8</td>
<td>9.4</td>
<td>12.8</td>
</tr>
<tr>
<td>D Post (mm Hg)</td>
<td>7.3 ± 5.2</td>
<td>6.5 ± 5.1</td>
<td>11.0 ± 4.1††</td>
<td>6.0 ± 5.7§</td>
</tr>
<tr>
<td>D Post (%)</td>
<td>9.8</td>
<td>8.2</td>
<td>14.0</td>
<td>7.7</td>
</tr>
</tbody>
</table>

*CA = continuous aerobic training group; IA = interval aerobic training group; R = resistance training group; C = control group.

†p = 0.01 vs. C Post.
††p = 0.02 vs. AI Post.
§p = 0.03 vs. C Pre.
the treadmill stress test, with 70% of maximum heart rate for CA and a duration of 20 minutes plus 5 warm-up minutes and 5 cool-down minutes, for a total of 30 minutes of training. The intensities for the IA group were 60 and 80% of maximum heart rate alternating every 2 minutes for 20 minutes, plus 5 warm-up minutes and 5 cool-down minutes, for a total of 30 minutes of training.

The R group was first submitted to one maximum repetition (1RM) evaluation, which consists of obtaining maximum load on the equipment in up to 5 attempts, with 3-minute intervals between them. The attempts during which the participants did not complete one execution or 2 repetitions correctly were not validated. If the subject did not achieve the maximum load in up to 5 attempts, the test was considered not to be valid for that specific type of equipment. The sessions for the R group consisted of 2 series of each proposed exercise with 6–10 repetitions, with 50% 1RM load for warm-up. The experimental series was started 2 minutes after warm-up with 75% 1RM, with a volume of 6–10 submaximal repetitions. Training was always started 7 days after the 1RM test. Nine resistance exercises routinely used in gyms were chosen. Three types of training

Figure 1. A) Systolic blood pressure (SBP) in the 24 hours before the research protocol. B) 24-hour systolic blood pressure (SBP) 1 day after the research protocol. C = control group; CA = continuous aerobic training group; IA = interval aerobic training group; R = resistance training group.
equipment were chosen by permitting exercises similar to the movements used in daily life: bench press, leg press, and open row. The other 6 were incorporated to characterize a session of resistance exercises: leg extensor bench, dumbbell curl, flexor bench, adductor chair, abductor chair, and triceps pulley.

The control group did not perform supervised physical activities during the study period but maintained its previous routine activities.

The training program lasted 12 weeks with 3 sessions per week on alternate days, for 36 sessions.

Ambulatory blood pressure monitoring (ABPM) was performed before the beginning of treatment and 1 day after the end of training. Ambulatory BP monitoring was employed using a SPACELABS MEDICAL monitor model 90.207 for BP measurement, installed by the researcher, always starting at 10 AM, permitting automatic 24-hour BP recording. The device was programmed to obtain measurements every 15 minutes during the period from 07 to 23 hours (wakefulness) and every 30 minutes from 23 to 07 hours on the following morning (sleep). Data were recorded on the device and obtained by cable connection with

Figure 2. A) Diastolic blood pressure (DBP) in the 24 hours before the research protocol. B) 24-hour diastolic blood pressure (DBP) 1 day after the research protocol. C = control group; CA = continuous aerobic training group; IA = interval aerobic training group; R = resistance training group.
a computer at the conclusion of each BP monitoring cycle. The subject received a diary for the detailed recording of daily activities during ABPM. Delta SBP and DBP were calculated between the wakefulness and sleep periods.

**Statistical Analyses**

Data were analyzed statistically using a mixed effects model adjusted for age, sex, and body mass index with the aid of the SAS 9 software (17). In this model, the subjects were considered to be the random effect, and the groups, times, and interactions between them were considered to be the fixed effects.

**Results**

Table 1 shows the SBP and DBP values obtained for the 4 groups before and after the study period. Table 2 shows the difference (delta) between the pressure values obtained during wakefulness and sleep.

Figures 1A, B illustrate 24-hour SBP before and after the training period, respectively. Figures 2A, B illustrate DBP, showing an important nocturnal fall in it in the R group compared with control and compared with group IA. The maximum DBP fall occurred at 1 pm.

**Discussion**

This study demonstrated the effect of resistance training on hypertensive subjects regarding the potentiation of the nocturnal fall in DBP, with a decline of more than 10% after the intervention. The nocturnal fall in BP is associated with better sleep quality and with a lower cardiovascular risk (13,16,20).

Few studies have assessed the fall in BP after different exercise modalities. Regarding the effects of a single exercise session, a study that assessed the nocturnal fall in BP after a single session of aerobic exercise revealed a beneficial effect on prehypertensive diabetic subjects (11). However, hypertensive older individuals under treatment submitted to a single session of a circuit of resistance exercises showed nocturnal elevation of SBP and DBP (18). By comparing a single session of aerobic or resistance exercise in 10 diabetic patients, Morais et al. (10) demonstrated a greater nocturnal BP fall after resistance exercise than after aerobic exercise, in agreement with the findings of this study.

Considering the effect of physical training, Sturgeon et al. (23) studied 23 middle-aged subjects submitted to 6 months of CA and did not detect a difference between dippers and nondippers before or after the intervention. Another study detected nocturnal DBP elevation after 8 weeks of resistance training in middle-aged prehypertensive and obese individuals (1).

Mechanisms underlying the increased reduction in BP during sleep among those undergoing resistance training at this point are purely speculative and suggest additional study to define them. However, maybe the findings favoring the R intervention lie in fewer episodes of awakening and a better quality of sleep (16). Another explanation may lie in the potential that a greater recruitment of muscle mass during acute exercise would lead to a higher heart rate and BP, with subsequent adaptation to chronic training. This might be associated with a reduction of stimulation of the muscle metaboreceptors and mechanoreceptors and a net reduction in muscle sympathetic nerve activity (8,19).

We did not detect a significant difference in 24-hour BP after the different types of training applied, a fact that may have been due to the time and intensity of the exercises performed. Previous studies that evaluated the fall in BP after 3 months of continuous aerobic exercise did not detect a fall in BP more than a 24-hour period among subjects who did not show a physiological nocturnal decline in BP, suggesting that other mechanisms may be involved in this subtype of hypertensive individuals (12). In the current study, assessment of the mean basal nocturnal fall in training groups revealed that the subjects submitted to the exercise protocols were nondippers. Another study also did not detect a fall in BP after 6 months of aerobic training despite the occurrence of benefits such as the reduction of carotid artery intima-media thickness and improved nitric oxide levels (5). However, a fall in BP was detected after resistance training alone (24) and after aerobic training alone (9,14,22) or in combination with aerobic training (9,21,22) among hypertensive subjects under treatment.

**Practical Applications**

Resistance training with 9 resistance exercises routinely used in gyms, conducted 3 times a week for 12 weeks, with 75% 1RM, after adequate warm-up, with a volume of 6–10 submaximal repetitions, promoted a greater nocturnal fall in DBP during sleep among hypertensive older subjects under treatment compared with control and CA. Among patients with an attenuated BP decline, the implementation of R can be of help for the nocturnal BP pattern, increasing the decline, which is associated with a better cardiovascular risk. This is an additional benefit of resistance training, which has already been indicated for the improvement and maintenance of functionality and the prevention of sarcopenia in elderly subjects.

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**References**


Resistance Training in Sleep Blood Pressure


