Postexercise Hypotension Is Not Sustained in Normal and Hypertensive Humans

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Blood pressure falls after a single session of exercise. The duration for which this fall in blood pressure persists is not known. Sustained hypotension after a single session of exercise may have important implications in the treatment of patients with mild hypertension. We studied 24 subjects (12 normotensive subjects and 12 patients with mild or borderline hypertension). Blood pressure was measured in the laboratory for 30 minutes before and for an hour after graded bicycle exercise to maximal voluntary capacity. Subjects then left the hospital and measured their blood pressures at home (three measurements every 2 hours) following a strict measurement protocol for the rest of the day (usually between 8 and 12 hours). These home blood pressure measurements were compared with home blood pressure measurements recorded at the same times on a nonexercise control day. At 30 minutes after the graded maximal exercise test, the hypertensive patients experienced a fall in blood pressure from 142±3.5/93±6.5 mm Hg (mean±SEM) to 124±4.5/79±2.8 mm Hg (p<0.01). For the normotensive subjects, blood pressure after exercise fell from 117±3.1/70±2.1 mm Hg to 109±3.1/62±2.8 mm Hg (p<0.01). Despite these striking blood pressure reductions for the second half hour after exercise, blood pressure measurements recorded at home were not significantly different on the exercise and control days in either group. We conclude that although a single bout of exercise lowers blood pressure for a short (1-hour) period, this hypotension is not sustained.

In 1922, Schneider and Truesdell reported that standing blood pressures were lower 2 minutes after a step exercise protocol. A subsequent anecdotal report by Fitzgerald2 suggested that blood pressure in labile hypertension was reduced for 4–10 hours after 25 minutes of jogging. It has been proposed therefore that a single session of exercise once or twice a day may assist in controlling blood pressure purely on the basis of the hypotensive effect after exercise.2–3 Sustained postexercise hypotension may also significantly affect interventional studies of blood pressure, especially studies involving the effects of exercise training. Indeed, the more recent studies on the effects of physical training on blood pressure have allowed 24–48 hours between the last session of exercise and blood pressure measurement.4–7 However, despite extensive studies on the acute fall of blood pressure after exercise, the duration of this blood pressure reduction and its possible role in the management of hypertension has not been systematically studied. We therefore examined whether hypotension after exercise persisted for the rest of the exercise day in normotensive and hypertensive subjects.

Methods

Subjects

We studied 12 normotensive subjects (26.2±3.2 years of age; eight men and four women) and 12 mild and borderline hypertensive patients (32.4±3.8 years of age; nine men and three women). All patients and subjects had sedentary occupations and participated in occasional leisure time exercise; none were athletes. None of the subjects or patients were on any medication. No patient had been treated with antihypertensive medication for at least 6 months. Hypertensive patients were free of end organ damage based on clinical, electrocardiographic, biochemical, and radiological data. Informed consent was obtained from each subject, and the study was approved by the institutional human subjects review committee.

Measurements and Interventions

All studies started at 8:00 AM, and subjects were instructed to avoid any exercise for at least 36 hours.
before the exercise and control days. Blood pressure was measured using a semiautomated self-inflating sphygmomanometer (Copal UA 231, Takeda Medical Inc., Tokyo), the accuracy of which has been described in an earlier report. Measurements were taken every 5 minutes for a 30-minute period of supine undisturbed rest. Heart rate was recorded from the electrocardiograph. Subjects then underwent a graded maximal exercise test (bicycle ergometer) that started at a work load of 50 W, with an increment of 25 W every 5 minutes. Exercise lasted between 27 and 46 minutes and was terminated when subjects were exhausted. After exercise, blood pressure was again measured every 5 minutes for 1 hour while subjects were supine and undisturbed.

Subjects then returned home with a sphygmomanometer and measured their blood pressures and heart rates (three measurements every 2 hours). All subjects were previously instructed in detail with regard to measuring their blood pressures. A strict protocol for blood pressure measurement included the following: subjects were alone when measuring their blood pressure; measurements were taken in the sitting position with the arm resting on the table, and blood pressure was measured after 3 minutes of sitting. The times of measurement and the blood pressures obtained were recorded in a diary. These home blood pressure measurements were recorded for the rest of the day after exercise. Measurements were repeated at approximately the same time of day on a nonexercise control day. Activities outside the hospital were, as far as possible, kept constant on both the exercise and control days.

Statistical Analysis

To assess the acute effects of exercise, average blood pressure recorded for the half hour before exercise was compared with average blood pressure for the second half hour after exercise using Student's paired t test (two-tailed). To investigate any sustained hypotensive effect of exercise, blood pressures recorded at home on the exercise day were compared with blood pressures recorded at the same time of day on the nonexercise, control day, also using Student's paired t test (two-tailed). This analysis was applied to average values for the control and exercise days within each group and was also used within each subject's results to determine whether specific individuals showed sustained hypotension after exercise. Correlations were used to detect strength of association (e.g., between work done and fall in blood pressure). Significance was assumed at the p<0.05 level. Results are presented as mean±SEM.

Results

Measurements in Laboratory

After the maximal exercise test, blood pressure fell from 142±3.5/93±6.2 mm Hg to 124±4.5/79±2.8 mm Hg in the hypertensive subjects (p<0.01). Heart rate was 70±1.6 beats/min before exercise and 76±2.2 beats/min after exercise (p<0.01). In the normotensive subjects, blood pressure fell from 117±3.1/70±2.1 mm Hg to 109±3.1/62±2.8 mm Hg (p<0.01), and heart rate increased from 67±2.0 to 73±1.6 beats/min (p<0.01) after exercise (Figure 1). There was no significant relation between before-exercise heart rate and blood pressure and total work capacity and the blood pressure fall after exercise.

Home Blood Pressure Measurements

Comparable measurements on the control and exercise days were obtained at 2, 4, 6, 8, 10, and 12 hours after exercise. For the 12 normotensive subjects, the number of subjects for whom readings were available at these times after exercise, on both exer-
exercise and control days, were 12, 12, 11, 12, 8, and 4 subjects, respectively. For the 12 hypertensive subjects, the number of people for whom readings were available for comparison at the same times of day on both exercise and control days, at 2, 4, 6, 8, 10, and 12 hours after exercise, were 11, 11, 12, 11, 11, and 5 patients, respectively.

Neither the normotensive (Figure 2) nor the hypertensive (Figure 3) subjects showed evidence for sustained postexercise hypotension. For the normotensive subjects, the only significant difference between exercise and control home blood pressures was seen at 8 hours after exercise, when postexercise blood pressure was higher than control-day blood pressures (Figure 2). For the hypertensive patients, home blood pressures on the exercise day did not differ significantly from blood pressures on the control day. Neither normotensive nor hypertensive subjects showed significant differences in heart rates on exercise and control days.

When subjects were considered individually, mean blood pressure was lower on the exercise day in only two hypertensive subjects (1 man, 1 woman) and in none of the normotensive subjects. However, mean blood pressure was higher in one of the male hypertensive subjects on the exercise day and in one of the male normotensive subjects. There were no distinctive characteristics of these individuals' age, blood pressure, or heart rate to explain these responses.

The male hypertensive subject who showed a sustained blood pressure reduction with exercise was subsequently retested. The sustained hypotension...
was not evident on the second study, suggesting that the lower blood pressure levels on the first study were either inconsistent or due to a sampling error.

Discussion

The important finding in this study is that although a single bout of maximal exercise profoundly lowered blood pressure for an hour immediately after exercise, there was no sustained blood pressure reduction. Even at 2 hours after exercise, blood pressure was not significantly lower when compared with a control day. These data indicate that a single session of exercise daily (as opposed to exercise training) is unlikely to provide a clinically significant blood pressure reduction in normotensive or hypertensive people.

Clearly, however, there is a marked fall in blood pressure in the period immediately after exercise, in both normotensive and hypertensive subjects. The mechanism of this hypotension is unclear. Bjurstedt et al. have reported marked orthostatic impairment in subjects after exhausting exercise of short duration. They have suggested that postexercise acidosis or hyperthermia may interfere with orthostatic vasoconstriction. Bennett et al. have suggested that there may be an increase in sensitivity of cardiopulmonary receptors after exercise. Sensitivity of the arterial baroreceptor reflex is markedly increased, especially at 1 hour after exercise, and there appears to be a reduction in resting sympathetic nerve discharge after exercise.

Interestingly, changes associated with endurance training such as blood pressure reduction, augmented cardiopulmonary reflex sensitivity, and decreased sympathetic activity are similar to those seen after acute exercise. We have also reported that blood pressure reduction with endurance training is associated with an increase in arterial baroreceptor reflex sensitivity. An important question therefore is whether the blood pressure reduction reported after endurance training is a true training effect or is it merely a transient effect secondary to acute exercise?

Although some studies fail to specify the exact timing of the blood pressure measurement in relation to the last session of exercise, other investigators have allowed between 24 and 48 hours between the last exercise session and blood pressure measurement so as to eliminate any contribution of the short-term effects of exercise. Because of the short duration of the hypotension after a single exercise session and the interval allowed between exercise and blood pressure measurement in these studies, it is likely that the blood pressure reduction seen with endurance training is a true prolonged effect of training and cannot be explained by the transient hypotension seen after a single session of exercise.

To our knowledge, the only other controlled study investigating the duration of postexercise hypotension only followed up blood pressure for up to 90 minutes after exercise. We found no evidence for a sustained reduction in blood pressure. It is conceivable that the fall in blood pressure after exercise may persist if subjects remain in the supine position for a number of hours. If subjects continue normal daily activities, however, there is no evidence for a blood pressure reduction. It is possible that the mechanisms maintaining the blood pressure reduction in the supine position are overridden when subjects are allowed to be ambulatory. A further consideration is that a maximal exercise protocol was followed for this study. It is possible, but unlikely, that lower levels of exercise may result in a more prolonged fall in blood pressure.

These data also do not exclude the possibility that highly selected populations (e.g., athletes or extremely sedentary people) may experience sustained blood pressure reductions after exercise.

A strength of the present study is that the effects of factors such as postural changes and blood pressure variability are minimized. The sitting position was used for all blood pressure measurements outside the hospital. The large number of blood pressure recordings on each of the control and exercise days would mitigate the effects of blood pressure variability on our data. Blood pressures were measured at the same times of day, so that diurnal variations in blood pressure would not influence our comparisons.

In conclusion, although a single session of exercise markedly lowers blood pressure for about 1 hour after exercise, there is no clinically significant sustained blood pressure reduction. A single daily session of exercise, independent of a training effect, is not an effective means of blood pressure reduction through the day and cannot explain the sustained fall in blood pressure associated with endurance training.

References


KEY WORDS • exercise • blood pressure • hypotension • borderline hypertension
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