Blood Pressure Response After Weight Training Exercise

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ABSTRACT

The purpose of this study was to describe the blood pressure response after heavy resistance exercise. Blood pressure was measured by auscultation in six young men before and during a 60-minute period following a bout of weight training. Weight training consisted of three sets of four exercises (arm curl, bench press, bent-arm row and squat) performed using 70 percent of one-repetition maximum for as many repetitions as possible. Mean (± SE) baseline blood pressure, measured 15 minutes before exercise, was 119/86 ± 4/4 mmHg. Immediately following exercise, it had dropped (p < .05) below pre-exercise levels to 99/62 ± 10/3 mmHg. However, one minute after the termination of weight training, pressure had rebounded to 116/75 ± 12/8 mmHg, and thereafter did not change during the 60 minutes of recovery. Subjects reported no exceptional subjective distress, and had no obvious EKG abnormalities. It is concluded that there is a post-exercise trough in blood pressure associated with the sudden termination of heavy resistance weight training with systolic and diastolic pressures dropping more than 20 mmHg below normal resting levels.

KEY WORDS: Exercise, recovery, blood pressure, weight training.

Introduction

Systolic blood pressure is elevated during weight training exercise in healthy individuals (3, 7, 11, 13, 15), and this increase appears to be a function of exercise intensity (7, 15) or the size of the involved muscle mass (13). Blood pressure returns to pre-exercise levels, or slightly lower, within five minutes of the cessation of exercise (9).

It is not clear if systolic blood pressure simply declines gradually during recovery, as described by DeVries (2). Alternatively, there are three possibilities: 1. systolic blood pressure may "overshoot" and reach levels exceeding maximal exercise values, as has been noted after treadmill and cycling exercise (14); 2. systolic blood pressure may drop suddenly within seconds after the termination of exercise, to about resting levels, then "rebound" to about peak exercise levels, and then decline gradually, as is common after dynamic exercise (2); or 3. systolic blood pressure may both drop suddenly and then rebound above peak exercise values before declining gradually (8).

This study was designed to determine if blood pressure following weight training exercise shows either the sudden drop and rebound or the overshoot which have been reported after other kinds of exercise. The purpose of this study was to evaluate the response of blood pressure during recovery from weight training exercise.

Methods

Subjects were six healthy men, 22 to 33 years of age. The subjects' mean (± SD) height, weight, and fitness were 174.2 ± 4.8 cm, 72.3 ± 8.1 kg, and 12.9 ± 3.3%, respectively. All subjects were physical education students who had previous resistance training experience. All were active in recreational activities, but none had been involved in a weight training program during the six months preceding the study. Each gave written informed consent.

Two tests on separate days were given to determine each subject's one repetition maximum (1 RM) on four isotonic exercises (standing two-arm curl, supine bench press, bent-arm row, and parallel squat) performed using free weights. To determine the 1 RM for each exercise, the subjects lifted a light weight three or four times as a warm-up. Then, investigators added weights until the subject could not perform the exercise in a controlled manner. Weight was added so that the maximal lift would occur in about the fifth effort. The criterion measure for the 1 RM was the heaviest lifted on either day for each strength test. For the six subjects, mean (± SE) 1 RM for the exercises were: two-arm curl, 55.7 ± 5.7 kg; bench, 88.6 ± 8.2 kg; bent-arm row, 75.4 ± 9.5 kg; and parallel squat, 135.6 ± 9.9 kg.

The weightlifting regimen consisted of three circuits of the four exercises, in the order listed above. Resistance was 70 percent of each subject's 1 RM for each exercise, and as many repetitions as possible were performed. A 30-second rest was allowed between exercises. Subjects remained
standing for the pre-exercise measurements, and throughout the exercise and recovery, except during the supine bench press and bent-arm row.

Systolic and diastolic blood pressures were measured by auscultation, with the first diastolic phase being recorded. Measurements were made 15 minutes before exercise, immediately before and immediately following exercise, and 1, 2, 15, 30, and 60 minutes following exercise. The measurements referred to as immediately following exercise were completed within the first 10 seconds of recovery. The primary investigator performed the measurements in five of six subjects, and himself served as the sixth subject. His responses were similar to those of the other subjects.

Oxygen uptake and heart rate were determined for the five minutes preceding exercise, for each minute during exercise, and for the first five minutes of recovery. Metabolic measurements were each minute using a semiautomated system (16). Minute ventilation was measured with a Parkinson-Gowan CD-4 gasometer and recorded on a Gould Brush recorder. Expired air was analyzed for oxygen and carbon dioxide percentages using Beckman OM-11 and LB-2 electronic analyzers, respectively. The analyzers were calibrated using 100 percent nitrogen and a standard gas previously analyzed using a micro-Scholander chemical gas analyzer. Heart rate was determined from electrocardiogram recordings. Subjects were required to wear a noseclip and breathe through a mouthpiece throughout the weight training session. They were not advised about breathing style or pattern, and were not specifically instructed to use or avoid a Valsalva maneuver.

Blood pressure data were analyzed using a one-way analysis of variance with planned comparisons. The alpha level was set at .05 for all significance tests.

Results

Blood pressure responses are graphically presented in Figure 1. Time on the X-axis during exercise is expressed as a percentage of exercise time, to adjust for individual differences in exercise duration. There were two reasons for these differences. First, although rest periods were closed regulated at 30 seconds, occasionally a subject required slightly longer to move from station to station because of difficulty in maneuvering with the wires and tubes connecting him to the EKG and expired gas analyzers. Second, there were inter-subject differences in rate of lifting and number of repetitions completed. The duration of exercise ranged from 11 to 18 minutes, with an average of 14 minutes. The mean number of repetitions performed during the first circuit was 12, but only seven could be completed during the third circuit.

Mean oxygen uptake and heart rate during weight lifting were 1.96 l-min⁻¹ and 158 bt-min⁻¹, respectively. Oxygen uptake and heart rate responses are presented in Figure 2.

Arterial blood pressures 15 minutes before exercise (119/86 ± 4/4 mmHg) and immediately before exercise (122/90 ± 5/4 mmHg) did not differ (p > .05). Since all subjects were familiar with the exercise physiology laboratory, and comfortable in those surroundings, we are confident that the blood pressure recorded 15 minutes before was representative of a resting (standing) value. It was possible...
that the measurement made immediately prior to exercise reflected some anticipatory effects, and it was not included in data analysis. The value obtained 15 minutes before exercise was used as the baseline value.

Blood pressure immediately after exercise, 99/62 ± 10/3 mmHg, was much lower (p < .05) than baseline. During the first minute of recovery, blood pressure rebounded upward to 116/74 ± 12/8 mmHg. Thereafter, blood pressure remained unchanged during the 60 minutes of recovery, systolic pressure was not significantly lower (p = .19) and diastolic pressure was slightly lower (p < .05) than before exercise.

Discussion

Typically, within seconds after abrupt termination of sustained rhythmic exercise, systolic blood pressure drops to pre-exercise levels, then rebounds upward (2). In this study, the trough in blood pressure immediately following weight training exercise was greatly exaggerated, with systolic pressure 20 mmHg below pre-exercise levels and diastolic pressures 24 mmHg below pre-exercise levels. This trough was short-lived: mean systolic and diastolic blood pressure rebounded upward almost to mean pre-exercise values within one minute of the termination of exercise, and then remained unchanged through the remainder of the recovery. Blood pressures throughout the recovery period were lower than pre-exercise values. Such persistent reductions have been reported previously (9).

The trough we report was so marked that, not only were pressures significantly lower than pre-exercise values, pressures immediately after exercise were also significantly lower than the recovery values from one to 60 minutes post-exercise.

We did not measure blood pressure during the weight lifting itself. MacDougall et al (11) reported intra-arterial systolic pressures of > 400 mmHg during heavy resistance exercise. Auscultatory measurements of systolic blood pressure during weight training exercise have generally exceeded 150 mmHg (3, 6, 15). There is evidence that the blood pressure response during exercise may be attenuated by weight training experience (3) and by avoiding the Valsalva maneuver (12). In the present study, it is likely that systolic blood pressure was 150 mmHg or higher at the end of the exercise bout, before dropping within seconds to under 100 mmHg. We can be certain that the post-exercise trough was the result of a sudden and precipitous drop in systolic blood pressure.

The sudden fall in systolic blood pressure following sustained rhythmic exercise is primarily due to the immediate decrease in preload resulting from the abrupt loss of venous return via the "muscle pump" (10). This effect is exaggerated by the reduced blood volume consequent to a plasma volume shift. However, plasma volume shift does not explain the reduced postexercise blood pressure that we are reporting, as the time course of the PV reduction and blood pressure reduction are not similar (1).

Recovery blood pressures were lower than baseline throughout recovery. A possible reason may be that the release of vasodilator metabolites from skeletal muscles, which has been suggested as a mechanism for the reduced blood pressure following walking exercise (9), is expected to be very great after weight training exercise. Although based on our results, it is not possible to conclude that weight training would have a beneficial effect on resting blood pressure, our data are certainly not inconsistent with this premise.

Our data may appear to be in conflict with the generally accepted view that blood pressure is elevated during exercise and that it gradually falls during recovery (2). This is not necessarily so. First, our results cannot be compared with results of studies in which pressure was not measured until at least 30 seconds into recovery. Second, some previous studies have shown a postexercise drop in blood pressure. Westcott and Howes (15) measured diastolic pressure immediately upon the final repetition in a set of arm curls, and values were reported to be equal to or lower than resting values.

Postexercise troughs in blood pressure occur after cycling exercise (10), and there are reports of an accompanying rebound that actually exceeds values measured during exercise (8). However, this trough has not been reported in all studies which have evaluated blood pressure immediately after heavy resistance exercise (5).

Our findings, with those Westcott and Howes (15) and other investigators (8, 10), emphasize the need for including the exact time frame in reports of blood pressure during recovery from exercise.

Our data suggest that the postexercise trough in blood pressure is exaggerated after heavy resistance exercise compared to cycling or running. MacDougall et al (11) suggest that high systolic blood pressure occurs during weightlifting exercise because considerable mechanical resistance to blood flow is offered by the contracting muscles. We speculate that physiological adaptions which lower peripheral resistance (e.g., arterial dilation) would be maximal during weight training. So when the exercise is suddenly terminated, and the mechanical resistance to blood flow is removed, the blood pressure (which is directly related to peripheral resistance) is very low.

For a number of reasons, we are assuming that cardiac output did not drop precipitously following exercise. First, diastolic pressure had the same trough as systolic, suggesting that the cause was peripheral, not central. Second, oxygen uptake during the first full minute of recovery was not inordinately low; it followed a fast but smooth return toward normal during the second through fifth minutes of recovery. Third, heart rate (although measured at the end of each minute, and not immediately following exercise) also followed a fast but smooth return toward normal; there was no indication of a compensatory increase which might be expected to follow a decrease in cardiac output, nor was there indication of a decrease in heart rate which might
have contributed to a reduced cardiac output. It follows that either the arteriovenous oxygen difference widened to maintain oxygen uptake, or that the trough was so brief that the reduction in the oxygen delivery was not critical.

Blood pressure is affected by performance of the Valsalva maneuver (12). Our subjects were not specifically instructed to not perform this maneuver. It is unlikely that this maneuver would be performed on only the final repetition. Therefore, the smooth return to normal of heart rate and oxygen uptake, coupled with the duration of exercise, argues against a Valsalva maneuver being responsible for the drastic drop in blood pressure.

Our subjects did not report any exceptional subjective stress in association with the blood pressure trough. Nor, when single-lead EKG strips were examined for determination of heart rate, were any obvious EKG abnormalities noted. However, in less fit individuals, the sudden drop in blood pressure immediately post-exercise is potentially dangerous if it is associated with reduced oxygen delivery.

We conclude that the post-exercise trough in blood pressure associated with the sudden termination of weight training is more marked than the trough which occurs after sustained rhythmic exercise. In the first few seconds of recovery after heavy resistance exercise, systolic and diastolic blood pressure drop precipitously, with both values falling to 20 mmHg below pre-exercise levels for a short period of time.

Practical Applications

A prudent recommendation would be that individuals perform light exercise, and not stand still, immediately following the termination of weight training. Furthermore, our findings suggest that post-exercise blood pressure measurements must be interpreted carefully—a low pressure immediately after exercise may reflect this trough effect and not be indicative of cardiovascular insufficiency.

References